DESIGNING STEEP LANDFORM SLOPES INCORPORATING A GCL



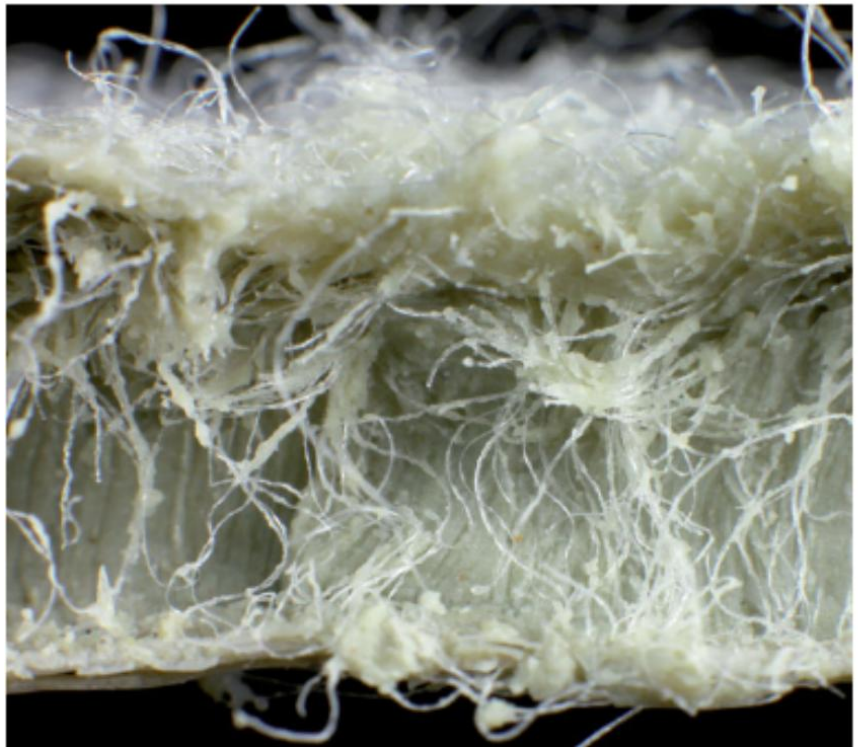
PRESENTER: CONNOR THOMSON
Co-authors: Udeshini Pathirage & Simon Sheldrick

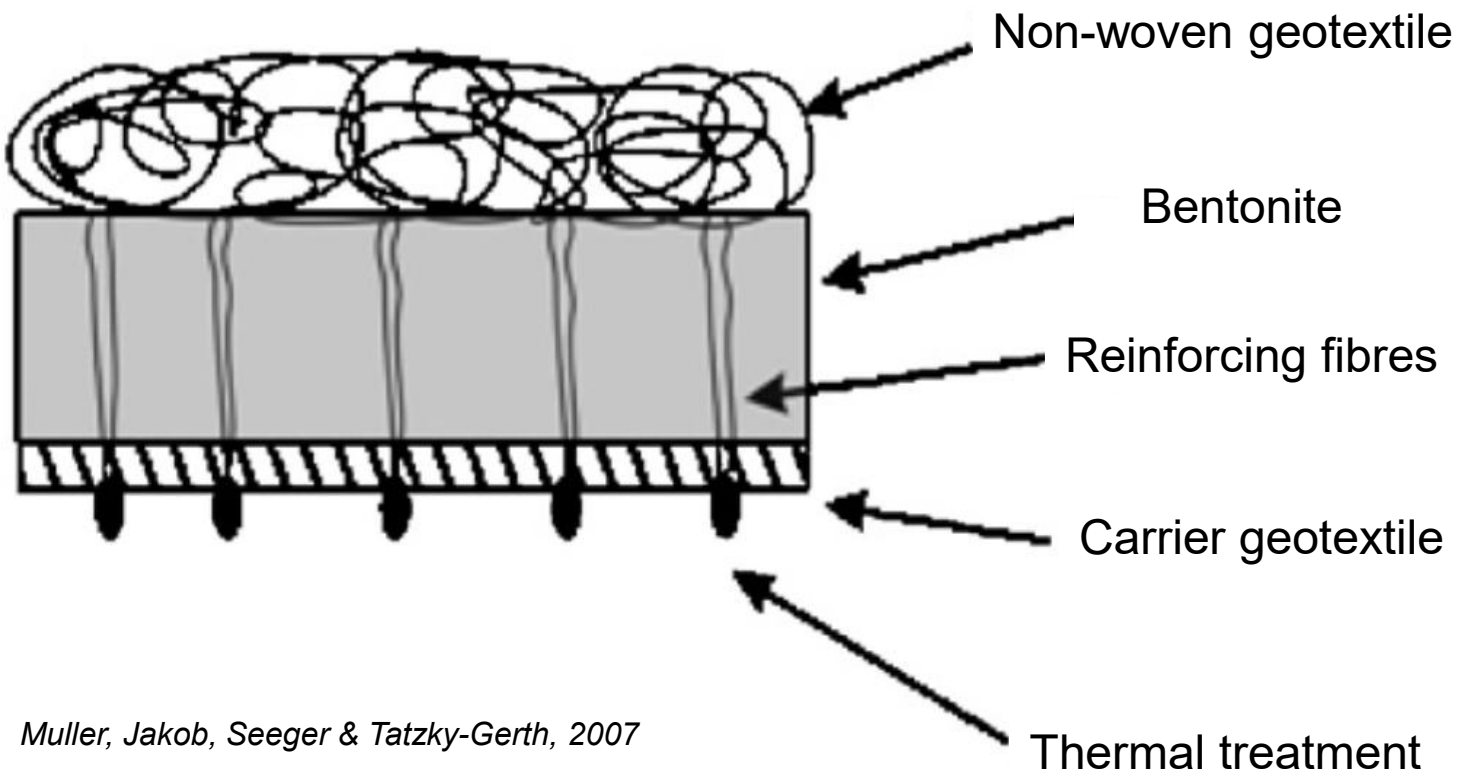
Why we use GCLs

1. Low permeability
2. Rapid installation
3. Simple joints/seaming
4. Effective alternative to compacted clay in some applications
5. Tolerates some differential settlement



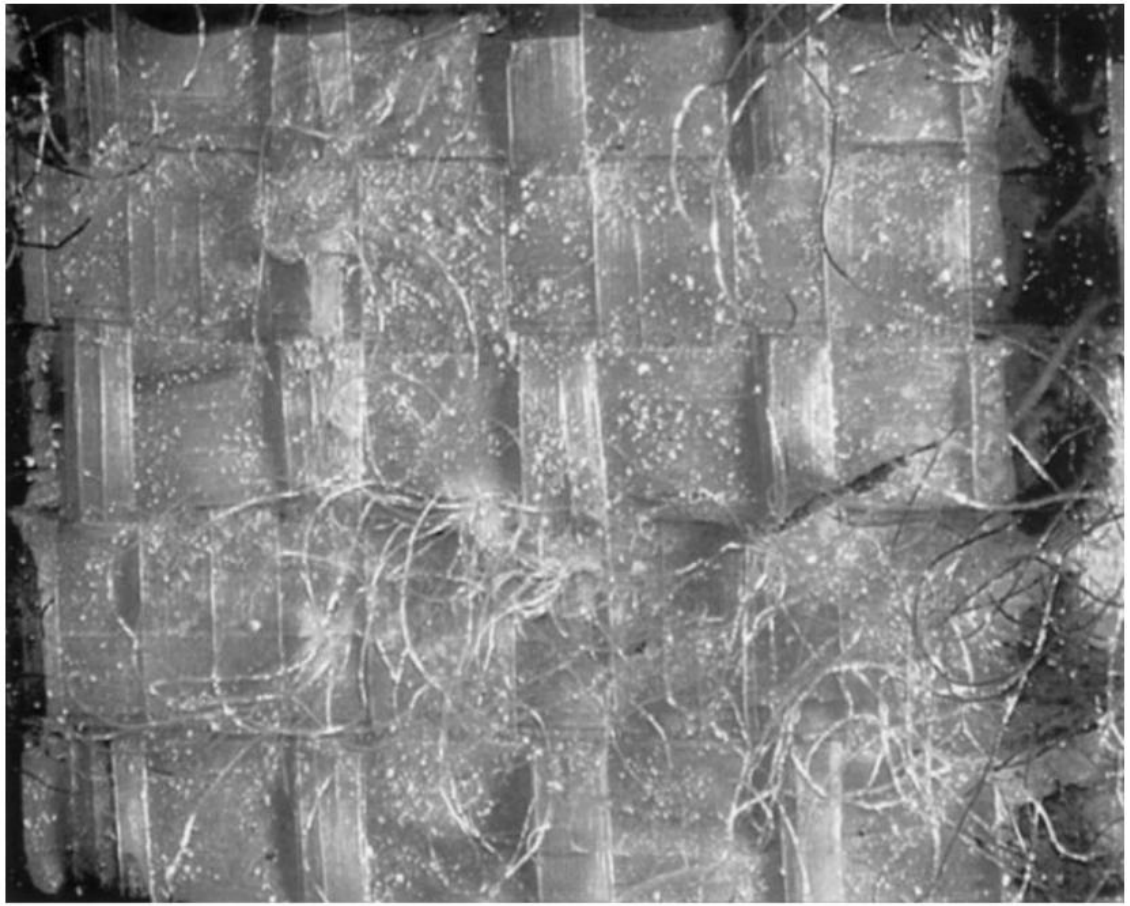
Types of GCLs used for slope applications





Muller, Jakob, Seeger & Tatzky-Gerth, 2007

Non-thermally treated



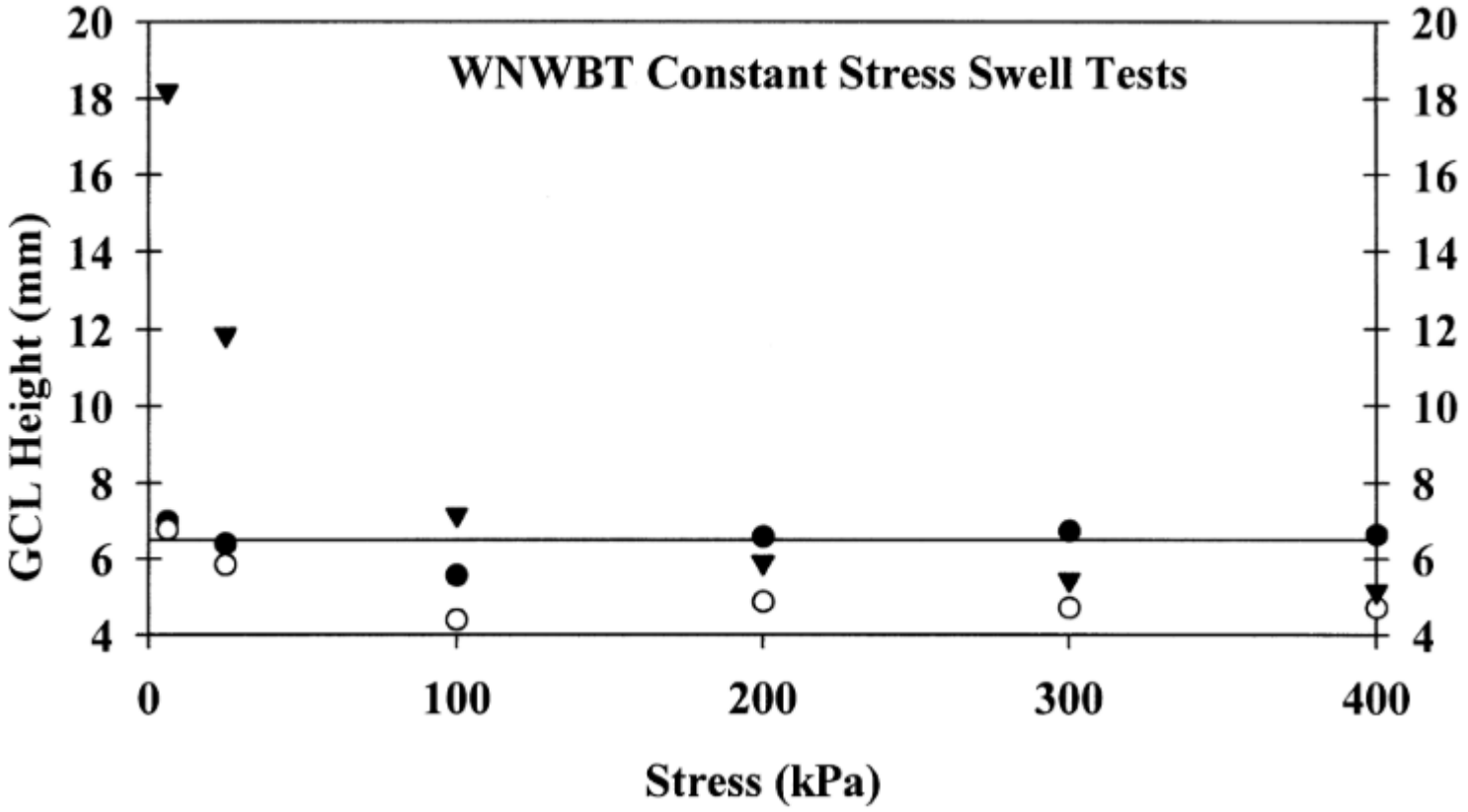
Thermally treated



Lake & Rowe, 2000

Short term strength of GCLs

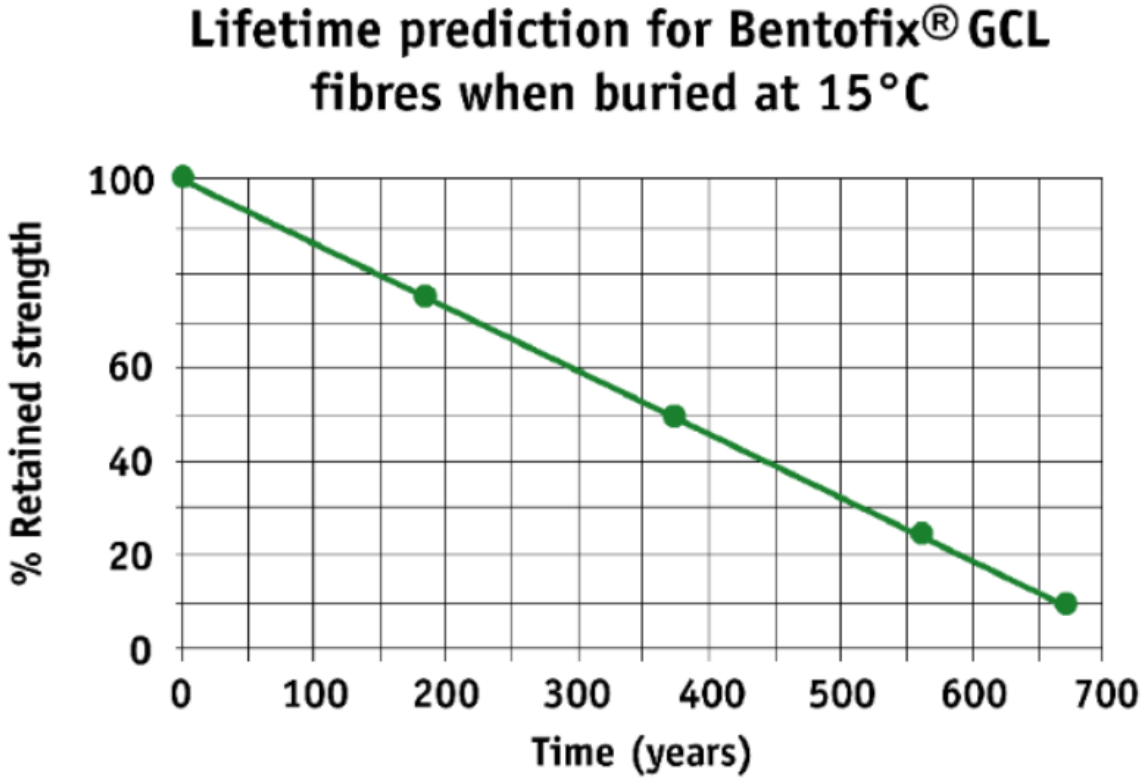
1. Reported shear strength test results are generally optimistic.
2. The polypropylene fibres typically have a break strain of approximately 50%.
3. How much will the GCL swell? Fully hydrated under low confining pressures > 300%
4. Hydrated bentonite (largely material specific) has a very low shear strength.



Lake & Rowe, 2000

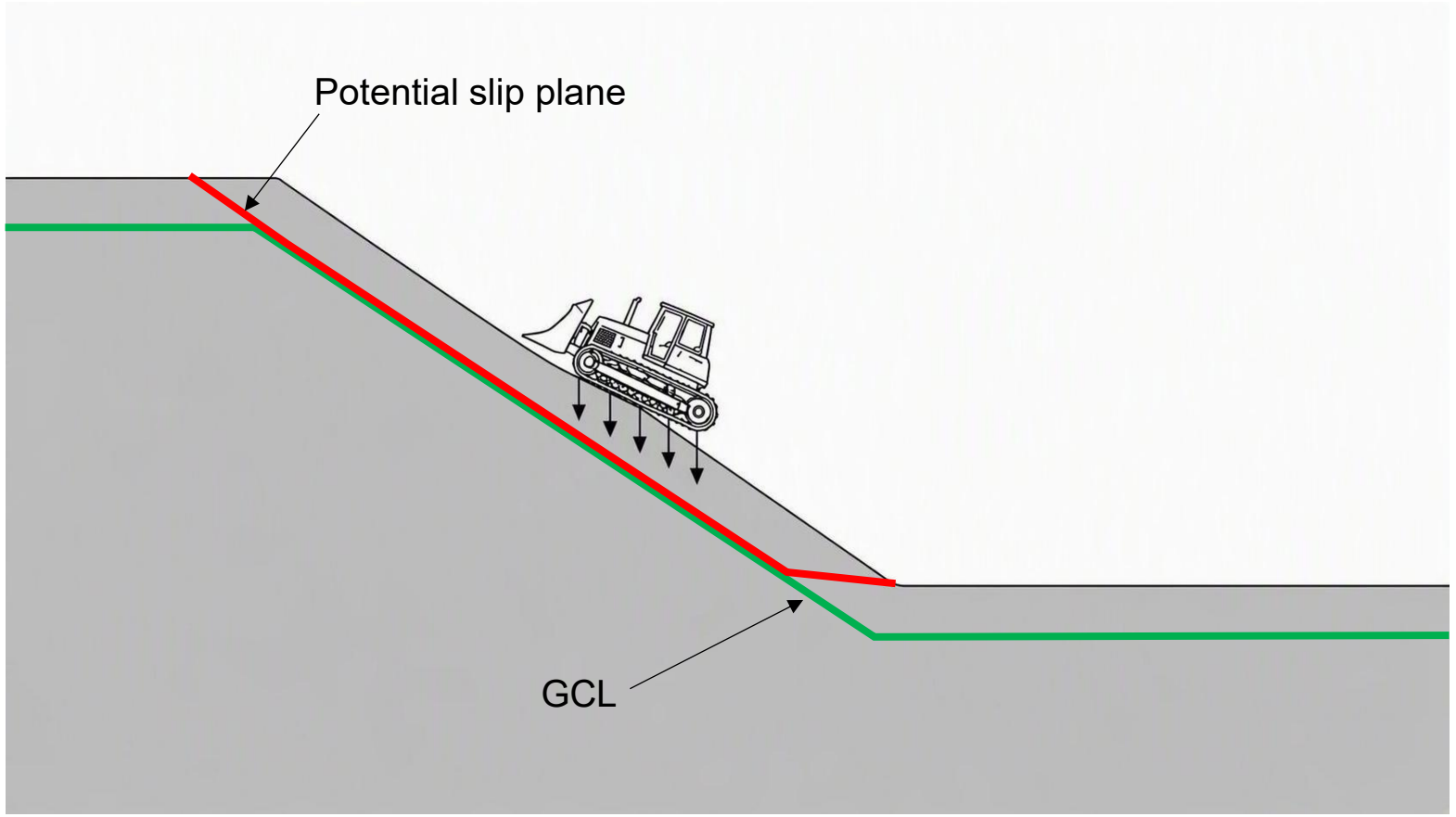
Long term strength of GCLs

Another consideration



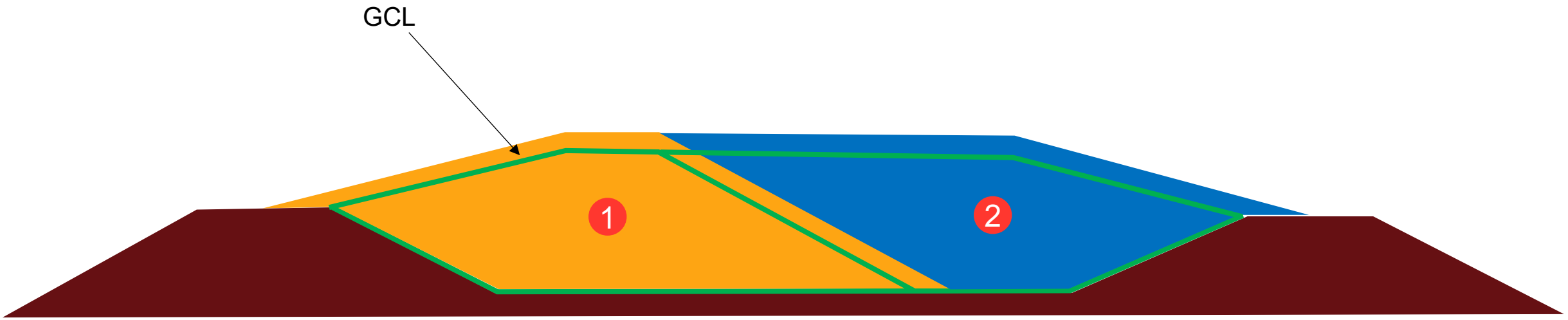
Von Maubeuge, Coulson & Hedrich, 2005

When is GCL strength most critical?

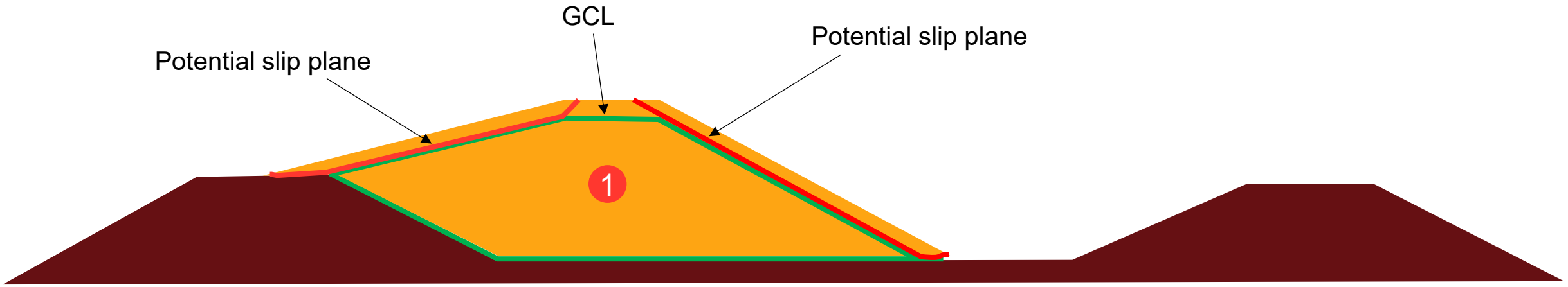


1. Long slopes
2. Steep slopes
3. Small toe buttress
4. Equipment loading (static and dynamic)
5. Cover soil load

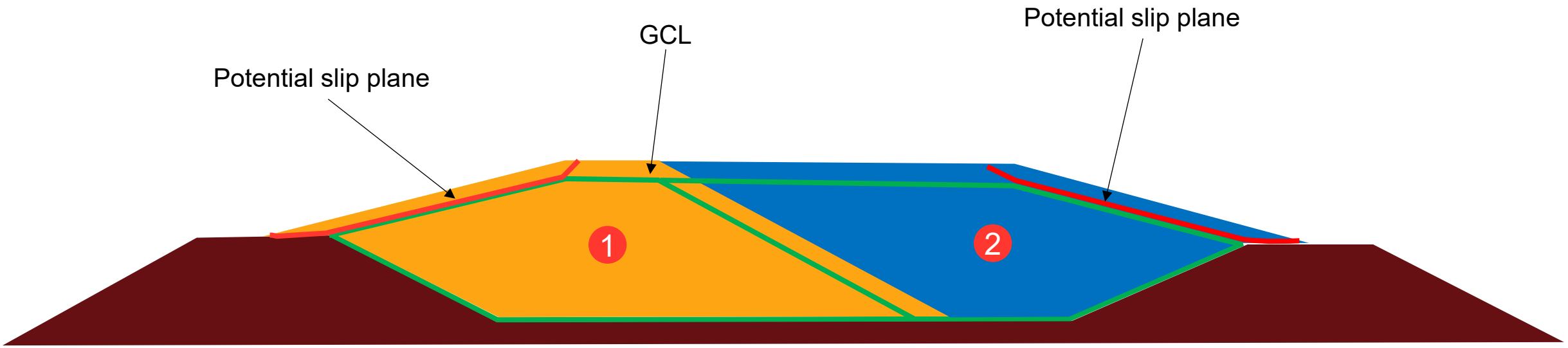
Identifying potential GCL failure modes?



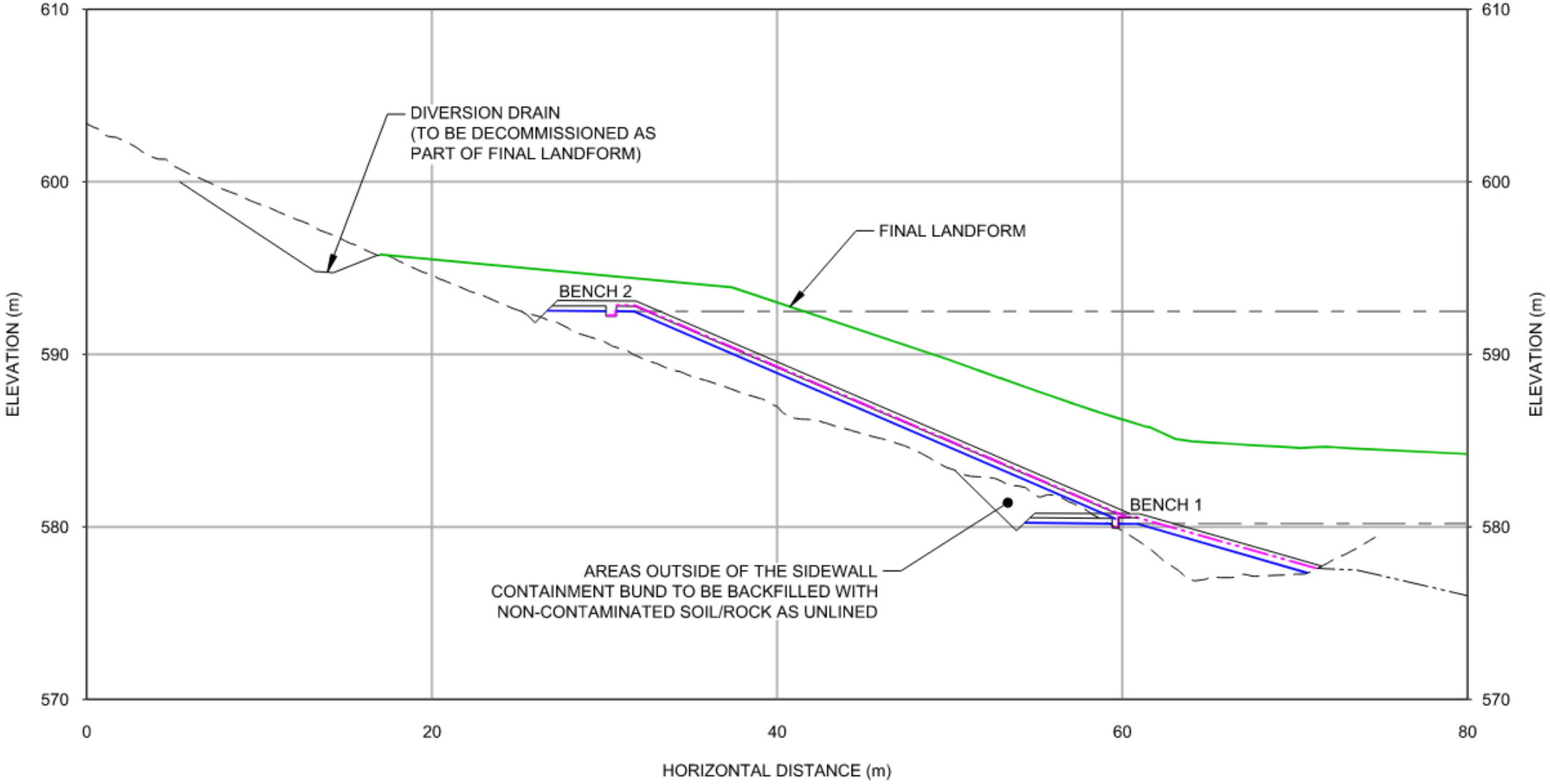
Identifying potential GCL failure modes?

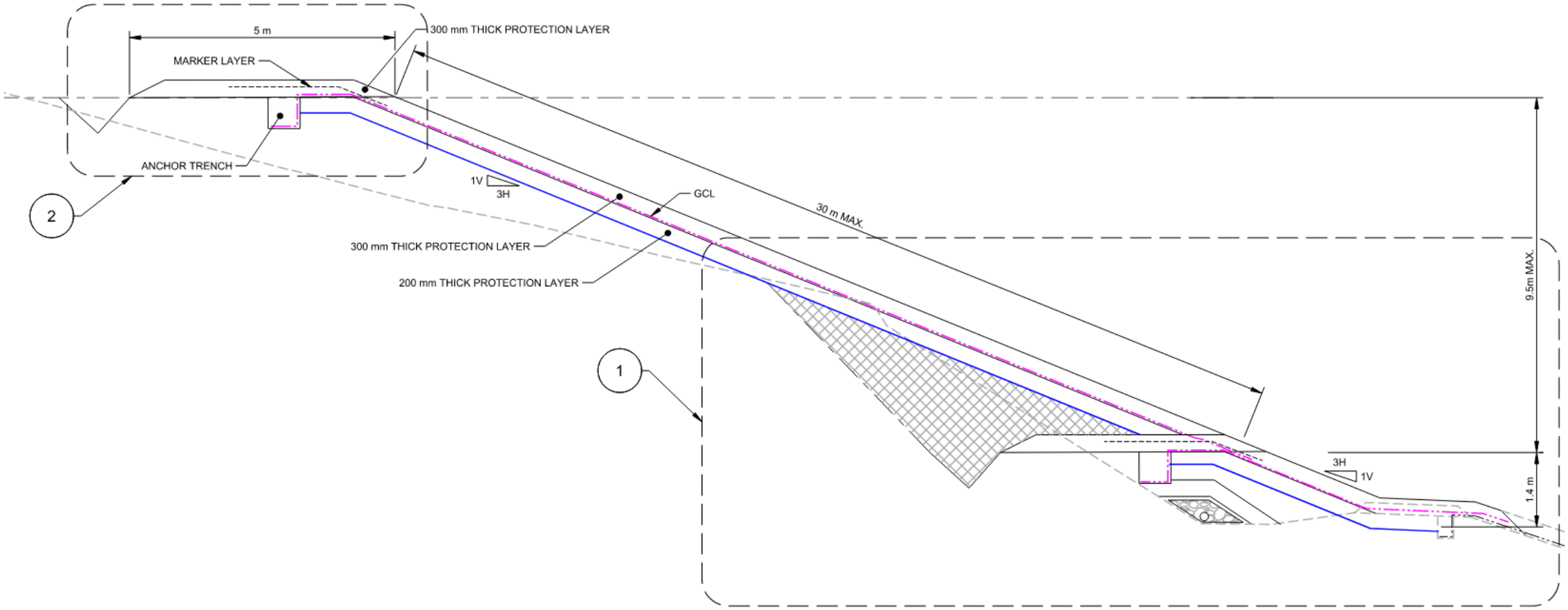


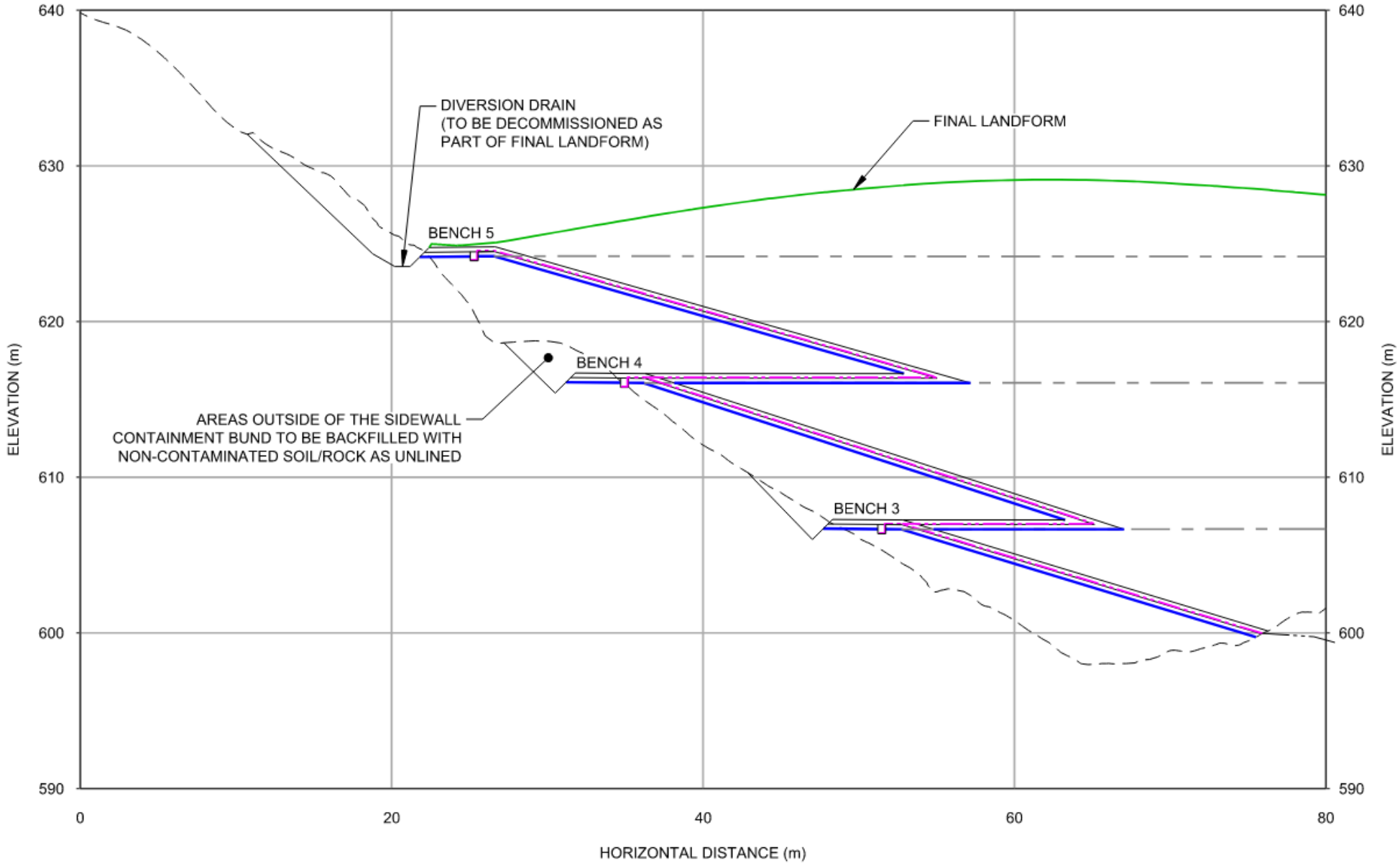
Identifying potential GCL failure modes?

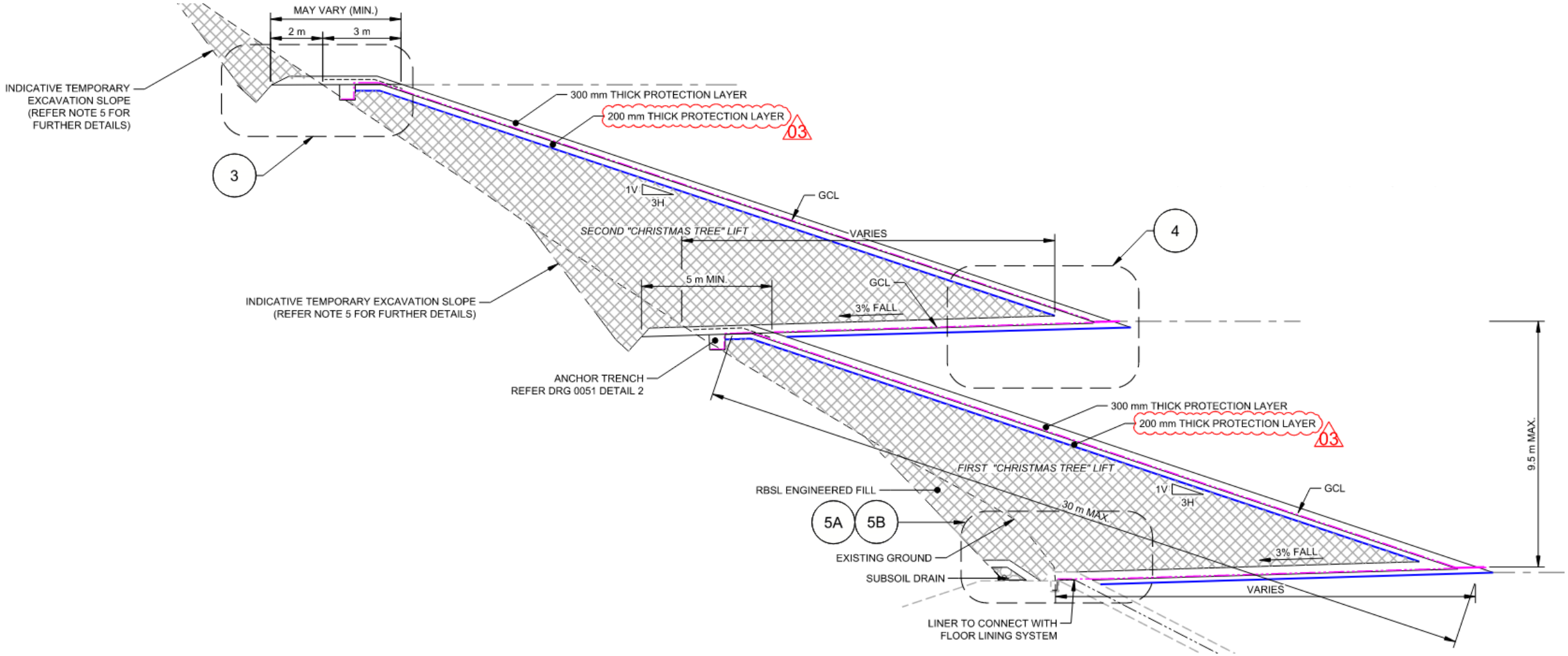


Project Example


610
600
590
580
570
ELEVATION (m)
DIVERSION DRAIN
(TO BE DECOMMISSIONED AS
PART OF FINAL LANDFORM)
FINAL LANDFORM
BENCH 2
BENCH 1
AREAS OUTSIDE OF THE SIDEWALL
CONTAINMENT BUND TO BE BACKFILLED WITH
NON-CONTAMINATED SOIL/ROCK AS UNLINED
0
20
40
60
80
HORIZONTAL DISTANCE (m)


5 m
300 mm THICK PROTECTION LAYER
MARKER LAYER
ANCHOR TRENCH
2
1V
3H
GCL
30 m MAX.
300 mm THICK PROTECTION LAYER
200 mm THICK PROTECTION LAYER
1
9.5m MAX.
3H
1V
1.4 m


DIVERSION DRAIN
(TO BE DECOMMISSIONED AS
PART OF FINAL LANDFORM)
FINAL LANDFORM
BENCH 5
BENCH 4
BENCH 3
AREAS OUTSIDE OF THE SIDEWALL
CONTAINMENT BUND TO BE BACKFILLED WITH
NON-CONTAMINATED SOIL/ROCK AS UNLINED
ELEVATION (m)
ELEVATION (m)
HORIZONTAL DISTANCE (m)
640
630
620
610
600
590
0
20
40
60
80


MAY VARY (MIN.)
2 m
3 m
INDICATIVE TEMPORARY EXCAVATION SLOPE (REFER NOTE 5 FOR FURTHER DETAILS)
300 mm THICK PROTECTION LAYER
200 mm THICK PROTECTION LAYER
03
3
1V
3H
GCL
SECOND "CHRISTMAS TREE" LIFT
VARIES
4
5 m MIN.
GCL
3% FALL
INDICATIVE TEMPORARY EXCAVATION SLOPE (REFER NOTE 5 FOR FURTHER DETAILS)
ANCHOR TRENCH REFER DRG 0051 DETAIL 2
300 mm THICK PROTECTION LAYER
200 mm THICK PROTECTION LAYER
03
FIRST "CHRISTMAS TREE" LIFT
RBSL ENGINEERED FILL
1V
3H
GCL
5A
5B
30 m MAX.
EXISTING GROUND
3% FALL
SUBSOIL DRAIN
VARIES
LINER TO CONNECT WITH FLOOR LINING SYSTEM
9.5 m MAX.

Cover material placement

1. Trial is often required as part of the specification
   - Method and equipment does not negatively impact the GCL
   - Equipment must not traverse the GCL if it results in visual damage
2. Cover soils must be placed from the base to crest of slopes
   - Using only approved equipment/load



Cover material placement

1. Timing
   - Cover material must be installed during same shift as GCL panel deployment
2. Weather
   - Wet weather must be considered, and cover in place before rainfall to prevent pre-hydration
3. Pre-hydration of GCL must be assessed on a case-by-case basis
   - Concern is damage to reinforcement/fibres and loss of bentonite
   - Damaged panels may need to be completely replaced



Additional considerations:

1. Airspace considerations
2. Drainage/seepage considerations
3. Effective containment / continuous GCL barrier
4. Construction loading
5. Constructability (bund/bench widths for construction, maximum slopes etc.)
6. Safety in design (deployment of GCL down slopes etc.)

References

1. Müller, W., Jakob, I., Seeger, S., & Tatzky-Gerth, R. (2008). Long-term shear strength of geosynthetic clay liners. *Geotextiles and Geomembranes, 26*(2), 130-144. https://doi.org/10.1016/j.geotexmem.2007.08.001
2. von Maubeuge, K. P., Coulson, J., & Hedrich, F. (2005). *Landfill cap design with geosynthetic clay liners*. Proceedings paper.
3. Yu, B., Kolonnage, Y., Amstberg, M., & Gibbs, D. (2026). GCL internal shear performance under various hydration conditions. *E3S Web of Conferences, 740*, 14004. https://doi.org/10.1051/e3sconf/202674014004
4. von Maubeuge, K. P., & Quirk, C. M. (2000). Geosynthetic clay liners and long-term slope stability. In *Proceedings on Geosynthetic Clay Liners*.
5. Lake, C. B., & Rowe, R. K. (2000). Swelling characteristics of needlepunched, thermally treated geosynthetic clay liners. *Geotextiles and Geomembranes, 18*(2-4), 77-101. https://doi.org/10.1016/S0266-1144(99)00022-9
6. Domitrović, D., & Kovačević Zelić, B. (2013). The relationship between swelling and shear strength properties of bentonites. In *Proceedings of the 18th International Conference on Soil Mechanics and Geotechnical Engineering* (pp. 219-222). Paris, France.