GEOTECHNICAL

ENVIRONMENTAL

BLEAK HILL III

ENVIRONMENTAL PERMIT APPLICATION

Stability Risk Assessment Report

GEC NO: GE220010501

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HAMER QUARRY COMPLEX: BLEAK HILL

WASTE RECOVERY PERMIT

Stability Risk Assessment

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1.0 INTRODUCTION

Report Context

1.1 The operator of the installation is CEMEX UK Materials Ltd.

1.2 Bleak Hill III comprises an extension to the north of the existing facility (Bleak Hill I and II) for the production of sand and gravel.

1.3 CEMEX seeks to gain a bespoke Waste Recovery Permit for the permanent deposit of inert waste to land at the site to facilitate the restoration scheme outlined in the planning permission. CEMEX propose to import approximately 381,579m^3 (or 725,000 tonnes) of inert waste for the restoration scheme, which intends to restore the site to agricultural land with a small pond in the southeast corner and with nature conservation provision and biodiversity enhancements around the boundaries.

1.4 Tetra Tech (TT) have instructed Geotechnical & Environmental Consulting Ltd. (GEC) to undertake Stability Risk Assessment (SRA) which will form part of the Waste Recovery Permit Application for the permanent placement of inert waste to facilitate the restoration scheme outlined in the planning permission (reference 19/11326).

1.5 The following documents and drawings have been supplied by the Client and referred to in the compilation of this Report:

- Bleak Hill Variation: Hydrological Rist Assessment – ESI Report No. 60311R1 June 2010.
- Bleak Hill Landfill – Variation to Permit CP3235PE, Stability Risk Assessment – Ove Arup Report No. 212173 – 00 – March 2011
- Hamer Quarry Complex: Bleak Hill III: Hydrogeological Risk Assessment for Waste Recovery Permit – Tetra Tech Report No B031732 – November 2022.
- Hamer Warren Bleak Hill I, II, III Environmental Statement Appendix 6 – Cemex 2019.

1.6 This document has been prepared to meet the requirements of the Application Part B, Stability Risk Assessment Report.

Conceptual Stability Site Model

<u>Location</u>

1.7 The Site is located approximately 5.5 km north-northeast of Ringwood and 4 km south-southwest of Fordingbridge. The centre of the site is located at NGR 413100, 110885 (Figure SRA 1.

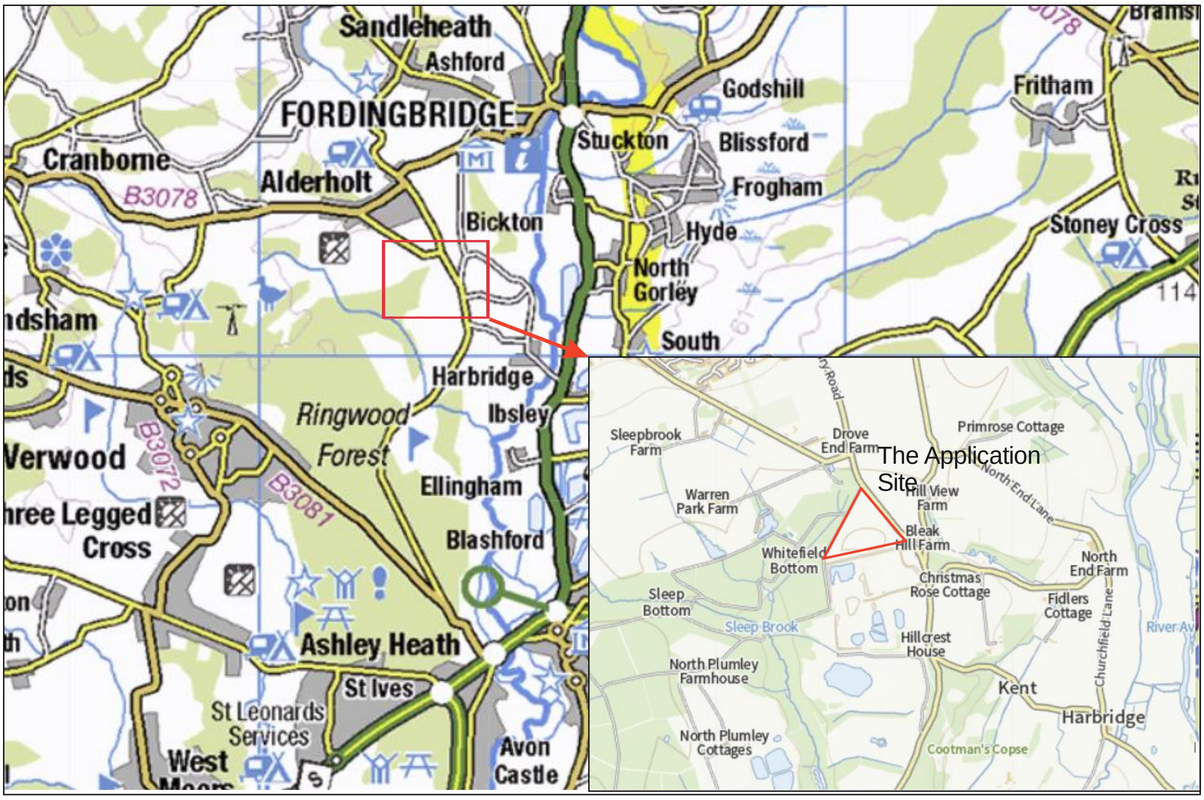


Figure SRA1 Site location details

1.8 The Waste Recovery Permit Application, to which this SRA refers, comprises an extension to the north of the existing Bleak Hill I and II works. The permit application covers a triangular plot of land covering an approximate area of 10.50 hectares termed Bleak Hill III.

1.9 Topography across the Site is mostly level, at around 50 m AOD. To the north ground elevations rise to approximately 60 m AOD before decreasing again in the vicinity of Ashford Water, a tributary of the River Avon about 2.6 km north of the Site, which it joins from the west. Ground elevations drop fairly steeply to the east of the Site where the Avon valley dominates the landscape, and more gently to the south-west, decreasing to about 42 m AOD, before falling more steeply in the direction of Hamer Brook. This is due to the Site being located on the interfluve between the River Avon and its tributary, Hamer Brook.

<u>Regional Geology</u>

Solid Geology

1.10 With reference to British Geological Survey Sheet 314 Ringwood 1:50000 Sold & Drift, the site is underlain by the Parkstone Sand Member of the Poole Formation.

1.11 The Lexicon of Named Rock Units describers the Parkstone Sand Member as part of four sequences of sands and clays which comprise the Polle Formation. The Parkstone Sand Member is generally described as comprising clean fine to coarse Sand.

Superficial Geology

1.12 BGS Sheet 314 indicates the site to have a superficial covering of River Terrace Deposits with Head Deposit present along the western edge of the site.

1.13 The Lexicon of Named Rock Units describes the River Terrace Deposits as sand and gravel, locally with lenses of silt, clay or peat.

Structural Geology

1.14 No structural features are shown within the area of the permit application boundary.

Local Geology

1.15 CEMEX has historically undertaken various phases of site investigation and borehole drilling for the purposes of mineral exploration at the Site. (the locations of these boreholes and those that are used for groundwater monitoring as shown on Figure 9.6). The information from these boreholes has allowed a detailed understanding of the geology at the Site to be developed.

1.16 The River Terrace Deposits are the mineral resource that has predominately been worked from within the Site where they have been found to be present up to a thickness of between 4 and 10 m. They are the deposits that will be worked from Bleak Hill III.

1.17 Within Bleak Hill III, the River Terrace Deposits tend to be around 5 m thick; apart from the south-eastern corner where a thickness 7 m was locally observed. Generally, the unit is described as a sequence of slightly clayey sands and flint gravels.

1.18 A stiff sandy clay, sometimes with laminations, tends to be observed beneath the River Terrace Deposits, although a clayey sand overlying the sandy clay can also locally be present. The sand is distinct and is differentiated from the River Terrace Deposits by its clay content and lack of gravel.

1.19 The sandy clay and clayey sand are the upper units of the Poole Formation (formerly the Bagshot Beds). It is assumed that the clayey sand found locally at the base of the River Terrace Deposits belongs to the Parkstone Sand Member; with the underlying sandy clay belonging to the Parkstone Clay Member.

1.20 The base of the Poole Formation has only been confirmed in three boreholes (W202, W203 and W204 – see Figure SRA2) along the southern boundary of Bleak Hill III. These boreholes show that the sandy Clay usually identified at the base of the River Terrace Deposits is in the order of 2 m thick. The full thickness of the Poole Formation ranges in thickness from c. 2 m in the west to over 7 m in the east of the Site.

1.21 It is understood, from the wider Site, that the thickening of the Poole Formation corresponds to the surface of the underlying London Clay being deeper to the east.

1.22 The boreholes that have penetrated the entire Poole Formation sequence indicate that it comprises a series of inter-bedded sandy clays and clayey sands. Individual beds are generally between 0.5 m and 2 m in thickness. This suggests that locally the sequence may be more variable than is suggested by the published geological mapping.

1.23 The London Clay is encountered beneath the Poole Formation; as described above it is present at a shallower depth (around 6 m or 44 m AOD) in the east of the Site than in the west (around 12 m or 38 m AOD). The London Clay is described as a stiff dark grey sandy clay with some fissuring and some sandy layers.

Hydrogeology

1.24 The superficial River Terrace Deposits and the Parkstone Sand Member bedrock present within the Site are classified by the Environment Agency as Secondary A Aquifers (i.e. permeable strata supporting local water supplies).

1.25 In the wider area the Reading Formation and the sandy units of the London Clay are classified as a Secondary A Aquifer; the non-sand units of the London Clay are classified as unproductive strata.

1.26 Groundwater levels at the Site vary from 48 m AOD to the north of the Site to 32 m AOD to the south. Groundwater monitoring between 2003 and 2017 presented in the Environmental Statement indicate the groundwater levels to be ca 45 m AOD in the Bleak Hill III area

1.27 The Site does not lie within a Source Protection Zones (SPZ). The closest SPZ is located approximately 1.8 km to the south. It is assumed that this abstraction takes water from the Chalk aquifer (i.e. beneath the London Clay). Irrespectively. given its distance from the Site there will be little hydraulic connection.

Hydrology

1.28 The Site lies on the interfluve between the River Avon (ca 1.5 km to the east) and its tributary Hamer Brook (to the west), The Avon valley includes a broad flood plain (about 500 m wide) with numerous drainage ditches flowing into the River Avon.

1.29 A tributary of Hamer Brook called Whitefield Brook flows along the western side of the Site with the spring source located 60 m to the west of Bleak Hill III. It joins Hamer Brook c. 500 m to the south-west of the Site.

1.30 Another smaller tributary of Turmer Brook, known locally as Lomer stream, is located on the eastern side of the Site. It rises from springs within Lomer Copse and flows eastwards towards Harbridge Green. It then flows southwards and discharges into Turmer Brook a few hundred metres downstream of its confluence with Hamer Brook. It passes c. 210 m from Bleak Hill III at its closest point in the south-eastern corner.

Basal Subgrade Model

1.31 The void will be created by the extraction of the sands and gravels of the River Terrace Deposits and the Parkstone Sand Member exposing the London Clay Formation which will form the basal subgrade of the extraction void.

1.32 The London Clay Formation was described, in 3 boreholes (W202, 203, 204) along the southern edge of the site, as a stiff dark grey sandy Clay with some fissuring and some sandy layers.

1.33 Groundwater monitoring placed the groundwater within the River Terrace Deposits at ca 45.00 m AOD However, artificial dewatering will be undertaken during the extraction and inert waste placement such that the void will remain dry during these operations.

Basal Lining System

1.34 No basal liner (attenuation layer) is considered necessary as the basal subgrade will comprise low permeability London Clay Formation.

Side Slope Subgrade Model

1.35 The side slope subgrade will be exposed during the mineral extraction works and will comprise the mixed lithologies of any superficial deposits Known collectively as Overburden) in turn overlying the sandy gravels of the River Terrace Deposits, in turn overlying the clayey Sands of the Parkstone Sand Member in turn overlying the London Clay Formation.

1.36 Cross section through the side slope subgrade is presented herein as Figure SRA2 This section is based on the cross-section presented as Figure 2.9 of the Stantec Hydrogeological Risk Assessment

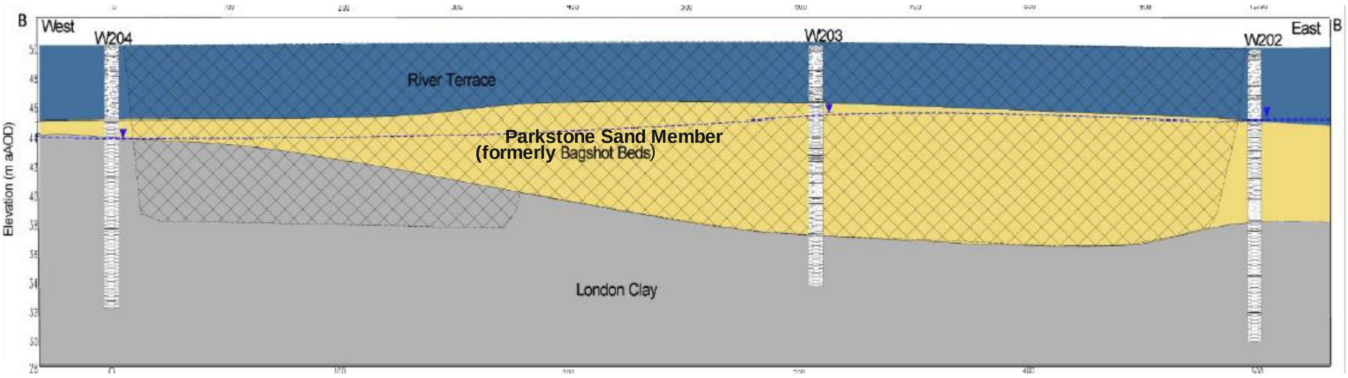


Figure SRA2 Cross-Section along southern edge of Bleak Hill III

Side Slope Lining Model

1.37 A clay side-slope liner will be constructed from excavated site derived London Clay Formation or suitable inert waste materials.

1.38 The attenuation layer will be constructed as a bund against the sidewalls and will have side slopes not steeper than 1 in 2, with a minimum crest width of 3m to allow safe plant access. A 0.6m wide x 0.5m deep key trench will be excavated into the London Clay prior to commencing the construction of the first lift as shown in figure 1 overleaf.

1.39 The attenuation layer will be constructed in a series of lifts as shown in the sketch below. Typically, each lift will be 2.5 – 3m high, however the height of the bunds may be adjusted to suit the height of the quarry faces.

1.40 The attenuation layer will be constructed in 300mm layers and compacted by multiple passes of earthmoving equipment.

Inert Waste Mass Model

1.41 It is proposed that the Bleak Hill III will be restored using inert waste only.

1.42 The inert waste is liable to comprise locally derived arisings from earthworks, foundation construction works and demolition debris.

1.43 The geology of the local area is variable and comprises both coarse- and fine-grained materials. As most of the inert waste is likely to comprise locally derived materials, with respect to stability the worst case would be a waste mass comprised entirely of fine-grained materials. Therefore, the inert waste model will comprise a generic fine-grained material and the characteristic geotechnical parameters attributed to this material will be based on a number of sources.

Table SRA1 Bibliography of Published Sources used in the Determination of the Characteristic Geotechnical Parameters of the Inert Waste

Author	Date	Title
Carter M., & Bentley S.P.	2016	Soil Properties and Correlations 2nd. Ed.
Look B.	2007	Handbook of Geotechnical Investigation and Design Tables
Duncan J.M., & Wright, S.G.	2005	Soil Strength & Slope Stability
CIRIA C583	2004	Engineering in the Lambeth Group[1]
Hight D.W., McMillan, F., Powell, J.J.M., Jardine, R.J., & Allenou, C.P.	2003	Some Characteristics of the London Clay: IN Tan et al. (Eds.) Characterisation and Engineering Properties of Natural Soils.[1]

[1] *the inclusion of these two strata specific references should not be taken as a suggestion of the Inert Waste content.*

1.44 The maximum temporary waste slope during placement operations will be restricted to 1(v):3(h).

1.45 The waste will be compacted in horizontal layers across the base of the cell to the pre-settlement restoration level.

Capping System Model

1.46 In accordance with the requirements of the Landfill Directive, an engineered cap (clay or plastic) is not required. The site is to be restored in accordance with the approved restoration scheme.

2.0 STABILITY RISK ASSESSMENT

Risk Screening

Basal Subgrade Screening

2.1 The basal subgrade will be formed of the in-situ London Clay Formation. As the void will be formed by the excavation and extraction of material there will be a net unloading of the basal subgrade. The replacement of the excavated material with inert waste will not fully reload the soil as there is a difference in the unit weight of the excavated material and the replaced inert waste this will cause only limited elastic recompression of the basal subgrade.

2.2 The London Clay Formation at basal void level will comprise firm to stiff Clays which are considered competent and medium compressibility and will not undergo large settlements. Although not considered a risk requiring stability analysis, it is recommended that careful inspection of the subgrade is undertaken prior to the placement of the inert waste. Further details and recommendations are presented in Section 3 of this SRA.

2.3 No stability analysis of this component is considered necessary.

Basal Lining System Screening

2.4 No basal liner (attenuation layer) is to be placed as the in-situ London Clay Formation will form a natural geological liner.

Side Slope Subgrade Screening

2.5 The side slopes will be formed as part of the mineral extraction process carried out by a suitably qualified and experienced specialists and subject to geotechnical appraisal under Regulation 33 of the Quarries Regulations. It can therefore be assumed that the void will have been designed to be stable during the extraction works. Given the stratigraphy and description of the side slope subgrade it is unlikely that the materials will become unstable during the inert waste placement phases of the works; however, a stability check of the side slope subgrade will be carried out for completeness and determine a long-term stable angle of repose.

Side Slope Lining System Screening

2.6 An artificially established side-lining system is to be placed against the side slope subgrade where it comprises River Terrace Deposits or Parkstone Sand Member. Where the side slopes comprise London Clay, this satisfies the requirements for an attenuation layer. Consequently, no artificially enhanced attenuation later is proposed

2.7 Groundwater outflows into the void are not expected as dewatering will be carried out to reduce groundwater levels during the operation of the quarry, and this dewatering will continue until the attenuation layer is completed.

2.8 Analysis of this component is considered necessary to investigate the short-term stability of this element prior to the placement of the inert waste.

Waste Mass Screening

2.9 This component will require a detailed geotechnical analysis in order to assess the stability of the waste mass.

Capping System Screening

2.10 Based on the proposed finished contours presented in Cemex Drawing No. P6/206/7 dated 14/11/2018 the site is to be restored to a lowland one area of surface water in the southeast of the site. The contours at the final restored level show a maximum difference in finished level of 5.00m over a length of ca 170m giving a gradient of 1(V): 34 (H) and as such will remain stable under all foreseeable conditions.

2.11 Therefore, a stability assessment of the sloping areas of the Restoration Soils is not required.

Justification of Modelling Approach and Software

2.12 Two-dimensional limiting equilibrium stability analyses will be used in the assessment of the stability of the various components of the proposed inert recovery site. The method of analysis used in each case was determined from an examination of the form of failure being considered.

2.13 The stability analyses were carried out using the Slope/W computer programme.

2.14 The Morgenstern and Price Method was used in the analyses to determine the degree of utilisation of the restoring forces under both total stress and effective stress conditions.

Justification of Geotechnical Parameters Selected for Analyses

Parameters Selected for Side Slope Subgrade Analyses

2.15 The side slope subgrade will comprise Overburden over River Terrace Deposits over Parkstone Sand Member in overlying the London Clay Formation. Based on the engineering descriptions of these materials recorded on the borehole logs and the values used in previous slope risk assessments, typical characteristic geotechnical parameters have been developed and are presented in Table SRA2.

Table SRA2 Side Slope Subgrade Stability – Summary of Characteristic Geotechnical Data

Material	Description	Medium Sand	Total Stress		Effective Stress	
		γ (kN/m^3)	c_u (kN/m^2)	ϕ_u (°)	c′ (kN/m^2)	ϕ' (°)
Overburden	Topsoil / Subsoil	18	30	0	1	23
River Terrace Deposits	Medium dense Sand and Gravel	20	Not Applicable Granular Material		0	36
Parkstone Sand Member	Clayey Sand	19	Assumed drained material		0	32
London Clay Formation	Firm to stiff Clay	19	75	0	1	25

Parameters Selected for Side Slope Liner Analyses

2.16 The side slope liner is to be constructed using an appropriate fine-grained material. Typical values for clay materials have been used to define the characteristic geotechnical values of the side slope liner material (Table SRA3).

Table SRA3 Side Slope Liner Stability – Summary of Characteristic Geotechnical Data

Material	Unit Weigh	Total Stress		Effective Stress	
	γ (kN/m^3)	c_u (kN/m^2)	ϕ_u (°)	c′ (kN/m^2)	ϕ' (°)
Side Liner	19	50	0	2	25

Parameters Selected for Waste Analyses

2.17 The Parameters of the inert waste appropriate for this site were selected on the basis of the information presented in the various publications listed in Table SRA1. As stated previously the inclusion of stratum specific references should not be taken as guidance to what may be included within the Inert Waste but purely as another source to help define a generic fine-grained material. In reality, it is likely to comprise a mixture of fine- and coarse-grained materials and demolition materials. Therefore, the treatment of the inert waste as fine-grained will be the worst-case as the inclusion of any coarse-grained material will increase its characteristic angle of shearing resistance.

Table SRA4 Waste Mass Stability - Summary of Characteristic Geotechnical Data

Material	Bulk Unit Weight γ_k	Total Stress		Effective Stress	
	(kN/m^3)	c_{uk} (kN/m^2)	ϕ_{uk} (°)	c'_k (kN/m^2)	ϕ'_k (°)
Waste Mass	17	50	0	5	25

Selection of Appropriate Factors of Safety

2.18 The stability analyses have been carried out in accordance with EC7. The United Kingdom have adopted Design Approach 1 (DA1) Combination 1 & 2 (C 1 & 2) whereby partial factors are applied to either the actions or the material properties and a resultant degree of utilisation of less than 1.00 is required.

Table SRA5 Partial Factors used in Design in Accordance with the UK National Annex to EC7

Design Approach	Combination	Partial Factor Sets	Partial Factor Value			
1	1	A1 + M1 + R1	Actions A1			
			Permanent (G)	Unfavourable	$\gamma_{G;dst}$	1.35
				Favourable	$\gamma_{G;stb}$	1.00
			Variable (Q)	Unfavourable	$\gamma_{Q;dst}$	1.50
				Favourable	$\gamma_{G;dst}$	0
			Materials M1			
			Coefficient of shearing resistance (*tan*ϕ)		$\gamma_{\phi'}$	1.00
			Effective cohesion (*c'*)		$\gamma_{c'}$	1.00
			Undrained shear strength (c_u)		γ_{cu}	1.00
			Resistance R1			
			Resistance		$\gamma_{R;e}$	1.00
	2	A2 + M2 + R1	Actions A2			
			Permanent (G)	Unfavourable	$\gamma_{G;dst}$	1.00
				Favourable	$\gamma_{G;stb}$	1.00
			Variable (Q)	Unfavourable	$\gamma_{Q;dst}$	1.30
				Favourable	$\gamma_{G;dst}$	0
			Materials M2			
			Coefficient of shearing resistance (*tan*ϕ)		$\gamma_{\phi'}$	1.25
			Effective cohesion (*c'*)		$\gamma_{c'}$	1.25
			Undrained shear strength (c_u)		γ_{cu}	1.40
			Resistance R1			
			Resistance		$\gamma_{R;e}$	1.00

2.19 The values of the partial factors used are termed "nationally determined parameters" and EC7 (as published by CEN) allows these to be specified in National Annexes which recognise regional variations in design philosophy.

2.20 LFE4 – Earthworks in Landfill Engineering – Chapter 2 confirms the adoption of Design Approach 1 Combinations 1 and 2, and the nationally adopted partial factors.

Analyses

Side Slope Subgrade

2.21 The side slopes of the void will be formed during the mineral extraction phase of the works and will be subject to appraisal under Regulation 33 of the Quarries Regulations. However, for completeness a stability of the side slope subgrade has been carried out using the cross section presented as Figure SRA2.

2.22 Dewatering will keep the groundwater beneath the base of the void during the inert waste placement operations. However, consideration will be given to the effect of groundwater rising to its natural level of ca 45 m AOD.

2.23 Based on the thickest sequence of sands and gravel, the highest side slope subgrade will be ca 15 m and will be formed at a gradient of 1(v):2(h).

2.24 The results of the side slope liner stability analyses are shown in Table SRA6 and the SlopeW worksheets presented in Appendix 1.

Table SRA6 Side Slope Subgrade Stability – Summary of Results

Run	File Name	Degree of Utilisation		Notes
		C1	C2	
01	SSG1	0.78		Short Term Stability Total Stress Analysis
02	SSG2		0.92	
03	SSG3	0.76		Effective Stress Analysis
04	SSG4		0.95	
05	SSG5		0.99	Groundwater at 45 m AOD

Side Slope Liner Analyses

2.25 A side slope liner (attenuation layer) will be placed against the side slope subgrade. Based on the results of the side slope subgrade analyses presented in Table SRA8 it is assumed that the side slopes are at (1(v) : 2(h)). The liner will be modelled with a 3m horizontal thickness at the top of the void and placement in 3m lifts. As the liner will be placed in advance of the inert waste placement it will be left unsupported in the short term only. Therefore, in line with the previous SRA, total stress only analysis will be carried out on the side slope liner.

2.26 Continued dewatering of the site will ensure that hydrostatic pressures associated with the perched groundwater will not affect the side slope liner.

2.27 The results of the side slope liner stability analyses are shown in Table SRA7 and the SlopeW worksheets presented in Appendix 2.

Table SRA7 Side Slope Liner Stability – Summary of Results

<table>
<tr><th rowspan="2">Run</th><th rowspan="2">File Name</th><th colspan="2">Characteristic Shear Strength</th><th colspan="2">Degree of Utilisation</th><th rowspan="2">Liner Thickness (m)</th><th rowspan="2">Notes</th></tr>
<tr><th>c</th><th>ϕ</th><th>C1</th><th>C2</th></tr>
<tr><td colspan="8">Side Slope Gradient 27 ° Side Slope Liner thickness 3.00m
Rotational Failure Entirely within Side Slope Liner</td></tr>
<tr><td>01</td><td>SSL1</td><td rowspan="2">50</td><td rowspan="2">0</td><td>0.21</td><td></td><td rowspan="2">3.00</td><td rowspan="2">Total stress
1st lift</td></tr>
<tr><td>02</td><td>SSL2</td><td></td><td>020</td></tr>
<tr><td>03</td><td>SSL3</td><td>2</td><td>25</td><td>0.88</td><td></td><td>3.00</td><td>Full effective stress conditions</td></tr>
</table>

<u>Waste Mass Analyses</u>

2.28 The post extraction void may be up to 15m deep; although it is unlikely that a temporary waste face 15.00m high will ever exist it will be considered in the inert waste stability analysis with waste faces during placement operations restricted to 1(v) : 3(h).

2.29 Leachate pore fluid pressures may develop in the waste mass during filling due to infiltration. It is noteworthy that the term leachate as applied refers to direct precipitation or groundwater present within the inert waste at time of placement.

2.30 Given the composition (inert materials), landfill gas pressures are unlikely to develop within the waste mass.

2.31 Waste stability must be assessed as part of the design process for the temporary waste slope configuration. A Stability assessment is required for failure modes wholly within the waste body. The analyses of the failures wholly within the waste were based on Table 3.43 “Failure Wholly within the Waste” of the Environmental Agency R&D Technical Report P1-385/TR2.

2.32 Slope/W has been used to undertake the investigation into failures wholly within the waste mass for both total and effective stress conditions.

2.33 The effects of variations in leachate pressure were modelled by investigating the effects of increased leachate levels on the factor of safety against instability within the waste body.

2.34 Results of the analyses are presented in Appendix 3 and are summarised in Table SRA8.

Table SRA8 Waste Mass Stability – Summary of Results

Run	File Name	Waste Strength	Leachate Level	Degree of Utilization		Notes
				C1	C2	
1	WM1	Total	Dry	0.47		Total Stress
2	WM2				0.44	
3	WM3	Effective	2.00m	0.59		Increasing leachate level measured from base of waste mass
4	WM4				0.71	
5	WM5		5.00m	0.62		
6	WM6				0.77	
7	WM7		10.00m	0.62		
8	WM8				0.77	
9	WM9		Not Present		1.43 (FoS)	Cohesion = 0kN/m^2

Assessment

Basal Subgrade

2.35 The basal subgrade is to comprise the in-situ London Clay Formation which is considered competent and with no net increase in stress at basal subgrade level predicted, no settlement other than short term elastic recompression is expected.

2.36 Therefore, subject to careful inspection prior to the placement of the inert waste, the basal subgrade is considered appropriate without any significant re-engineering.

Side Slope Sub-Grade

2.37 The side slopes of the void will be formed as part of the mineral extraction works. It is appropriate to assume that the extraction works will be subject to Geotechnical Appraisal under Regulation 33 of the Quarries Regulations and as part of that appraisal it will be demonstrated that the side slope subgrade is stable at the planned angle of excavation.

2.38 However, a stability assessment of the side slope subgrade has been carried out at the proposed gradient of 1(v) : 2(h) (27°). The results of the stability assessments indicate the side slope subgrade is stable in the short term under total stress conditions with a degree of utilisation of 0.92 being achieved under Combination 2 factoring. In the long term, under effective stress conditions, the stability analysis indicates that the slope will remain stable with a slight increase in the degree of utilisation to 0.95 under Combination 2 factoring. The similarity in the results is due to the side slope subgrade materials being largely coarse-grained.

2.39 During the placement of the inert waste dewatering of the void will continue which will keep the base of the void dry. Slope Run SSG5 analyses the effect of the groundwater rising to a standing level of 45 m AOD. The stability analysis demonstrates that this would increase the degree of utilisation to 0.99 under the more onerous Combination 2 factoring meaning the slope will remain stable.

2.40 Provided the side slope subgrade batter does not exceed 1(v) : 2 (h) the side slope subgrade will remain stable under all foreseeable conditions.

Side Slope Liner

2.41 The side slope liner with a horizontal thickness of 3.00m and a gradient of 1(v) : 2(h) has been analysed and shown to be stable in the short term under total stress conditions with a maximum degree of utilisation of 0.21 being returned under Combination 1 factoring.

2.42 Although it is planned to place the liner in 3m lifts ahead of the inert waste placement if left unsupported in the long-term such that fully drained effective stress conditions are achieved the side slope liner is shown to remain stable with a maximum degree of utilisation of 0.88 under Combination 2 factoring.

2.43 It can be concluded that side liner will remain stable under all foreseeable conditions prior to the buttressing effect of the inert waste being applied.

Waste Mass

2.44 The stability of the temporary waste face was analysed using the computer programme SLOPE/W to calculate the degree of utilisation of the restoring forces to prevent failure through the waste body for a range of circular failure surfaces using Morgenstern and Price’s method.

2.45 The importance of different leachate levels within the waste and their effect on overall stability was assessed. The effect of reduction of shear strength from peak to residual values has also been investigated.

2.46 The waste slope has a Degree of Utilisation of <1.00 (<100%) for all leachate levels up to 10.00m from the base of the waste body. A leachate level of 10.00m is considered extremely unlikely to occur under normal operating conditions and therefore represents a worst-case situation.

2.47 The waste slope has a Factor of Safety of 1.43 even if the value of the cohesion intercept of the waste reduces from 5kN/m^2 to 0kN/m^2

2.48 It is concluded that a 1(v) : 3(h) waste slope will be stable for the range of leachate levels anticipated.

Capping System

2.49 Not a consideration at this site.

3.0 MONITORING

The Risk-Based Monitoring Scheme

3.1 Monitoring of the stability of the site is proposed in the form set out below. The objectives are to identify any instances of overall settlement of the structure, identify instability of the waste mass itself and instability of the side slope subgrade and lining system at the earliest possible juncture.

Basal Subgrade Monitoring

3.2 Prior to the placement of the inert waste, it is recommended that the basal subgrade is carefully inspected. Special attention should be paid if any soft spots within the London Clay are identified.

3.3 If areas, of the basal subgrade, are considered to be soft or low strength it should be dealt with by the excavation of the softened area and replacement with properly compacted granular fill material to a minimum depth of 1.00m.

Side Slope Subgrade

3.4 The side slopes should be visually monitored for instability during the waste placement operations with special attention being paid to the upper slopes where the overburden daylight. In the event of any instances of instability appropriate action should be taken which may include buttressing the toe of the slope using inert waste material.

3.5 Provided the side slope liner is placed in lifts ahead of the inert waste placement at no more than 1(v) : 2(h) it should be stable under any foreseeable conditions. However, this does not preclude the need for regular inspection with particular attention being paid to separation between the liner and the side slope subgrade. If this, or any other instability is identified in the side slope liner, it should be buttressed with inert waste

Waste Mass Monitoring

3.6 The temporary slopes in the waste should be visually monitored and appropriate actions taken on any sign of instability. This would typically include a reduction in slope angle of the temporary waste slopes.

Restoration Soils and Finished Surface Monitoring

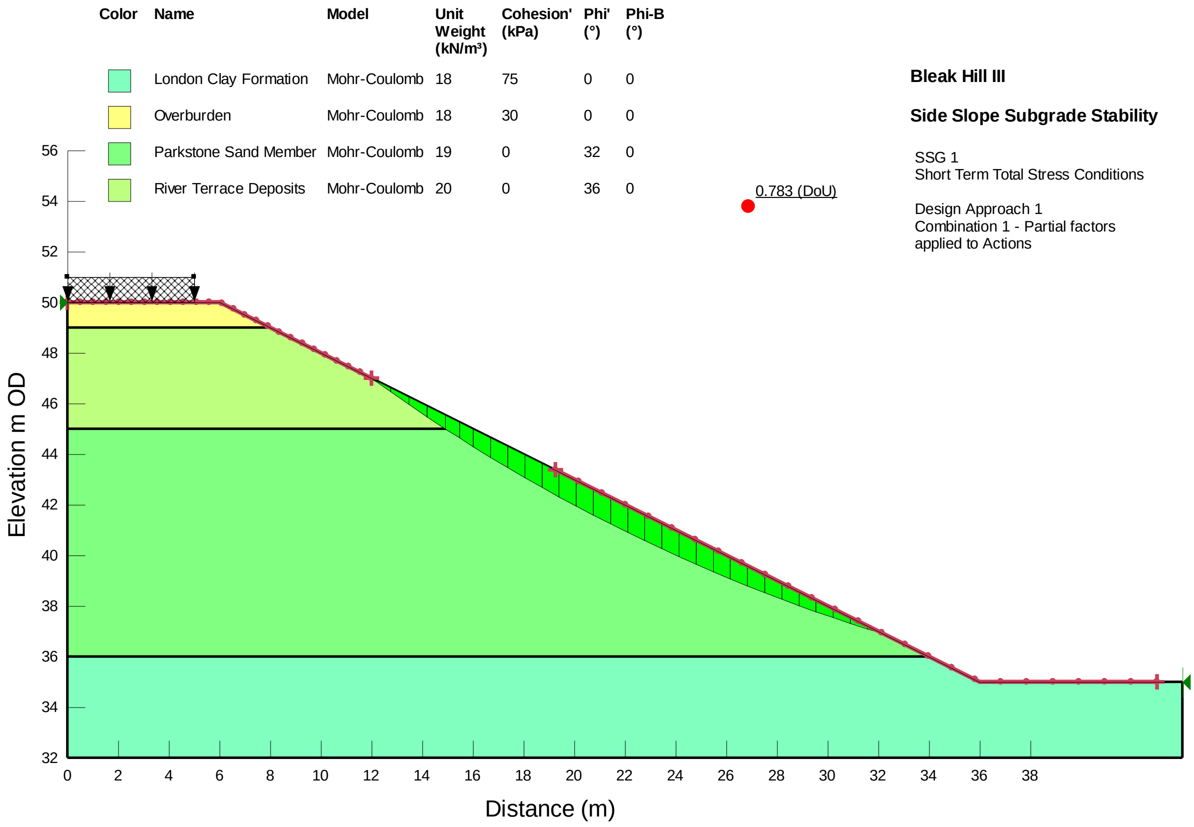
3.7 The condition of the ground surface of all restored areas will be monitored on a regular basis as part of the site inspection regimen.

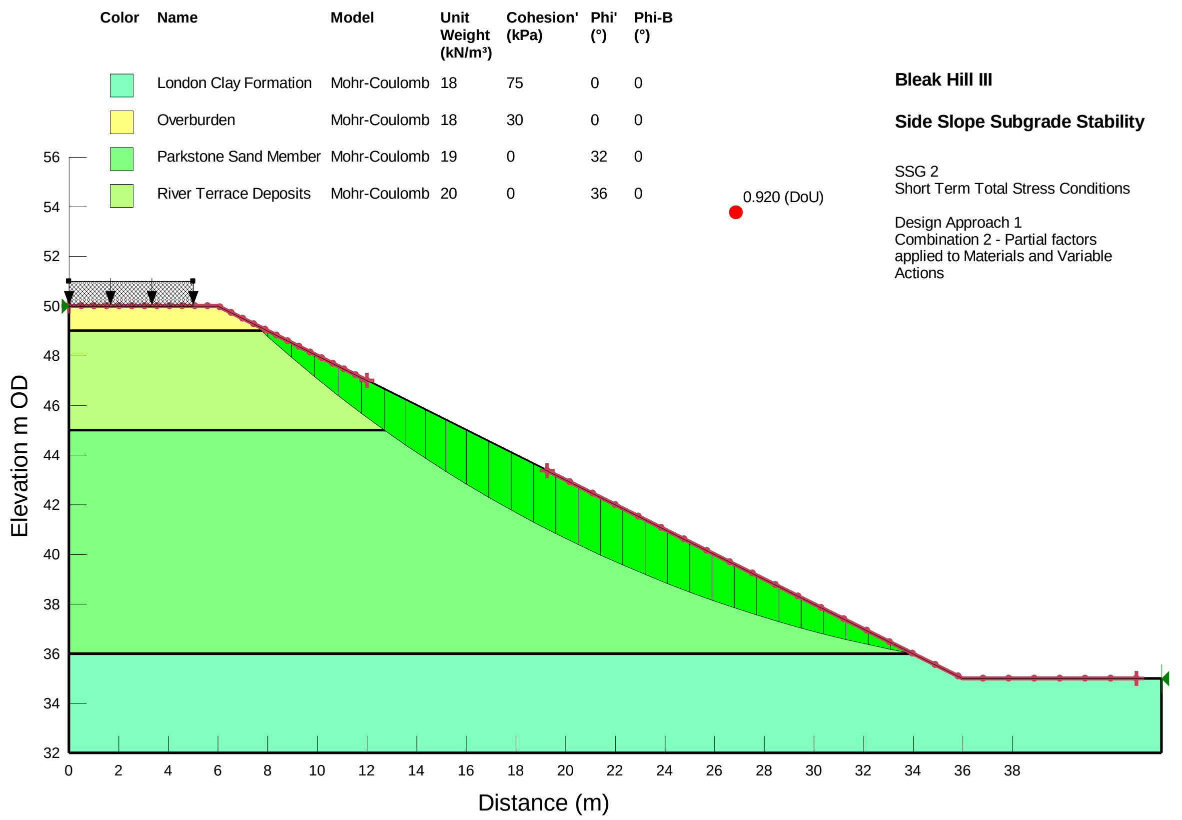
3.8 The surface will be checked for incipient signs of failure that might result from the occurrence of differential settlement within these deposits. These would include cracking, development of depressions or ponding and seepage of water. In the event that any symptom of incipient failure is detected the Environment Agency will be informed and a site action plan for remediation agreed.

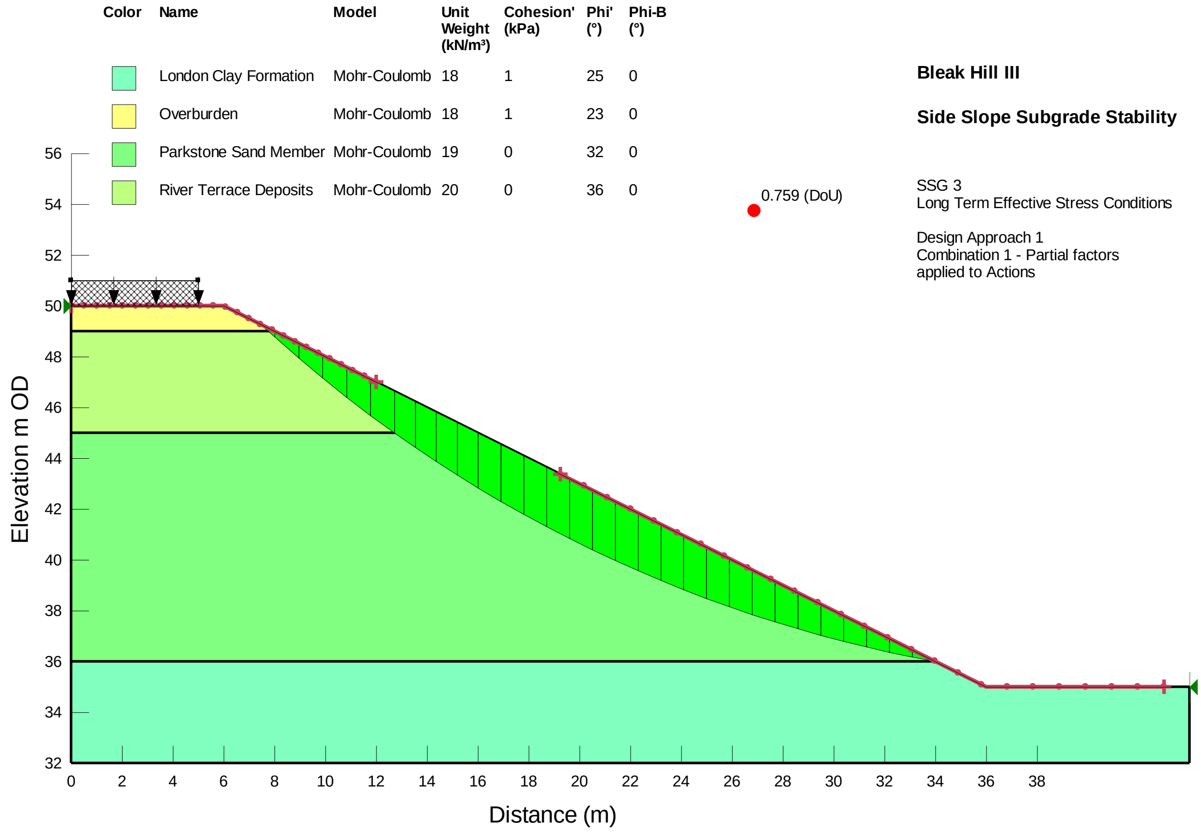
3.9 The Surface of the restored areas will be monitored by land survey techniques on a regular basis. These checks will be on a biannual basis for the first two years and then on an annual basis to the fifth year after restoration, when the periodicity reviewed with the Environment Agency.

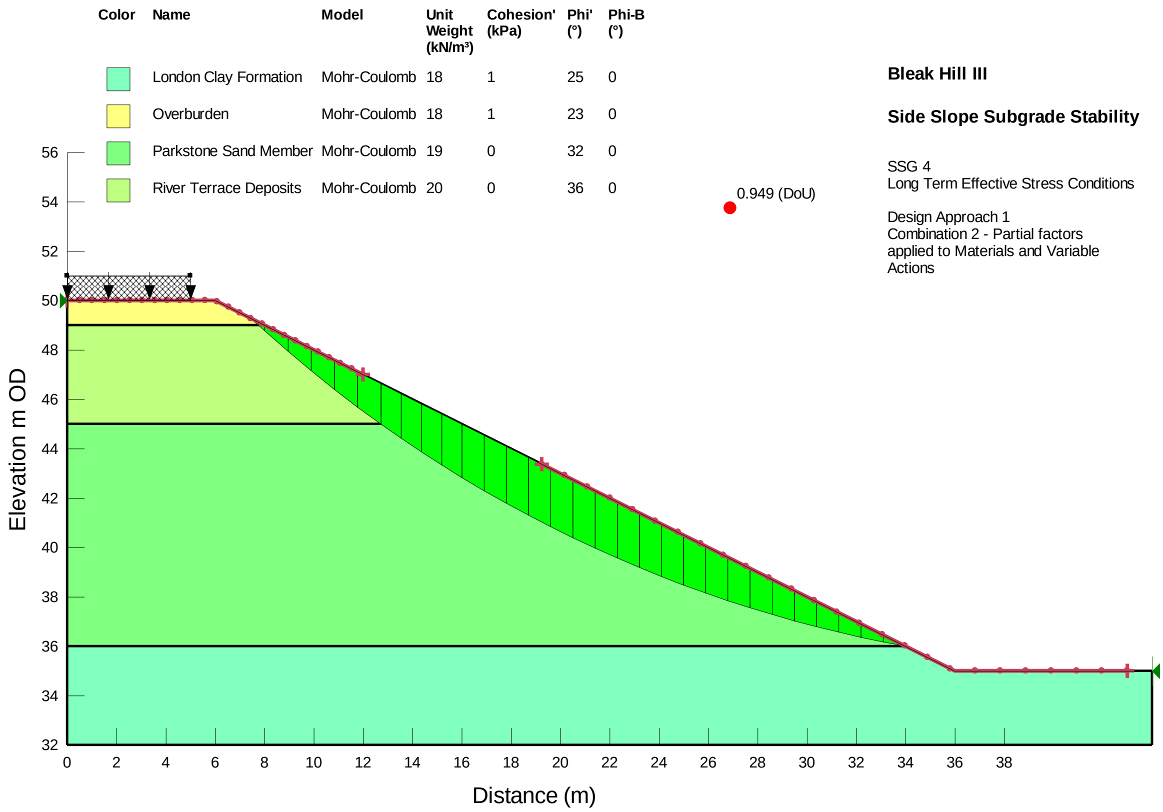
Appendix 1

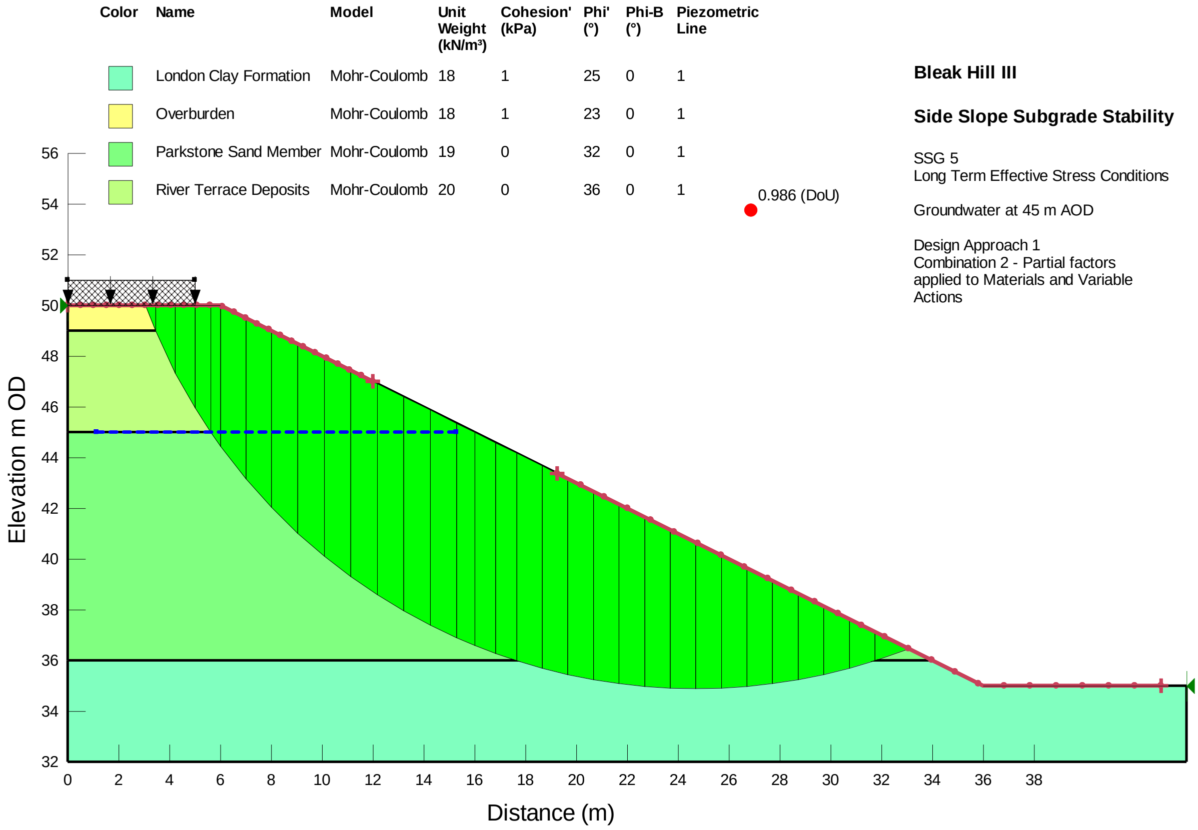
SlopeW Worksheets – Side Slope Subgrade


Color
Name
Model
Unit Weight (kN/m³)
Cohesion' (kPa)
Phi' (°)
Phi-B (°)
London Clay Formation Mohr-Coulomb 18 75 0 0
Overburden Mohr-Coulomb 18 30 0 0
Parkstone Sand Member Mohr-Coulomb 19 0 32 0
River Terrace Deposits Mohr-Coulomb 20 0 36 0
Bleak Hill III
Side Slope Subgrade Stability
SSG 1
Short Term Total Stress Conditions
Design Approach 1
Combination 1 - Partial factors applied to Actions
0.783 (DoU)
Elevation m OD
Distance (m)
56
54
52
50
48
46
44
42
40
38
36
34
32
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38


Color
Name
Model
Unit Weight (kN/m³)
Cohesion' (kPa)
Phi' (°)
Phi-B (°)
London Clay Formation Mohr-Coulomb 18 75 0 0
Overburden Mohr-Coulomb 18 30 0 0
Parkstone Sand Member Mohr-Coulomb 19 0 32 0
River Terrace Deposits Mohr-Coulomb 20 0 36 0
Bleak Hill III
Side Slope Subgrade Stability
SSG 2
Short Term Total Stress Conditions
Design Approach 1
Combination 2 - Partial factors applied to Materials and Variable Actions
0.920 (DoU)
Elevation m OD
Distance (m)
56
54
52
50
48
46
44
42
40
38
36
34
32
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38


Color Name Model Unit Weight (kN/m³) Cohesion' (kPa) Phi' (°) Phi-B (°)
London Clay Formation Mohr-Coulomb 18 1 25 0
Overburden Mohr-Coulomb 18 1 23 0
Parkstone Sand Member Mohr-Coulomb 19 0 32 0
River Terrace Deposits Mohr-Coulomb 20 0 36 0
Bleak Hill III
Side Slope Subgrade Stability
0.759 (DoU)
SSG 3
Long Term Effective Stress Conditions
Design Approach 1
Combination 1 - Partial factors applied to Actions
Elevation m OD
Distance (m)

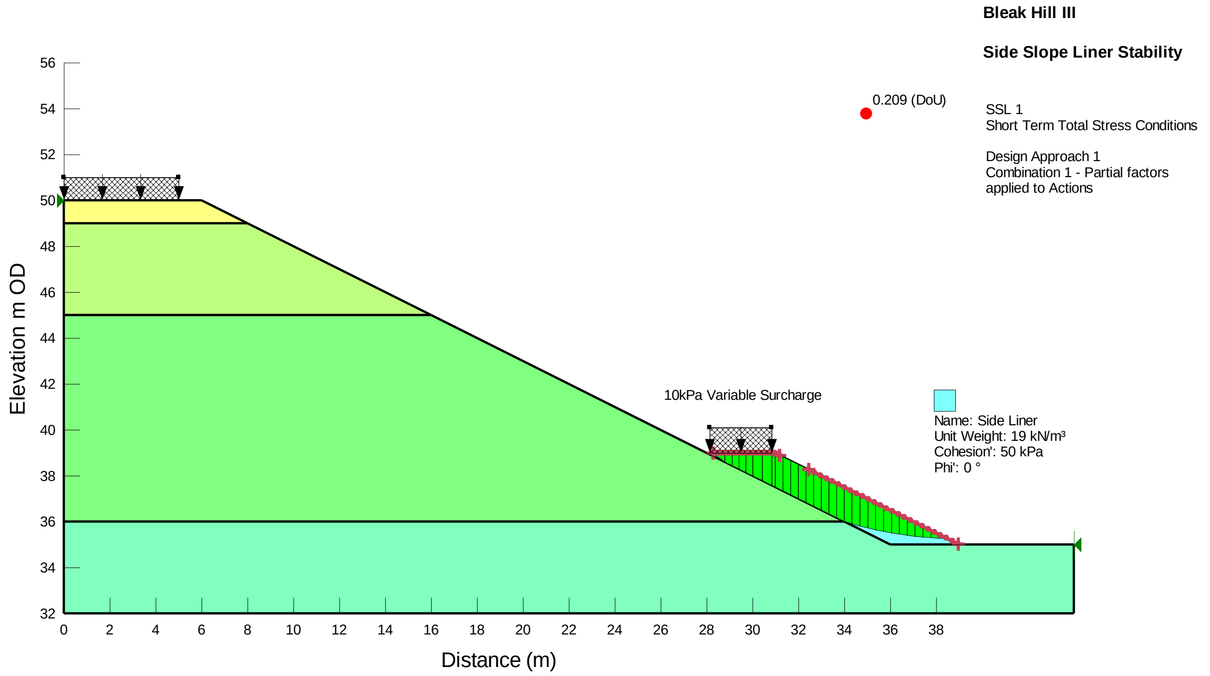

Color Name Model Unit Weight (kN/m³) Cohesion' (kPa) Phi' (°) Phi-B (°)
London Clay Formation Mohr-Coulomb 18 1 25 0
Overburden Mohr-Coulomb 18 1 23 0
Parkstone Sand Member Mohr-Coulomb 19 0 32 0
River Terrace Deposits Mohr-Coulomb 20 0 36 0
Bleak Hill III
Side Slope Subgrade Stability
0.949 (DoU)
SSG 4
Long Term Effective Stress Conditions
Design Approach 1
Combination 2 - Partial factors applied to Materials and Variable Actions
Elevation m OD
Distance (m)

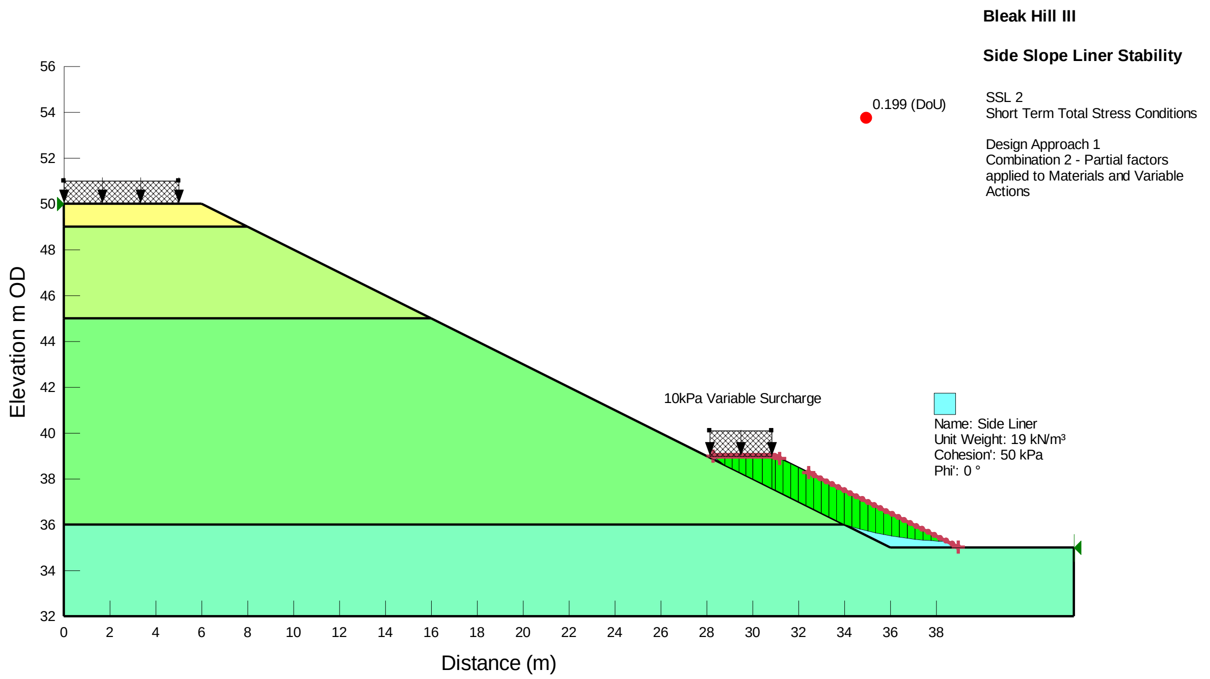


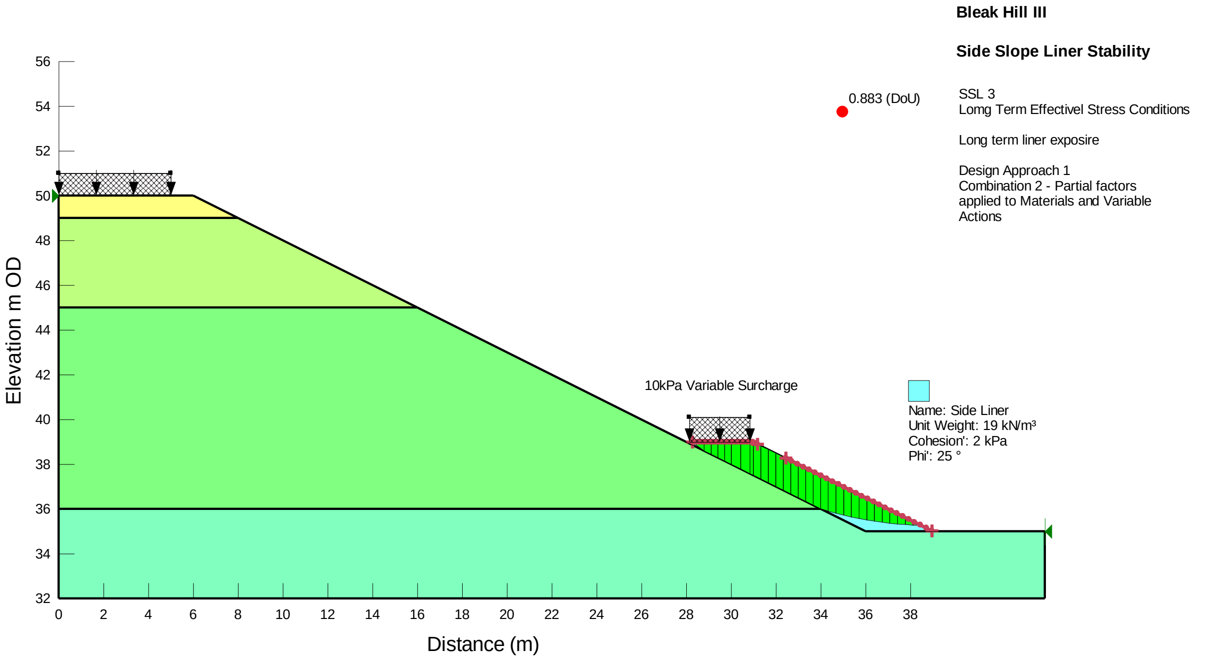
Color
Name
Model
Unit Weight (kN/m³)
Cohesion' (kPa)
Phi' (°)
Phi-B (°)
Piezometric Line
London Clay Formation Mohr-Coulomb 18 1 25 0 1
Overburden Mohr-Coulomb 18 1 23 0 1
Parkstone Sand Member Mohr-Coulomb 19 0 32 0 1
River Terrace Deposits Mohr-Coulomb 20 0 36 0 1
0.986 (DoU)
Bleak Hill III
Side Slope Subgrade Stability
SSG 5
Long Term Effective Stress Conditions
Groundwater at 45 m AOD
Design Approach 1
Combination 2 - Partial factors applied to Materials and Variable Actions
Elevation m OD
56
54
52
50
48
46
44
42
40
38
36
34
32
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
Distance (m)

Appendix 2

SlopeW Worksheets – Side Slope Liner

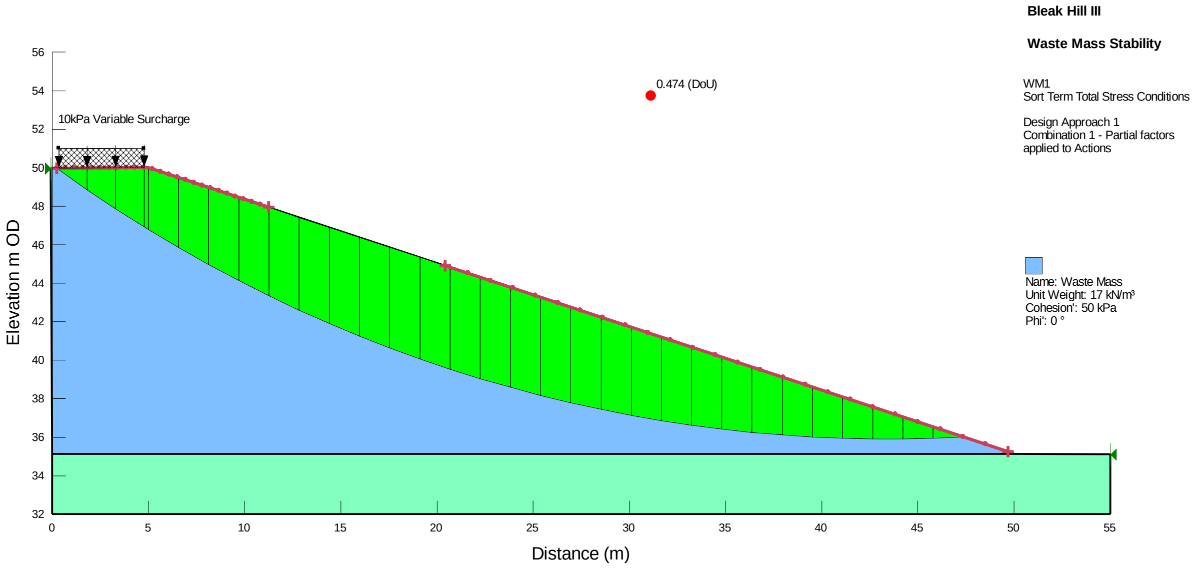

Bleak Hill III
Side Slope Liner Stability
0.209 (DoU)
SSL 1
Short Term Total Stress Conditions
Design Approach 1
Combination 1 - Partial factors applied to Actions
10kPa Variable Surcharge
Name: Side Liner
Unit Weight: 19 kN/m³
Cohesion': 50 kPa
Phi': 0 °
Elevation m OD
Distance (m)

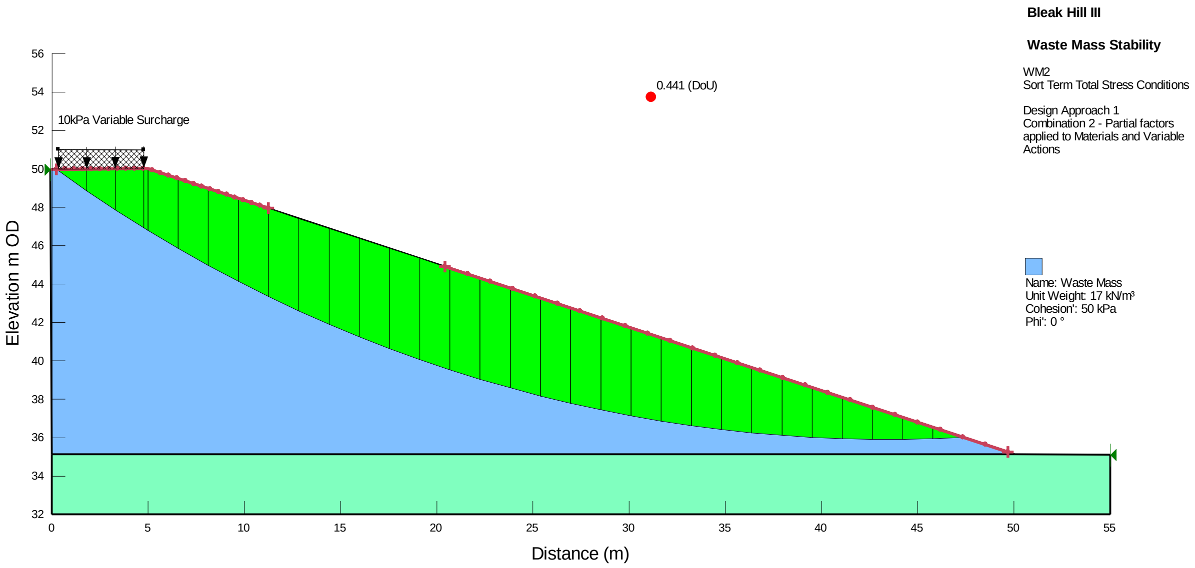

Bleak Hill III
Side Slope Liner Stability
0.199 (DoU)
SSL 2
Short Term Total Stress Conditions
Design Approach 1
Combination 2 - Partial factors applied to Materials and Variable Actions
10kPa Variable Surcharge
Name: Side Liner
Unit Weight: 19 kN/m³
Cohesion': 50 kPa
Phi': 0 °
Elevation m OD
Distance (m)

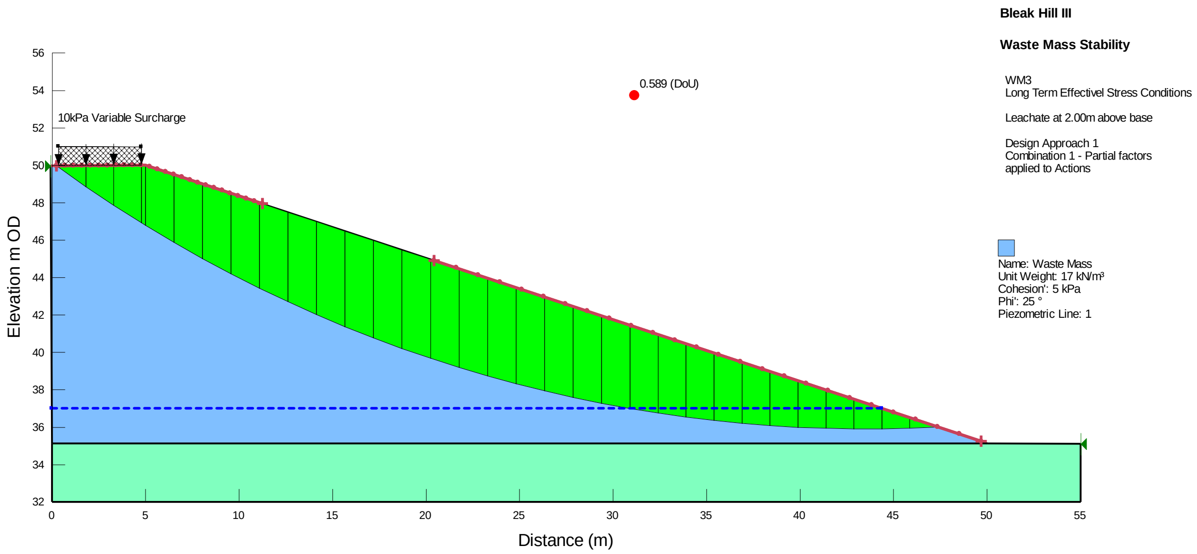

Bleak Hill III
Side Slope Liner Stability
0.883 (DoU)
SSL 3
Lomg Term Effectivel Stress Conditions
Long term liner exposire
Design Approach 1
Combination 2 - Partial factors applied to Materials and Variable Actions
10kPa Variable Surcharge
Name: Side Liner
Unit Weight: 19 kN/m³
Cohesion': 2 kPa
Phi': 25 °
Elevation m OD
Distance (m)
56
54
52
50
48
46
44
42
40
38
36
34
32
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38

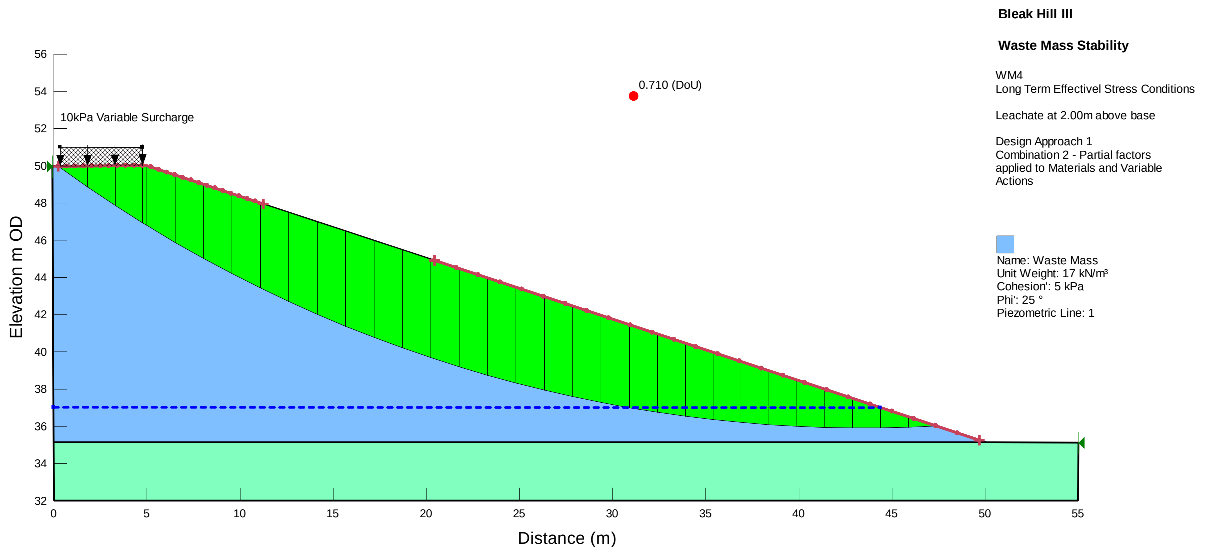
Appendix 3

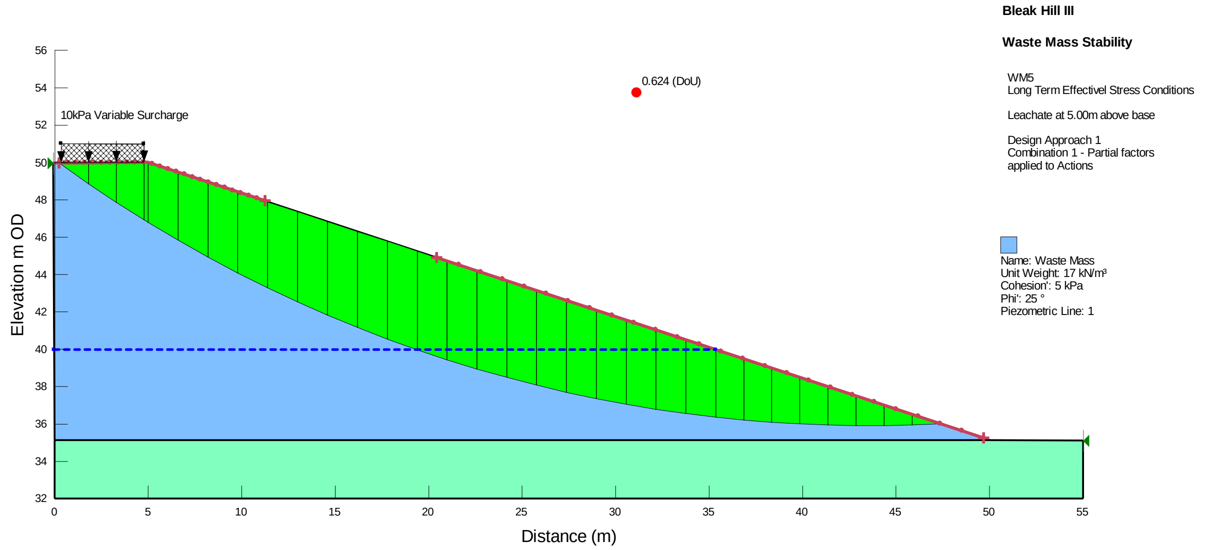
SlopeW Worksheets – Inert Waste

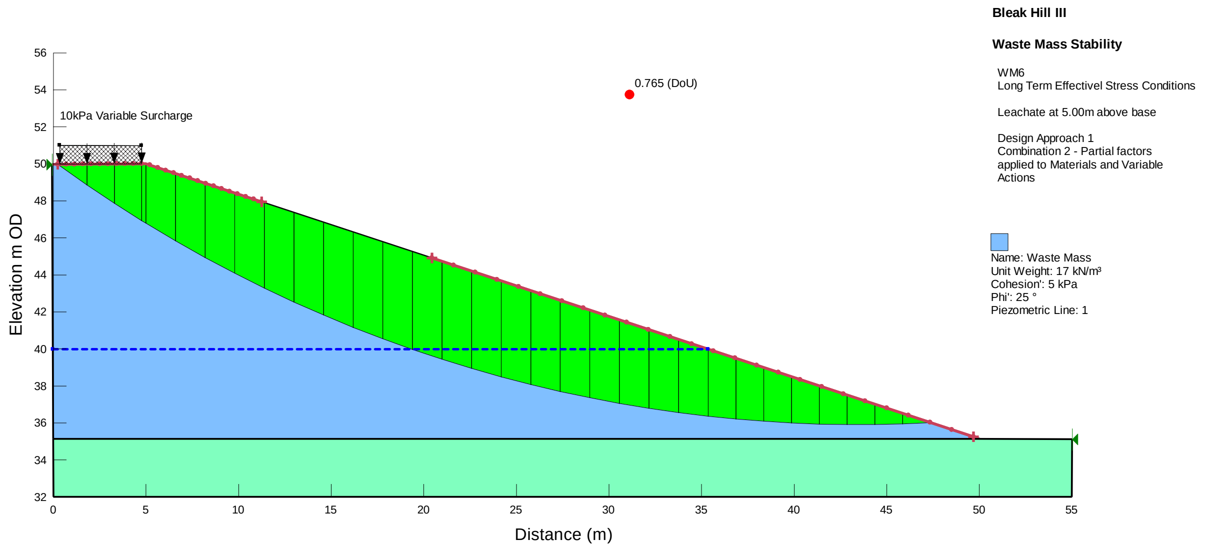

Bleak Hill III
Waste Mass Stability
WM1
Sort Term Total Stress Conditions
Design Approach 1
Combination 1 - Partial factors applied to Actions
Name: Waste Mass
Unit Weight: 17 kN/m³
Cohesion': 50 kPa
Phi': 0 °
0.474 (DoU)
10kPa Variable Surcharge
Elevation m OD
Distance (m)

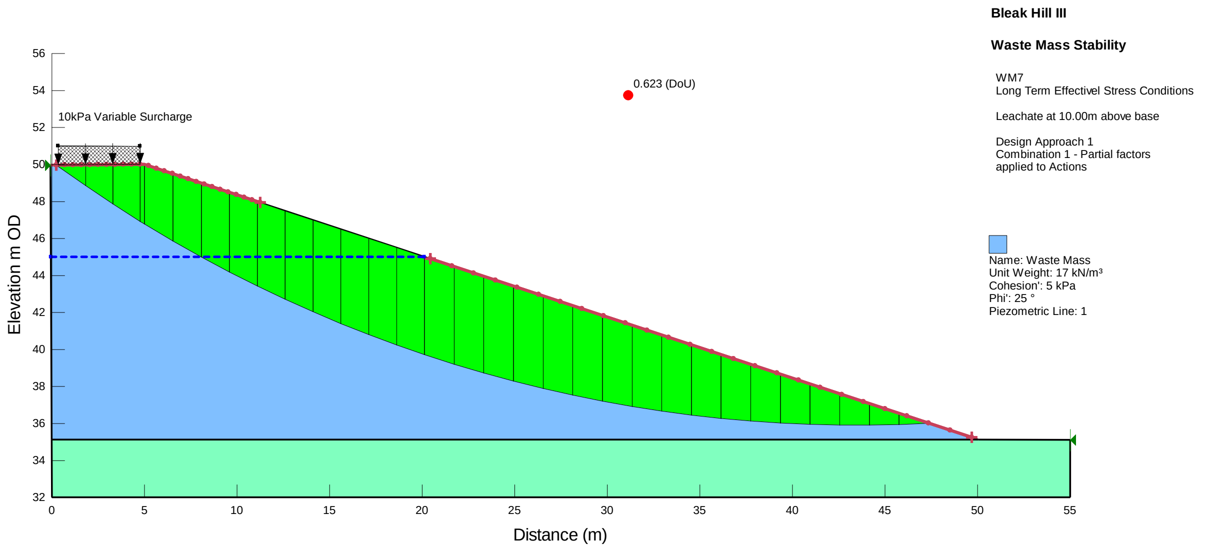

Bleak Hill III
Waste Mass Stability
WM2
Sort Term Total Stress Conditions
Design Approach 1
Combination 2 - Partial factors applied to Materials and Variable Actions
Name: Waste Mass
Unit Weight: 17 kN/m³
Cohesion': 50 kPa
Phi': 0 °
0.441 (DoU)
10kPa Variable Surcharge
Elevation m OD
Distance (m)

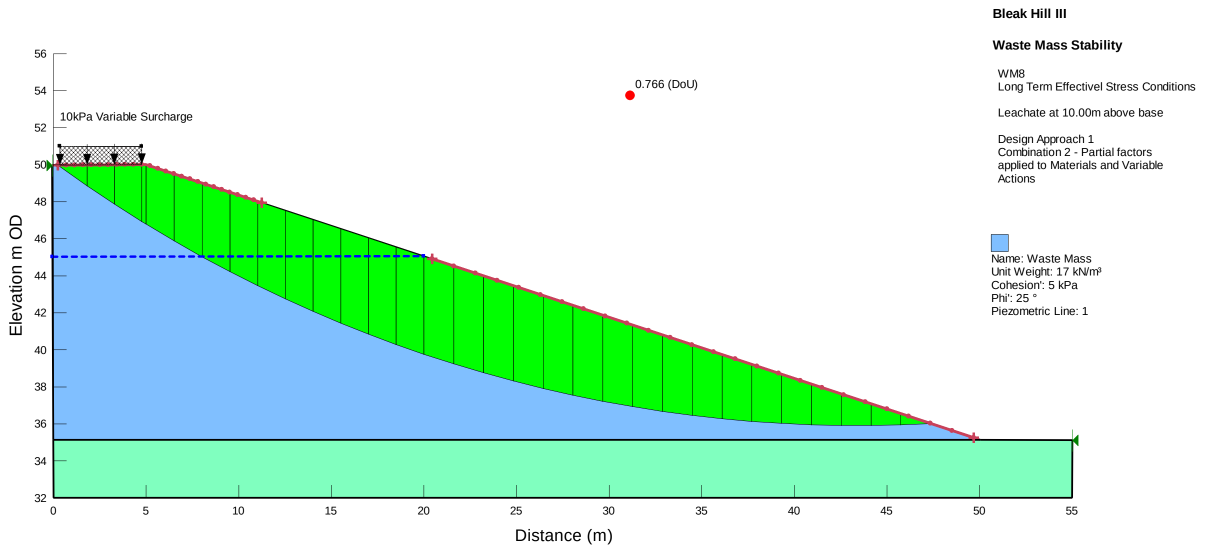

Bleak Hill III
Waste Mass Stability
WM3
Long Term Effectivel Stress Conditions
Leachate at 2.00m above base
Design Approach 1
Combination 1 - Partial factors applied to Actions
Name: Waste Mass
Unit Weight: 17 kN/m³
Cohesion': 5 kPa
Phi': 25 °
Piezometric Line: 1
0.589 (DoU)
10kPa Variable Surcharge
Elevation m OD
Distance (m)

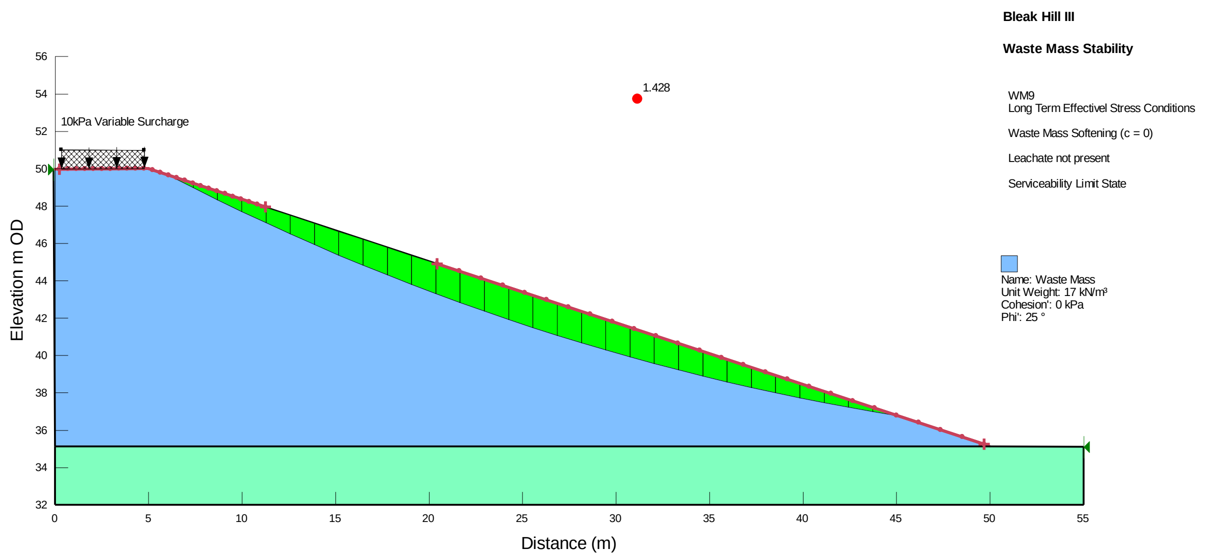

Bleak Hill III
Waste Mass Stability
WM4
Long Term Effectivel Stress Conditions
Leachate at 2.00m above base
Design Approach 1
Combination 2 - Partial factors applied to Materials and Variable Actions
Name: Waste Mass
Unit Weight: 17 kN/m³
Cohesion': 5 kPa
Phi': 25 °
Piezometric Line: 1
0.710 (DoU)
10kPa Variable Surcharge
Elevation m OD
Distance (m)


Bleak Hill III
Waste Mass Stability
WM5
Long Term Effectivel Stress Conditions
Leachate at 5.00m above base
Design Approach 1
Combination 1 - Partial factors applied to Actions
Name: Waste Mass
Unit Weight: 17 kN/m³
Cohesion': 5 kPa
Phi': 25 °
Piezometric Line: 1
0.624 (DoU)
10kPa Variable Surcharge
Elevation m OD
Distance (m)


Bleak Hill III
Waste Mass Stability
WM6
Long Term Effectivel Stress Conditions
Leachate at 5.00m above base
Design Approach 1
Combination 2 - Partial factors applied to Materials and Variable Actions
Name: Waste Mass
Unit Weight: 17 kN/m³
Cohesion': 5 kPa
Phi': 25 °
Piezometric Line: 1
0.765 (DoU)
10kPa Variable Surcharge
Elevation m OD
Distance (m)


Bleak Hill III
Waste Mass Stability
WM7
Long Term Effectivel Stress Conditions
Leachate at 10.00m above base
Design Approach 1
Combination 1 - Partial factors applied to Actions
Name: Waste Mass
Unit Weight: 17 kN/m³
Cohesion': 5 kPa
Phi': 25 °
Piezometric Line: 1
0.623 (DoU)
10kPa Variable Surcharge
Elevation m OD
Distance (m)


Bleak Hill III
Waste Mass Stability
WM8
Long Term Effectivel Stress Conditions
Leachate at 10.00m above base
Design Approach 1
Combination 2 - Partial factors applied to Materials and Variable Actions
Name: Waste Mass
Unit Weight: 17 kN/m³
Cohesion': 5 kPa
Phi': 25 °
Piezometric Line: 1
0.766 (DoU)
10kPa Variable Surcharge
Elevation m OD
Distance (m)


Bleak Hill III
Waste Mass Stability
WM9
Long Term Effectivel Stress Conditions
Waste Mass Softening (c = 0)
Leachate not present
Serviceability Limit State
Name: Waste Mass
Unit Weight: 17 kN/m³
Cohesion': 0 kPa
Phi': 25 °
1.428
10kPa Variable Surcharge
Elevation m OD
Distance (m)