GEOTECHNICAL

ENVIRONMENTAL

BERKSWELL QUARRY

VARIATION TO PERMIT

Stability Risk Assessment Report

GEC NO: GE220382406

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1.0 INTRODUCTION

Report Context

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

1.2 Berkswell Quarry currently benefits from an Environmental Permit (Ref. EPR/BB3433RC) which allows for the construction of silt lagoons as part of the importation of inert materials.

1.3 Tetra Tech (TT) have instructed Geotechnical & Environmental Consulting Ltd. (GEC) to undertake a Stability Risk Assessment (SRA) in support of the variation to the existing Waste Recovery Permit at Berkswell Quarry.

1.4 This environmental permit variation is to vary the current environmental permit and extend the permit boundary to increase the quantity of inert waste permitted by 1,800,000 tonnes (1,000,000m3), from 1,576,500 to 3,376,500 tonnes, in order to achieve the proposed restoration profiles as depicted in HRA Figure 2.

1.5 The proposed development comprises the importation of inert waste to restore the quarry void within the extension area as approved under Planning Permission 2003/1480. The site will be restored back to agricultural land and broadleaf woodland in accordance with the restoration scheme (Drg. No. BE 10 / 138).

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

- Berkswell Quarry: Environmental Permit Variation Application – Environmental Setting and Site Design – Tetra Tech Report No. B031730 June 2020.
- Berkswell Quarry Hydrogeological Risk Assessment– Tetra Tech Report No. B1730 June 2022.
- CEMEX Water Level Report – Excel Spreadsheet
- Engineering borehole logs various – 1994 - 2021.

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

Conceptual Stability Site Model

Location

1.8 The Site is located in the Metropolitan Borough of Solihull in the county of West Midlands, approximately 2.25km northwest of the Village of Berkswell and 2.50km east of Hampton in Arden. The centre of the site is located at NGR 422697, 280213 (Figure SRA 1).

Figure SRA1 Site location details

1.9 The permit variation, to which this SRA refers, comprises two areas; one to the northwest and one to the southeast of the currently permitted area. The permit variation of the two areas covers a combined area of approximately area of 26 hectares.

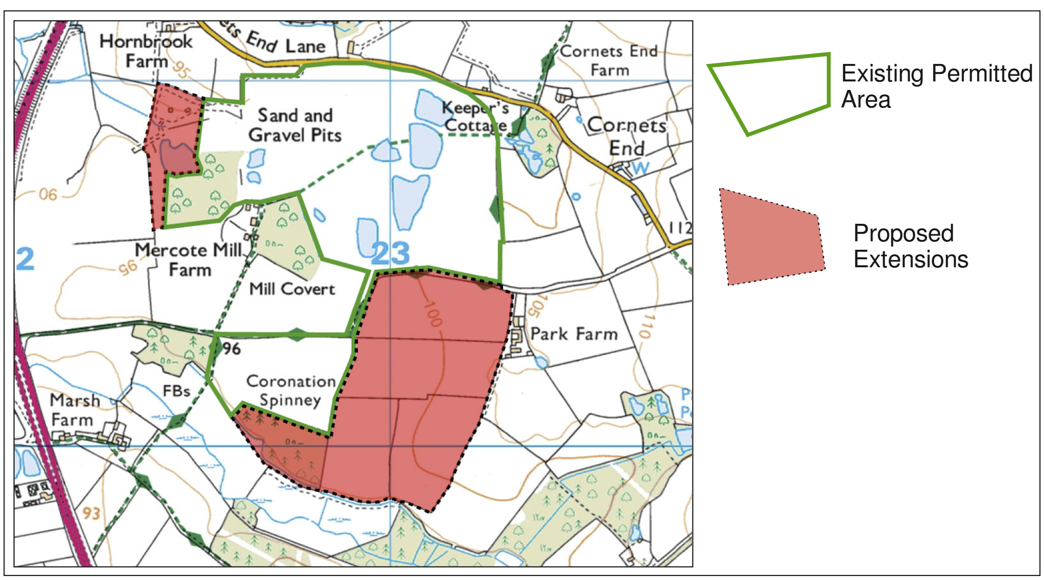


Figure SRA2 Site layout

<u>Regional Geology</u>

1.10 The area of the site is covered by British Geological Sheet 168 Birmingham 1:50000 Solid and Drift 1996, an exert of which is presented as SRA3 below.

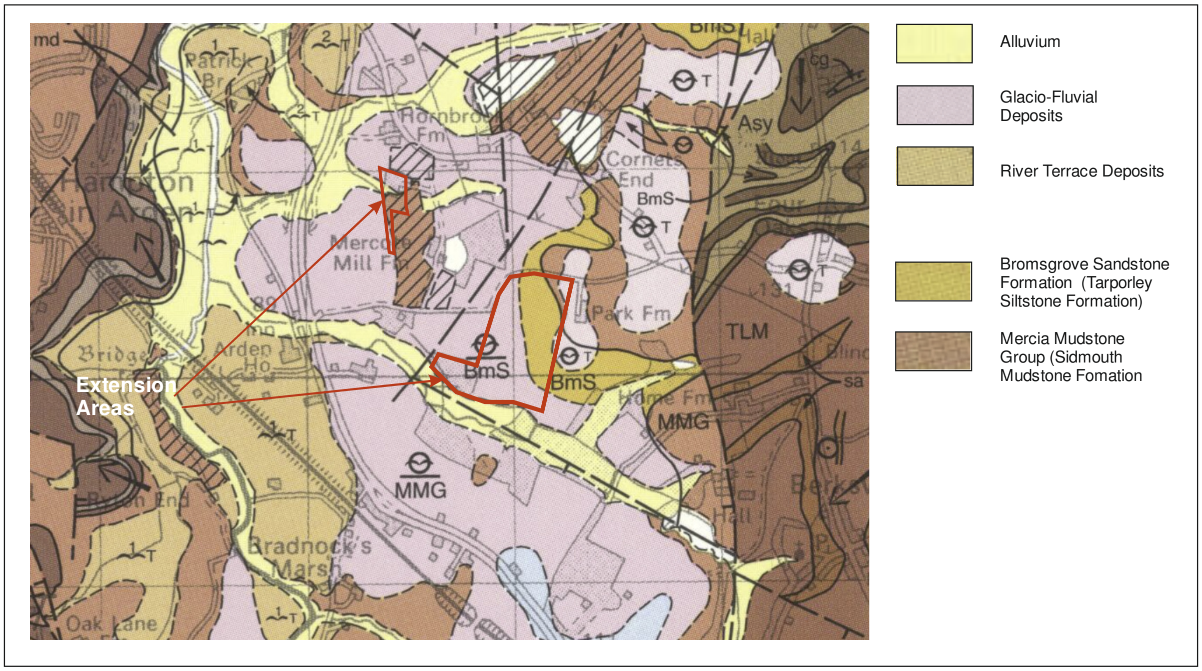


Figure SRA3 Regional geology of the site

Solid Geology

1.11 With reference to British Geological Survey map sheet, the permit variation area in the southeast is underlain by the Tarporley Siltstone Formation (TPSF); whilst the smaller extension area to the northwest is underlain by the Sidmouth Mudstone Formation, both of these strata are part of the Meria Mudstone Group.

1.12 The Lexicon of Named Rock Units describers the TPSF as interlaminated and interbedded siltstones, mudstones and sandstones in approximately equal proportions; whilst the Sidmouth Mudstone Formation (SIM) is described as dominantly mudstone and siltstone, red-brown with common grey-green reduction patches and spots. The upper boundary of the SIM is with the TPSF and is described as conformable and gradational. Therefore, both these strata will be combined and described as the Mercia Mudstone Group (MMG) for the purposes of this stability risk assessment.

Superficial Geology

1.13 BGS Sheet 168 indicates the site to have a superficial covering of Mid Pleistocene Glacio-Fluvial Deposits (UGF). Alluvium is present immediately to the south of the southeastern extension area and may be present in the north of the northwestern extension area.

1.14 The Lexicon of Named Rock Units gives only a generic description of the UGF as coarse-grained sands and gravels. It is the UGF that forms the extractable mineral at the extension sites

Structural Geology

1.15 A northeast - southwest trending fault is shown on Figure SRA3 and forms a fault-bounded geological boundary between the TPSF to the east and the SIM to the west. Given the relative geological ages of the two strata a down throw to the east of the fault trace is considered probable.

Local Geology

1.16 The former site owners / operators have historically undertaken various phases of site investigation and borehole drilling for the purposes of mineral exploration and groundwater monitoring. Many of these borehole locations are close to each other and provide the same information concerning the local geology of the extension areas. Therefore 9no. of boreholes have been selected which give a good cover of the two extension areas and allow the stratigraphy of the two areas to be understood (Table SRA1).

Table SRA1 Local geology of the study areas

Bh No.	**Overburden**		**Glacio Fluvial Deposits**		**Mercia Mudstone Group**	
	From mbgl (mAOD)	**Thickness (m)**	**From mbgl (mAOD)**	**Thickness (m)**	**From mbgl (mAOD)**	**Thickness (m)**
Western Extension						
BH05/21	GL (88.46)	2.50	2.50 (85.96)	0.50	3.00 (85.46)	>1.00
BH06/21	GL (88.85)	1.50	1.50 (87.35)	1.10	2.60 (86.25)	>1.80
Southeastern Extension						
BH81	GL (98.36)	0.80	0.80 (97.56)	12.90	13.70 (84.66)	>0.30
GW01	GL (101.04)	0.30	0.30 (100.74)	6.00	6.30 (94.74	>3.70
GW11	GL (97.57)	0.30	0.30 (97.27)	14.20	14.50 (83.07)	>1.00
GW02	GL (101.76)	0.30	0.30 (101.76	4.00	4.30 (97.76)	>15.70
BH04/20	GL (100.64)	0.40	0.40 (100.24)	>15.10	Not Encountered	
BHC2A	GL (not recorded)	0.50	0.50	>8.00	Not Encountered	
MF05/16	GL (99.38)	0.60	0.60 (98.78)	16.40	17.00 (82.38)	>0.50

1.17 The term overburden has been used to describe the materials above the extractable economic mineral resource. The overburden generally comprised 0.30 to 0.80m of dark brown silty gravelly Clay in the southeastern extension area. The northwestern extension area the overburden comprised between 1.50 and 2.50 orange brown and dark brown silty Clay with minor amounts of mudstone gravel. It is likely that these thicker sequences of Overburden represent the Alluvium that is identified on the geological map (SRA3).

1.18 The undifferentiated Glacio-Fluvial Deposits (UGF) are present immediately beneath the overburden and generally comprised brown silty sub-rounded to well-rounded fine to coarse Gravel with subordinate amounts of Sand. The thickness of the UGF varied between the two extension areas with 0.50-1.00m of UGF being recorded in the northwestern extension area and >15.20m in the southeastern area

1.19 The MMG will form the basal subgrade of the extraction void and comprises a discontinuous superficial layer of stiff red brown sandy slightly gravelly Clay (Weathered Mercia Mudstone) over red brown Sandstone / Mudstone.

Hydrogeology

1.20 The superficial Glacio-Fluvial Deposits is classified by the Environment Agency as a Secondary A Aquifer (i.e. permeable strata supporting local water supplies). The underlying solid geology

1.21 The Sidmouth Mudstone Formation is classified by the EA as a Secondary B Aquifer - predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. These are generally the water-bearing parts of the former non-aquifers. The Tarporley Siltstone Formation is classified by the EA as a Principal Aquifer. These are layers of rock or drift deposits that have high intergranular and/or fracture permeability - meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale.

1.22 Groundwater monitoring has been carried out across the site and in the boreholes listed in Table SRA1 is present at 4.44mbgl to 4.73mbgl (87.92 to 89.28mAOD) in the northwestern area; and in the southeastern area between 3.35 and 7.24mbgl (98.04 and 93.77mAOD).

1.23 During the mineral extraction process groundwater levels were controlled (lowered) within the site by dewatering (pumping) from a sump located at the base of the site as shown in Figure 4 of the ESSD. It is anticipated that the groundwater management will continue until the cessation of inert waste placement.

Hydrology

1.24 There are two small streams located to the south of the proposed extension area that's located to the southeast of the site; one located on the southern boundary then second located approximately 95m southwest. There is also a stream located to the northwest of the proposed extension area that's located to the northwest of the site. These streams all flow towards the River Blythe which is located approximately 820m west of the site.

1.25 According to the EA's flood maps, the extension area is located within a Flood Zone 1 which is defined as a low probability of flooding (less than 1 in 1000 annual probability of river or sea flooding in any year).

Basal Subgrade Model

1.26 The void will be created by the extraction of the sands and gravels of the UGF exposing the Mercia Mudstone Group which will form the basal subgrade of the extraction void.

1.27 The Mercia Mudstone Group was described in the 9no. boreholes as comprising a discontinuous layer of stiff red brown sandy gravelly Clay (Weathered Mercia Mudstone Group) over red brown Sandstone / Mudstone.

1.28 Groundwater monitoring placed the groundwater within the UGF at ca 98mAOD However, groundwater management will continue throughout the extraction operations and inert waste placement such that the void will remain dry.

1.29 In the ESSD it states that the basal level of the extraction void will be 84mOD, therefore there may be some remnants of the UGF remaining at the base of the void.

Basal Lining System

1.30 Prior to the commencement of placement of inert waste, a geological barrier will be engineered using locally sourced Weathered Mercia Mudstone or imported clay / inert waste. The geological barrier will be constructed in compliance with the Environmental Permitting Regulations: Inert Waste Guidance 2010 which specifies that a geological barrier shall have a minimum thickness of 1m with a hydraulic conductivity of than 1 x 10^{-7}m/s

Side Slope Subgrade Model

1.31 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 Glacio-Fluvial Deposits, in turn overlying the sandy Clays of the Weathered Mercia Mudstone (if present) or the weak red brown Mudstones / Siltstones of the Mercia Mudstone Group.

1.32 Based on the minimum elevation of the extraction void of 84mAOD (ESSD) and the thickest sequence of UGF recorded in the local borehole logs, a maximum side slope subgrade height of 17.00m (BH04/20 – 100.64mAOD) may exist. The extraction void side slope subgrade will have a post extraction gradient of 1 (H) : 1 (V) prior to inert waste placement.

1.33 Cross section through the side slope subgrade is presented herein as Figure SRA4.

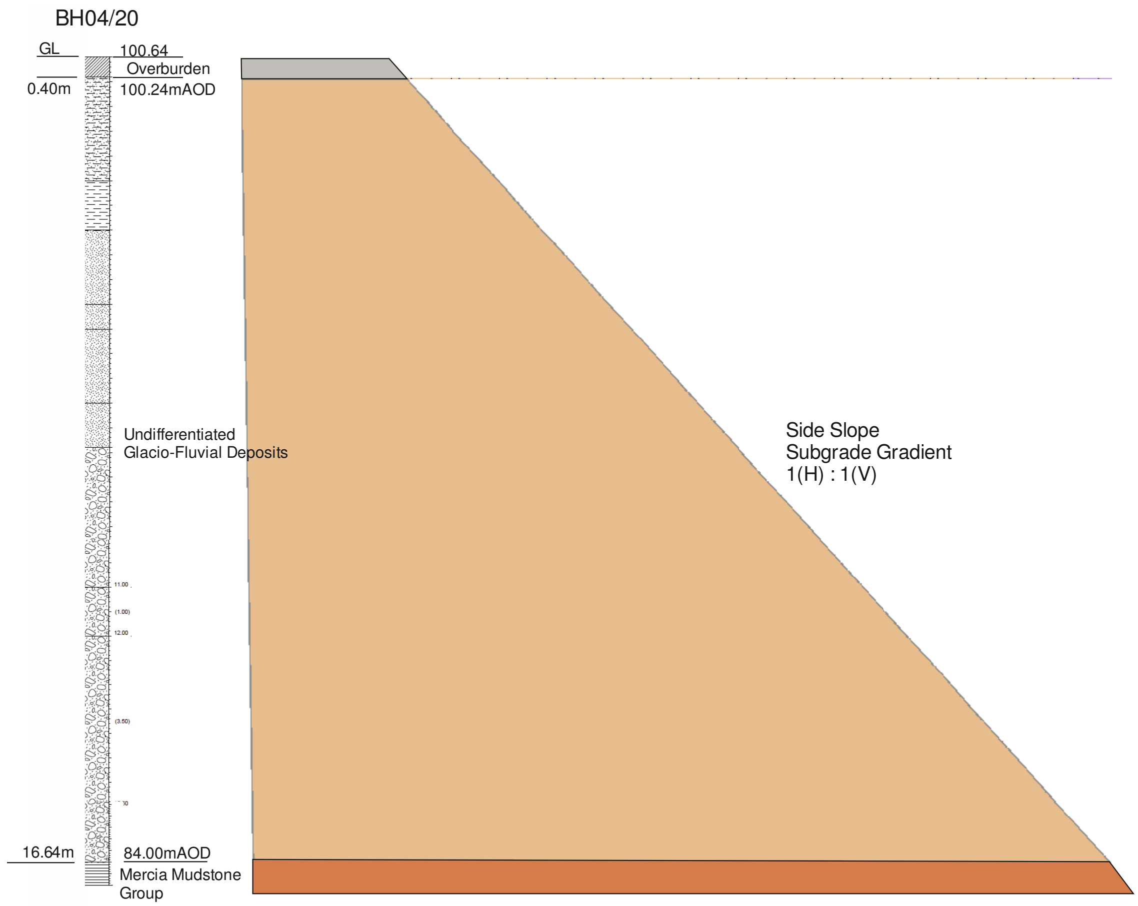


Figure SRA4 Cross-Section through side slope subgrade

Side Slope Lining Model

1.34 The side slope liner will comprise a geological barrier 1.00m thick with a minimum hydraulic conductivity of 1.0 x $10m^{-7}$ m/s.

1.35 The side slope liner will be constructed from selected imported inert waste which will have sufficient clay content to be capable of achieving the required properties for the attenuation layer. The physical suitability of the material will be assessed in accordance with the flow chart provided in the Environment Agency's 'Standards and Measures for the Deposit of Inert Waste on Land'.

1.36 The final method of placement of the side slope liner will be dependent on the results of the stability assessment but is likely to comprise either: full height placement or placement in lifts in advance of inert waste.

Inert Waste Mass Model

1.37 It is proposed that the Berkswell Quarry extension will be restored using inert waste only.

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

1.39 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 SRA2 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.*

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

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

Capping System Model

1.42 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 Mercia Mudstone Group (MMG). As the void will be formed by the excavation and extraction of the economic mineral 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 MMG at basal void level will comprise either firm to stiff gravelly Clays (Weathered Mercia Mudstone) or extremely weak to very weak red brown Mudstone / Sandstone. Both of these materials are considered competent and of medium compressibility to low 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 A geological basal attenuation layer is to be constructed on the in-situ MMG. The basal attenuation layer will be constructed from suitable imported Inert Waste). All materials will be selected and tested to ensure they achieve the require minimum hydraulic conductivity.

2.5 No stability assessment of this component 0f the inert waste facility is considered necessary.

Side Slope Subgrade Screening

2.6 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

2.7 An artificially established side-lining system is to be placed against the side slope subgrade. The side slope liner will be constructed from imported inert waste following the same selection criteria as used and described for the basal liner.

2.8 The basal liner will comprise a minimum of 1.00m (perpendicular thickness) of selected inert waste material with a minimum hydraulic conductivity of 1 x 10^{-7}m/s.

2.9 Groundwater outflows into the void are not expected as will continue through the waste placement operations.

2.10 Analysis of this component is considered necessary to investigate the short-term stability of this element prior to the placement of the inert waste and the effect of long term exposure without waste placement.

Waste Mass Screening

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

Capping System Screening

2.12 No capping system will be constructed at this inert wate facility. However, the site is to be restored to agricultural and broadleaf woodland in accordance with the approved restoration plans (Drawings P2/928/13/2, BE 10/13B and BE 20/23A). The proposed post-restoration ground surface has no steep slopes and follows the regional landform. Therefore, a stability assessment of any sloping areas of the Restoration Soils is not required.

Justification of Modelling Approach and Software

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

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

2.15 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

2.16 The side slope subgrade will comprise Overburden over Undifferentiated Glacio-Fluvial Deposits over Weathered or intact MMG. Based on the engineering descriptions of these materials recorded on the borehole logs characteristic geotechnical parameters have been developed and are presented in Table SRA3.

Table SRA3 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
Undifferentiated Glacio-Fluvial Deposits	Medium dense Sand and Gravel	20	Not Applicable Granular Material		5	36
Weathered MMG	Gravelly Clay	19	50	0	5	30
MMG	Bedrock	Impermeable Bedrock				

<u>Parameters Selected for Side Slope Liner Analyses</u>

2.17 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 SRA4).

Table SRA4 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	5	25

<u>Parameters Selected for Waste Analyses</u>

2.18 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 SRA2. 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 SRA5 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	3	25

Selection of Appropriate Factors of Safety

2.19 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 SRA6 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 (*tanφ*)		$\gamma_{\phi'}$	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 (*tanφ*)		$\gamma_{\phi'}$	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

2.20 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.

2.21 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

2.22 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 SRA4.

2.23 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 94 m AOD (see groundwater contouring HRA Figure 5).

2.24 Based on the thickest sequence of sands and gravel, the highest side slope subgrade will be ca 17m and will be formed at a gradient of 1(v):1(h).

2.25 The results of the side slope liner stability analyses are shown in Table SRA7 and the SlopeW worksheets presented in Appendix 1.

Table SRA7 Side Slope Subgrade Stability – Summary of Results

Run	File Name	Degree of Utilisation		Notes
		C1	C2	
01	SSG1	0.82		Short Term Stability Total Stress Analysis
02	SSG2		0.92	
03	SSG3	0.82		Effective Stress Analysis
04	SSG4		0.92	
05	SSG5		0.96	Groundwater at 94 m AOD

Side Slope Liner Analyses

2.26 A side slope liner will be placed against the side slope subgrade. Based on the results of the side slope subgrade analyses presented in Table SRA7 it is assumed that the side slopes are at (1(v) : 1(h)).

2.27 The liner will be modelled as a 1.00m thick layer applied to the side slope subgrade.

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

2.29 The results of the side slope liner stability analyses are shown in Table SRA8 and the SlopeW worksheets presented in Appendix 2.

Table SRA8 Side Slope Liner Stability – Summary of Results

Run	File Name	Characteristic Shear Strength		Degree of Utilisation		Liner Thickness (m)	Notes
		c	ϕ	C1	C2		
Side Slope Gradient 45° Side Slope Liner thickness 1.00m Failure Entirely within Side Slope Liner							
01	SSL1	50	0	0.37		1.00	Failure at boundary between liner and subgrade
02	SSL2				0.34		
03	SSL3	5	25	1.27		1.00	Liner unstable under full effective stress conditions

Waste Mass Analyses

2.30 The post extraction void may be up to 17m deep; although it is unlikely that a temporary waste face 17.00m 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).

2.31 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.

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

2.33 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.

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

2.35 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.

2.36 Results of the analyses are presented in Appendix 3 and are summarised in Table SRA9.

Table SRA9 Waste Mass Stability – Summary of Results

Run	File Name	Waste Strength	Leachate Level	Degree of Utilization		Notes
				C1	C2	
1	WM1	Total	Dry	0.20		Total Stress
2	WM2				0.19	
3	WM3	Effective	3.00m	0.54		Increasing leachate level measured from base of waste mass
4	WM4				0.64	
5	WM5		8.00m	0.54		
6	WM6				0.64	
7	WM7		14.00m	0.58		
8	WM8				0.70	
9	WM9		Not Present		1.56 (FoS)	Cohesion = 0kN/m^2

Assessment

Basal Subgrade

2.37 The basal subgrade is to comprise the in-situ weathered or intact Mercia Mudstone Group 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.

2.38 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

2.39 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.

2.40 However, a stability assessment of the side slope subgrade has been carried out at the proposed gradient of 1(v) : 1(h) (45°). 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 no change in the calculated degree of utilisation. The similarity in the results is due to the side slope subgrade materials being largely coarse-grained.

2.41 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 94mAOD. The stability analysis demonstrates that this would increase the degree of utilisation to 0.96 under the more onerous Combination 2 factoring meaning the slope will remain stable.

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

Side Slope Liner

2.43 A side slope liner will be placed against the side slope subgrade. Based on the results of the side slope subgrade analyses presented in Table SRA7 it is assumed that the side slopes are at (1(v) : 1(h)). The liner will be modelled as a 1.00m thick layer applied to the side slope subgrade.

2.44 The results of the side slope liner stability analyses are shown in Table SRA8 and the SlopeW worksheets presented in Appendix 2.

2.45 The side slope liner with a minimum perpendicular thickness of 1.00m and a gradient of 1(v) : 1(h) has been analysed and shown to be stable in the short term under total stress conditions with a maximum degree of utilisation of 0.37 being returned under Combination 1 factoring.

2.46 If the side slope liner is left exposed for long periods of time such that fully drained conditions (effective stress conditions) are achieved the side slope liner will become unstable with a degree of utilisation of 1.27 under combination 1 factoring.

2.47 Therefore, it is recommended that the side slope liner is placed in advance of the inert waste placement in 3m lifts and buttressed by the inert waste prior to full effective stress conditions being achieved.

2.48 It can be concluded that the side slope liner will remain stable provided the above placement method is followed.

Waste Mass

2.49 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.

2.50 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.

2.51 The waste slope has a Degree of Utilisation of <1.00 (<100%) for all leachate levels up to 14.00m from the base of the waste body. A leachate level of 14.00m is considered extremely unlikely to occur under normal operating conditions and therefore represents a worst-case situation.

2.52 The waste slope has a Factor of Safety of 1.56 even if the value of the cohesion intercept of the waste reduces from $5kN/m^2$ to $0kN/m^2$

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

Capping System

2.54 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 basal attenuation layer, it is recommended that the basal subgrade is carefully inspected. Special attention should be paid if any soft spots within the Weathered Mercia Mudstone Group.

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.

Basal Liner Monitoring

3.4 A basal attenuation layer with a minimum thickness of 1.00m is to be constructed prior to the importation of the inert waste.

3.5 The selection of appropriate liner material and their placement will be subject to appropriate CQA inspection such that it is considered as serviceable immediately post placement. However, if left exposed for long periods, dependant on the season, the liner may soften or undergo shrinkage and drying out. If it is apparent that the liner or section of basal liner is to be left exposed for long period it is recommended that a protective geotextile is placed to reduce the drying out of the basal liner.

3.6 Post placement trafficking off the liner should be kept to a minimum to avoid rutting of the attenuation layer.

It is recommended that a visual inspection of the placed liner should be carried out prior to the placement of the inert waste.

Side Slope Subgrade + Lining System

3.7 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.

3.8 Provided the side slope liner is placed in lifts ahead of the inert waste placement and not left unsupported for long period of time 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

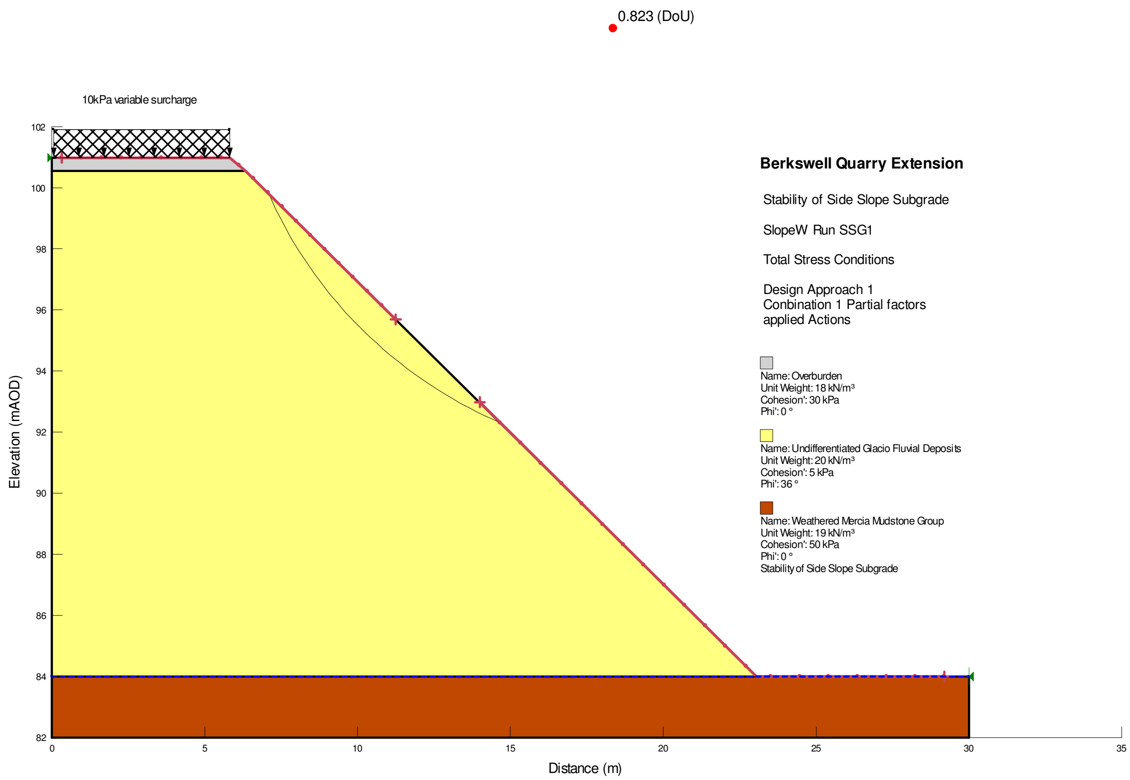
3.9 The temporary slopes in the waste should be visually monitored and appropriate actions taken on any sign of instability. This would typically include a reduction in slope angle of the temporary waste slopes.

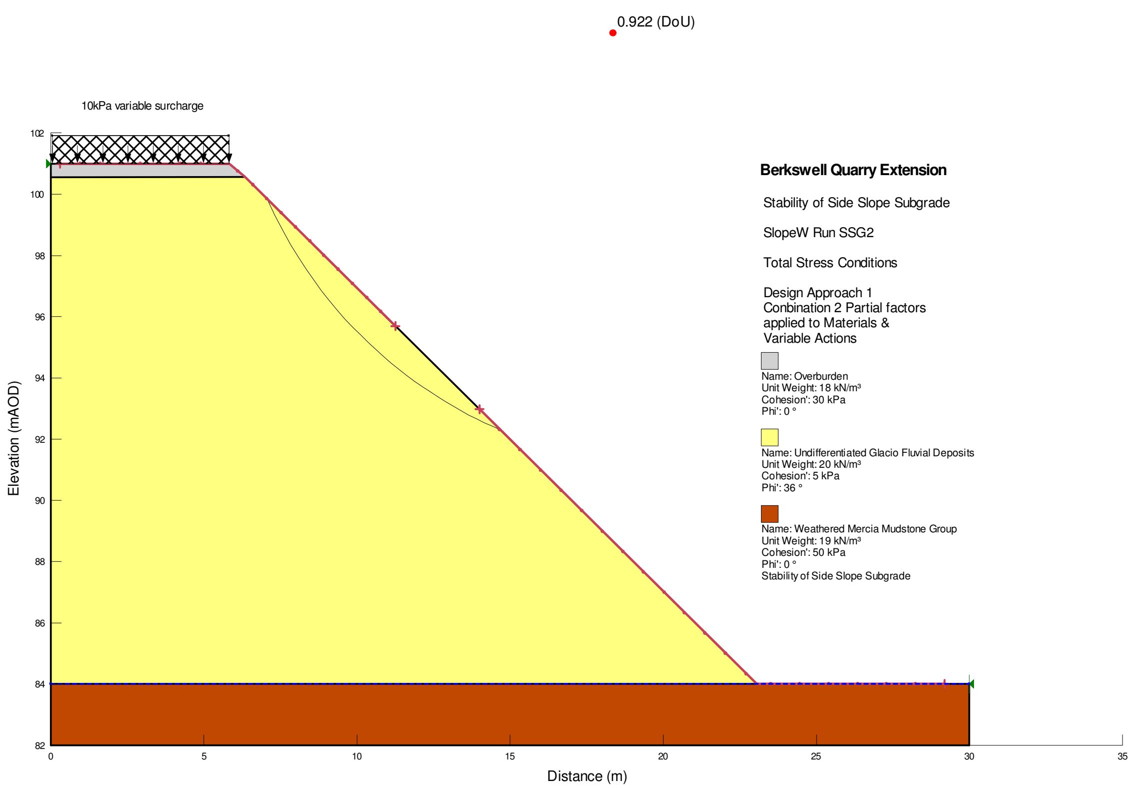
Restoration Soils and Finished Surface Monitoring

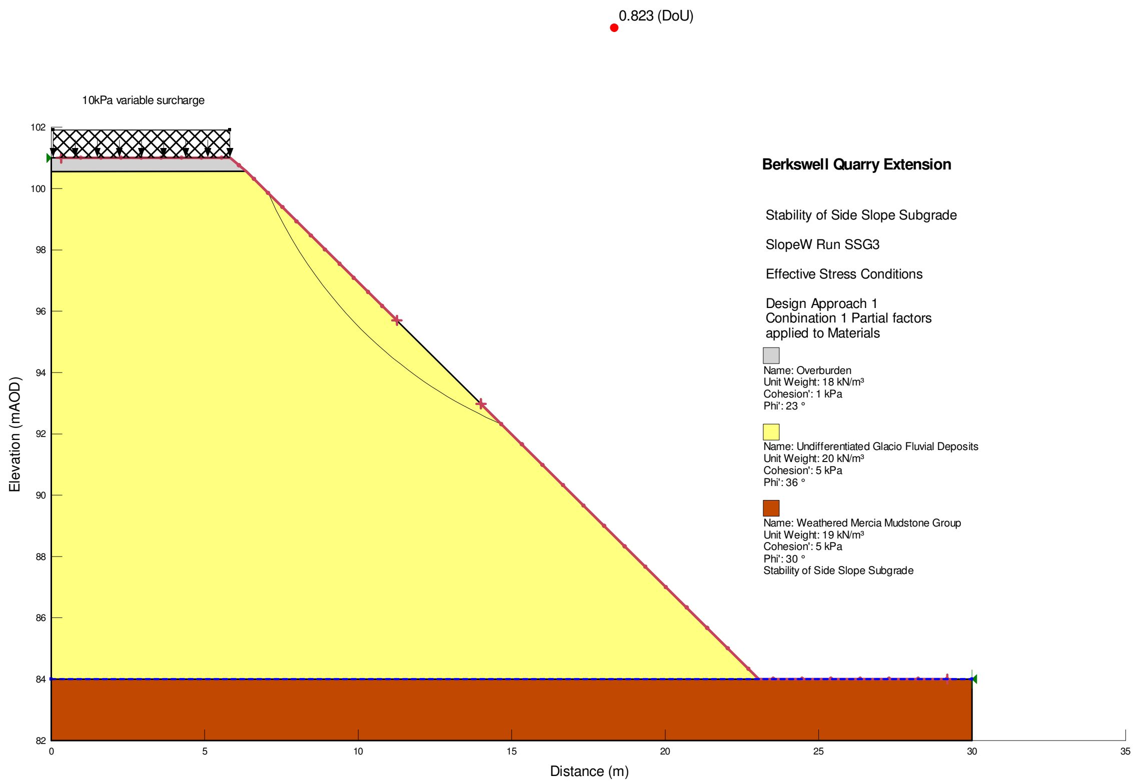
3.10 EA Guidance 'Landfill and deposit for recovery: aftercare and permit surrender' indicates that where records demonstrate that a recovery site has accepted only inert wastes during its lifetime, the site is applicable for a low risk surrender based on records alone. As such no further monitoring or post closure monitoring is deemed necessary. As such, no further closure and aftercare plan has been prepared in support of this Environmental Permit Application.

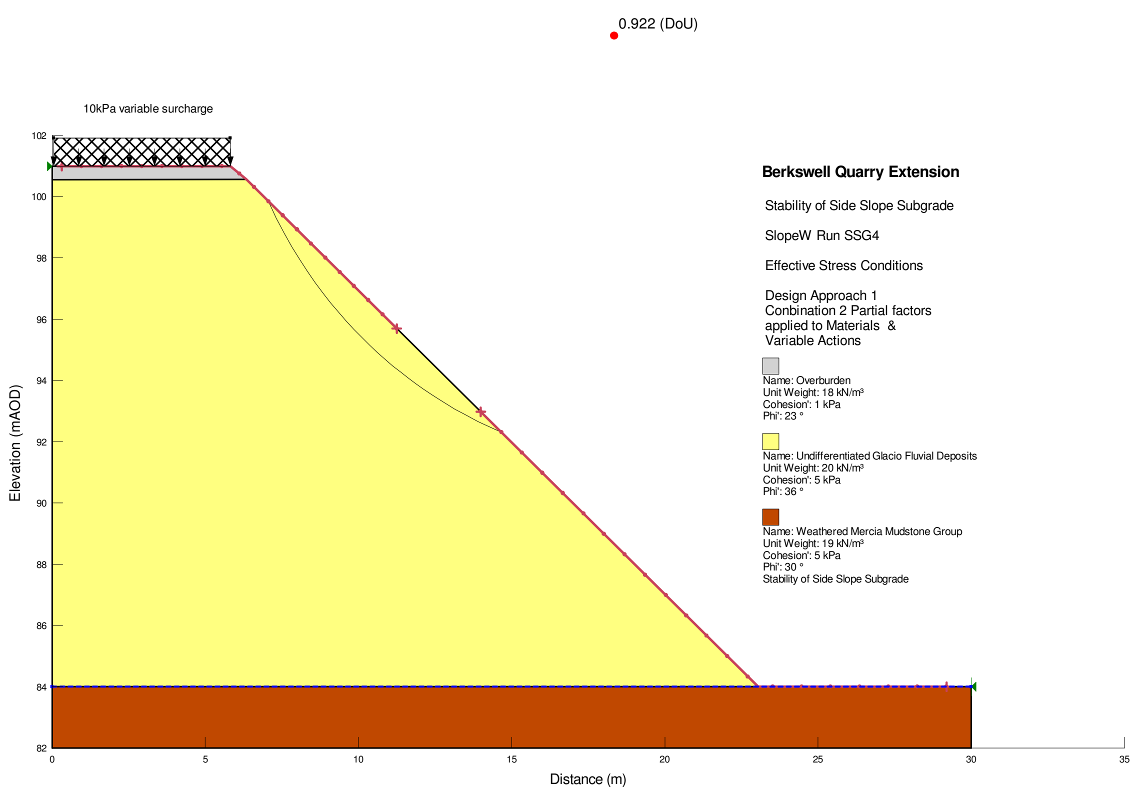
Appendix 1

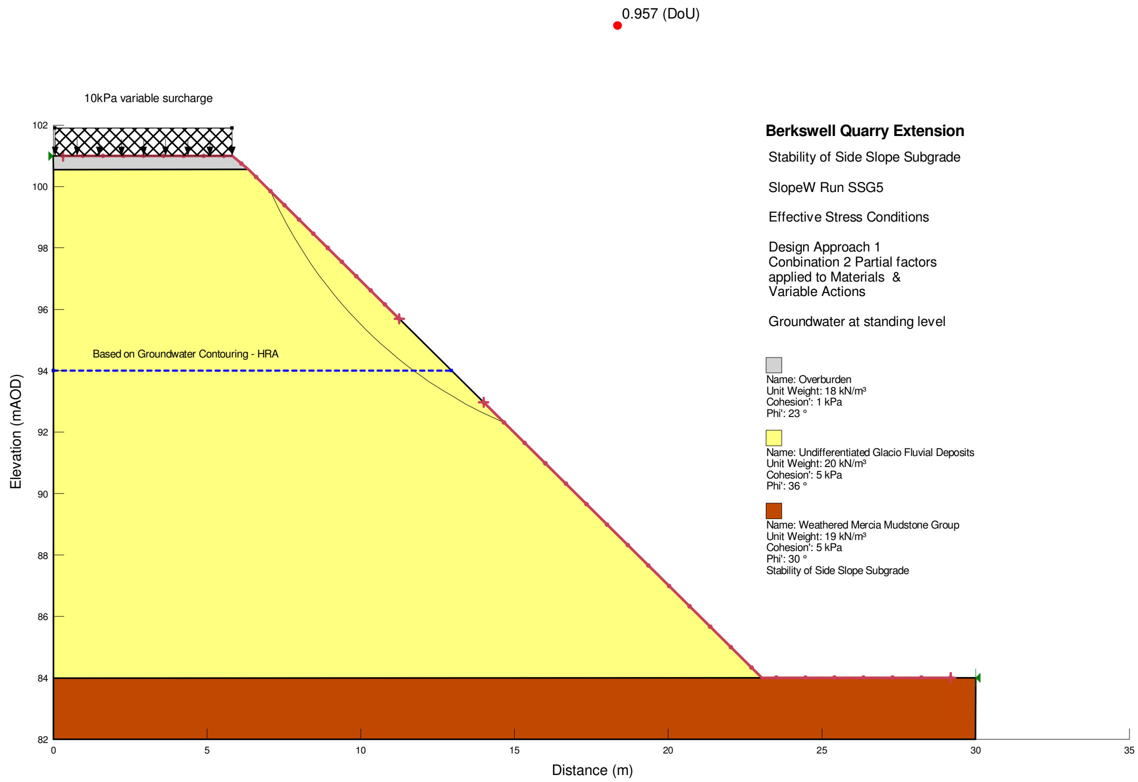
SlopeW Worksheets – Side Slope Subgrade


0.823 (DoU)
10kPa variable surcharge
Berkswell Quarry Extension
Stability of Side Slope Subgrade
SlopeW Run SSG1
Total Stress Conditions
Design Approach 1
Conbination 1 Partial factors
applied Actions
Name: Overburden
Unit Weight: 18 kN/m³
Cohesion': 30 kPa
Phi': 0 °
Name: Undifferentiated Glacio Fluvial Deposits
Unit Weight: 20 kN/m³
Cohesion': 5 kPa
Phi': 36 °
Name: Weathered Mercia Mudstone Group
Unit Weight: 19 kN/m³
Cohesion': 50 kPa
Phi': 0 °
Stability of Side Slope Subgrade
Elevation (mAOD)
Distance (m)


0.922 (DoU)
10kPa variable surcharge
Berkswell Quarry Extension
Stability of Side Slope Subgrade
SlopeW Run SSG2
Total Stress Conditions
Design Approach 1
Conbination 2 Partial factors
applied to Materials &
Variable Actions
Name: Overburden
Unit Weight: 18 kN/m³
Cohesion': 30 kPa
Phi': 0 °
Name: Undifferentiated Glacio Fluvial Deposits
Unit Weight: 20 kN/m³
Cohesion': 5 kPa
Phi': 36 °
Name: Weathered Mercia Mudstone Group
Unit Weight: 19 kN/m³
Cohesion': 50 kPa
Phi': 0 °
Stability of Side Slope Subgrade
Elevation (mAOD)
Distance (m)


0.823 (DoU)
10kPa variable surcharge
Berkswell Quarry Extension
Stability of Side Slope Subgrade
SlopeW Run SSG3
Effective Stress Conditions
Design Approach 1
Conbination 1 Partial factors
applied to Materials
Name: Overburden
Unit Weight: 18 kN/m³
Cohesion': 1 kPa
Phi': 23 °
Name: Undifferentiated Glacio Fluvial Deposits
Unit Weight: 20 kN/m³
Cohesion': 5 kPa
Phi': 36 °
Name: Weathered Mercia Mudstone Group
Unit Weight: 19 kN/m³
Cohesion': 5 kPa
Phi': 30 °
Stability of Side Slope Subgrade
Elevation (mAOD)
Distance (m)

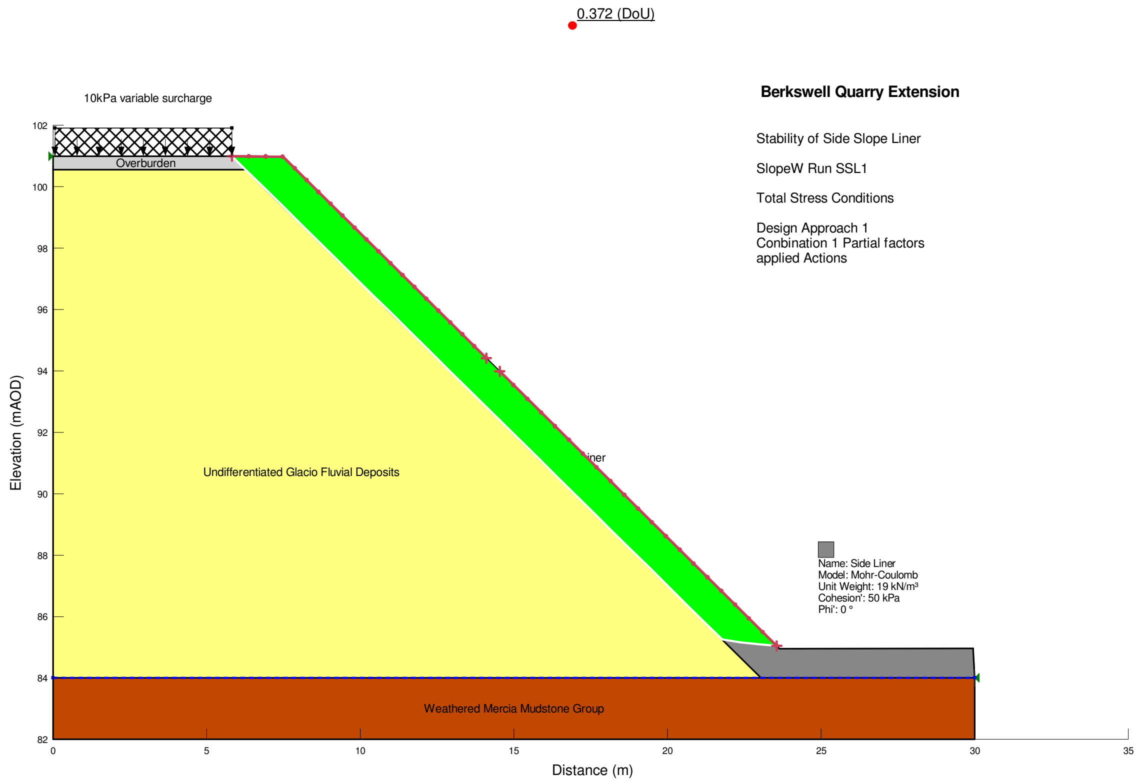

0.922 (DoU)
10kPa variable surcharge
Berkswell Quarry Extension
Stability of Side Slope Subgrade
SlopeW Run SSG4
Effective Stress Conditions
Design Approach 1
Conbination 2 Partial factors
applied to Materials &
Variable Actions
Name: Overburden
Unit Weight: 18 kN/m³
Cohesion': 1 kPa
Phi': 23 °
Name: Undifferentiated Glacio Fluvial Deposits
Unit Weight: 20 kN/m³
Cohesion': 5 kPa
Phi': 36 °
Name: Weathered Mercia Mudstone Group
Unit Weight: 19 kN/m³
Cohesion': 5 kPa
Phi': 30 °
Stability of Side Slope Subgrade
Elevation (mAOD)
Distance (m)



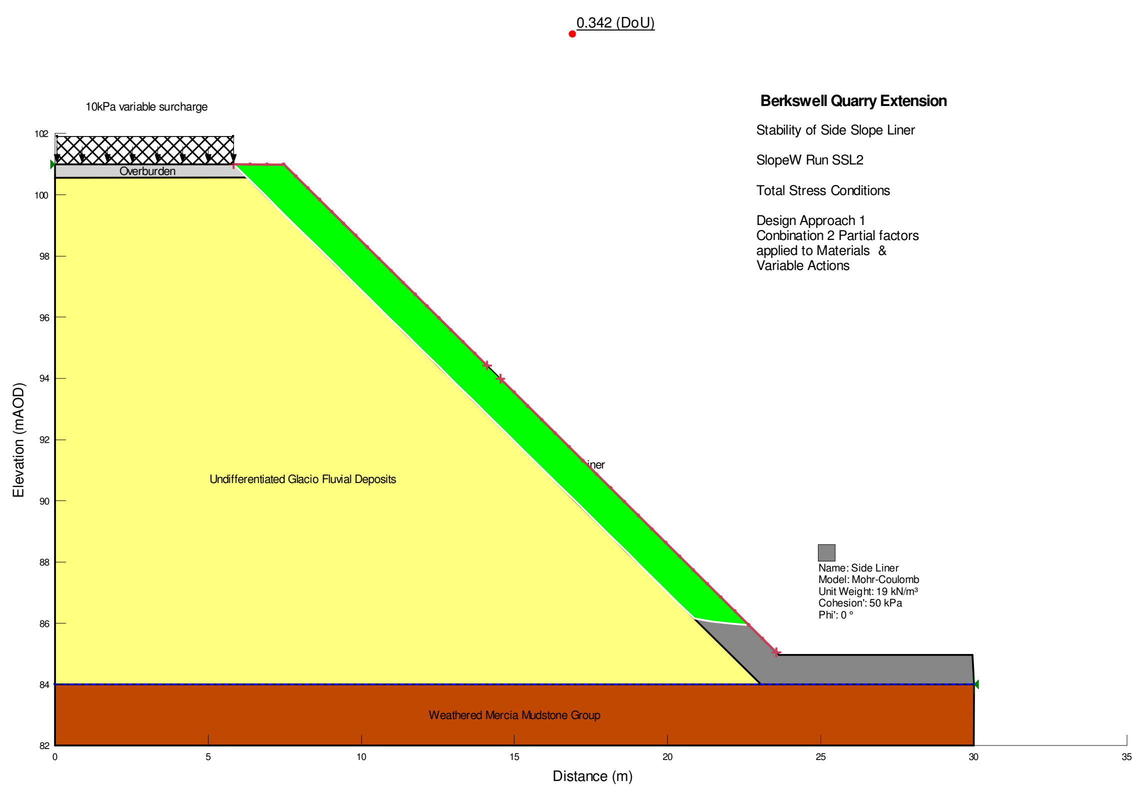
0.957 (DoU)
10kPa variable surcharge
Based on Groundwater Contouring - HRA
Berkswell Quarry Extension
Stability of Side Slope Subgrade
SlopeW Run SSG5
Effective Stress Conditions
Design Approach 1
Conbination 2 Partial factors
applied to Materials &
Variable Actions
Groundwater at standing level
Name: Overburden
Unit Weight: 18 kN/m³
Cohesion': 1 kPa
Phi': 23 °
Name: Undifferentiated Glacio Fluvial Deposits
Unit Weight: 20 kN/m³
Cohesion': 5 kPa
Phi': 36 °
Name: Weathered Mercia Mudstone Group
Unit Weight: 19 kN/m³
Cohesion': 5 kPa
Phi': 30 °
Stability of Side Slope Subgrade
Elevation (mAOD)
Distance (m)
102
100
98
96
94
92
90
88
86
84
82
0
5
10
15
20
25
30
35

Appendix 2

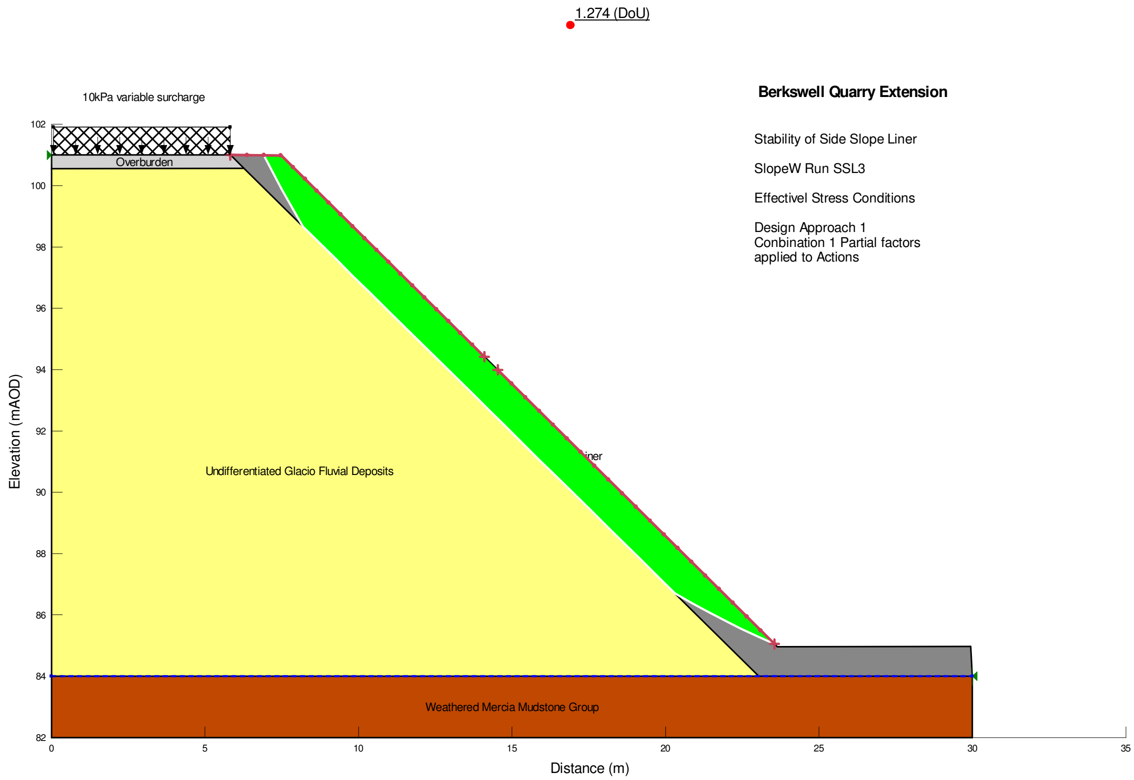
SlopeW Worksheets – Side Slope Liner



0.372 (DoU)
10kPa variable surcharge
Berkswell Quarry Extension
Stability of Side Slope Liner
SlopeW Run SSL1
Total Stress Conditions
Design Approach 1
Conbination 1 Partial factors
applied Actions
Overburden
Undifferentiated Glacio Fluvial Deposits
Name: Side Liner
Model: Mohr-Coulomb
Unit Weight: 19 kN/m³
Cohesion': 50 kPa
Phi': 0 °
Weathered Mercia Mudstone Group
Elevation (mAOD)
Distance (m)

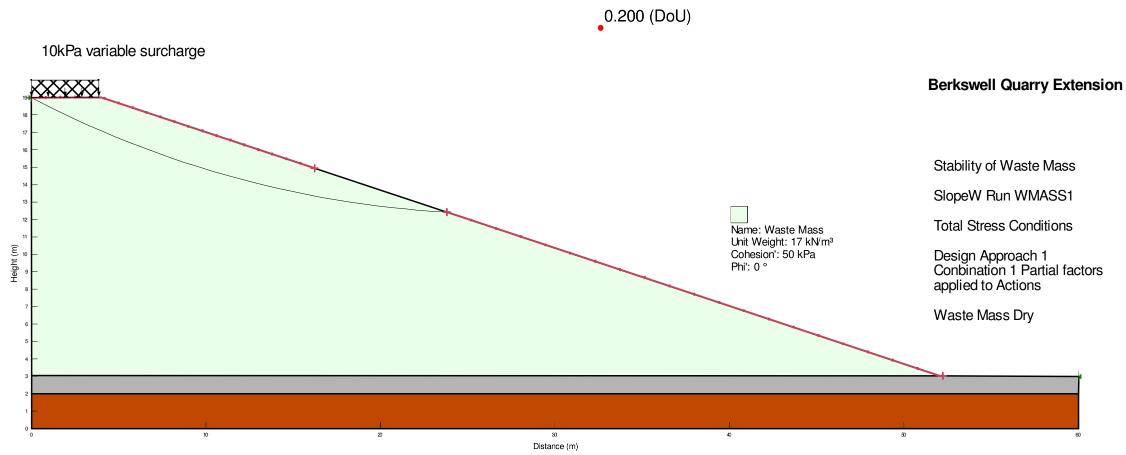


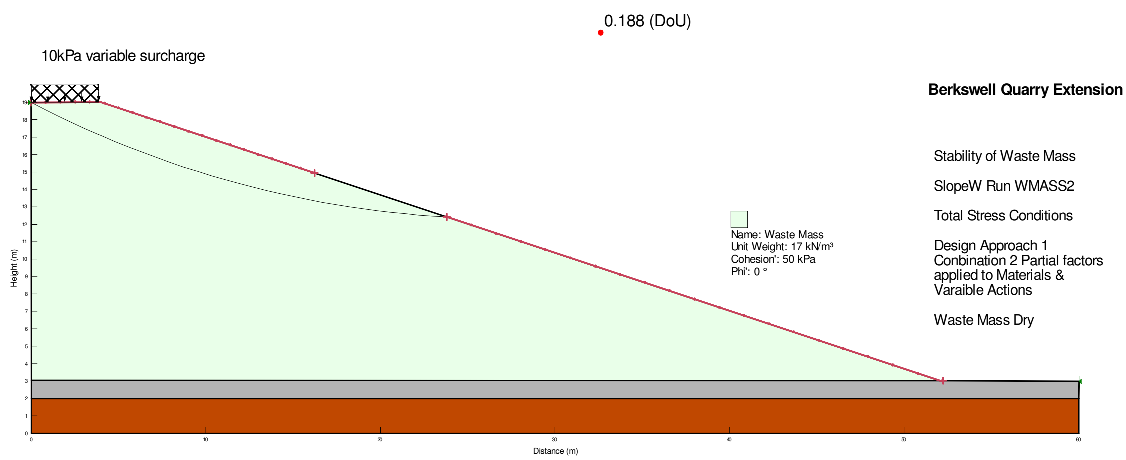
0.342 (DoU)
10kPa variable surcharge
Berkswell Quarry Extension
Stability of Side Slope Liner
SlopeW Run SSL2
Total Stress Conditions
Design Approach 1
Conbination 2 Partial factors
applied to Materials &
Variable Actions
Overburden
Undifferentiated Glacio Fluvial Deposits
Name: Side Liner
Model: Mohr-Coulomb
Unit Weight: 19 kN/m³
Cohesion': 50 kPa
Phi': 0 °
Weathered Mercia Mudstone Group
Elevation (mAOD)
Distance (m)

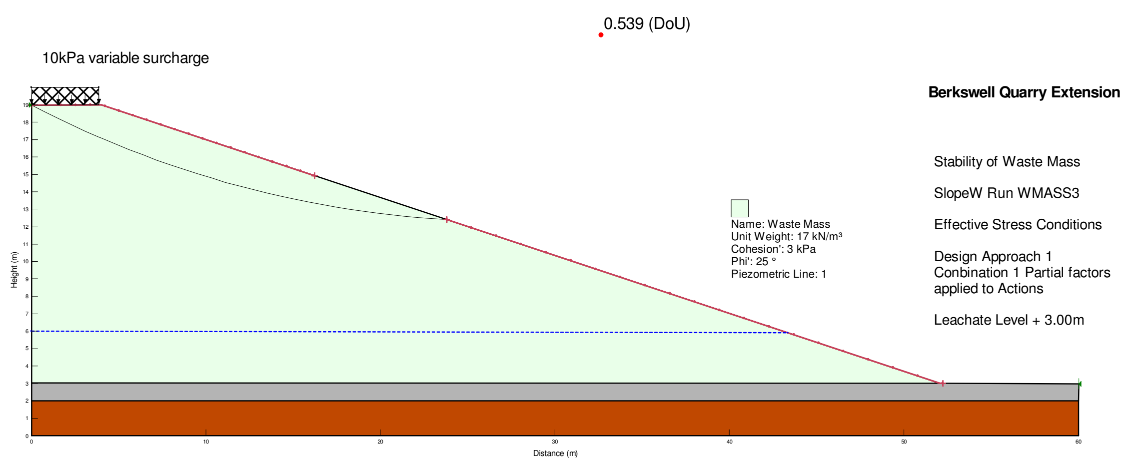

1.274 (DoU)
10kPa variable surcharge
Berkswell Quarry Extension
Stability of Side Slope Liner
SlopeW Run SSL3
Effectivel Stress Conditions
Design Approach 1
Conbination 1 Partial factors
applied to Actions
Overburden
Undifferentiated Glacio Fluvial Deposits
Weathered Mercia Mudstone Group
Elevation (mAOD)
Distance (m)
102
100
98
96
94
92
90
88
86
84
82
0
5
10
15
20
25
30
35

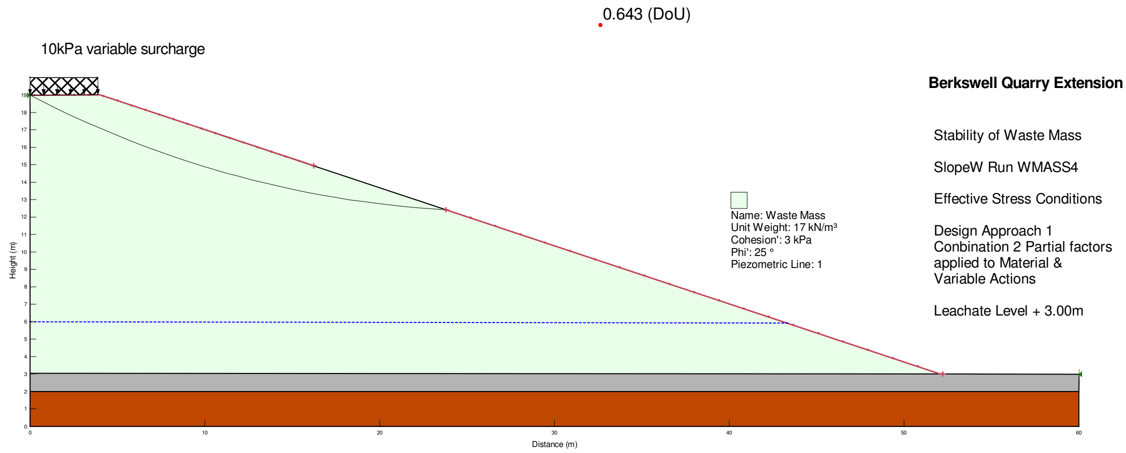
Appendix 3

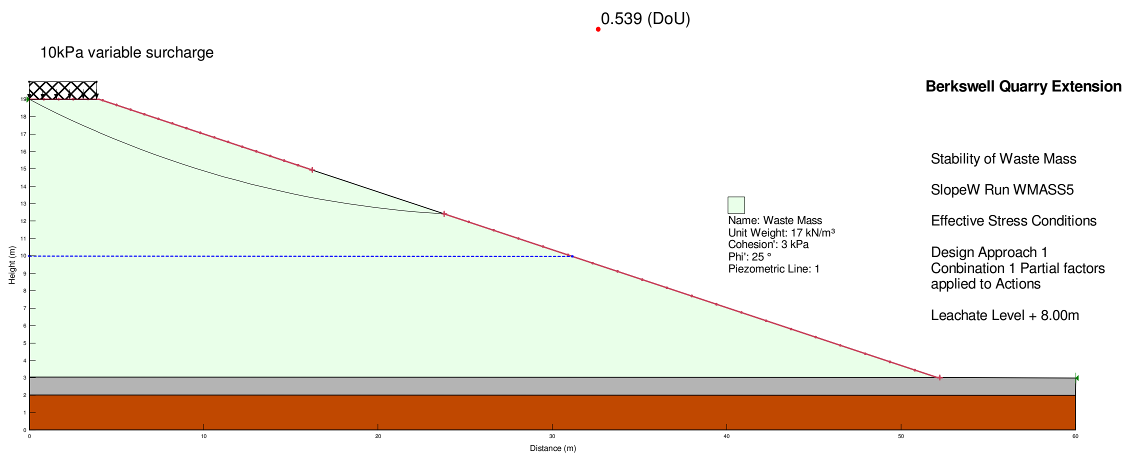
SlopeW Worksheets – Inert Waste

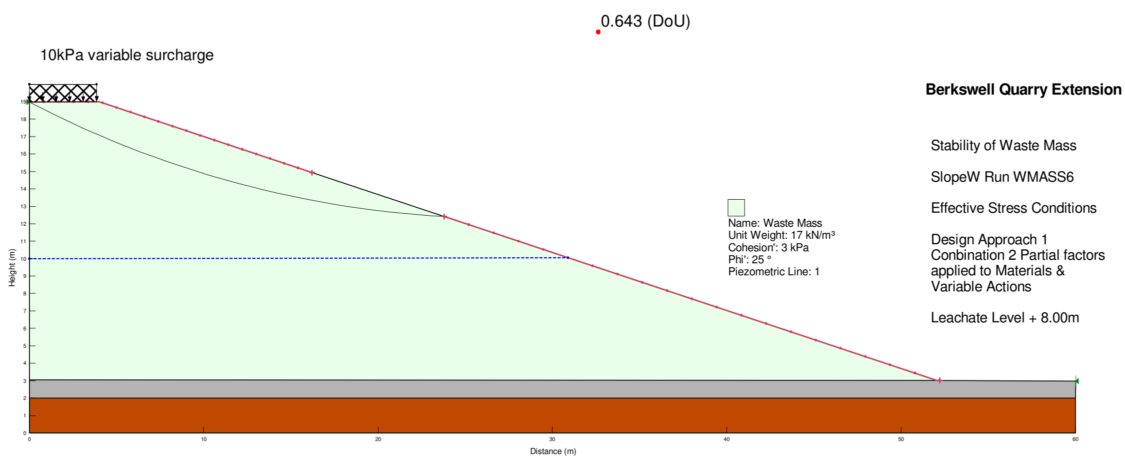

0.200 (DoU)
10kPa variable surcharge
Berkswell Quarry Extension
Stability of Waste Mass
SlopeW Run WMASS1
Total Stress Conditions
Design Approach 1
Conbination 1 Partial factors
applied to Actions
Waste Mass Dry
Name: Waste Mass
Unit Weight: 17 kN/m³
Cohesion': 50 kPa
Phi': 0 °
Height (m)
Distance (m)

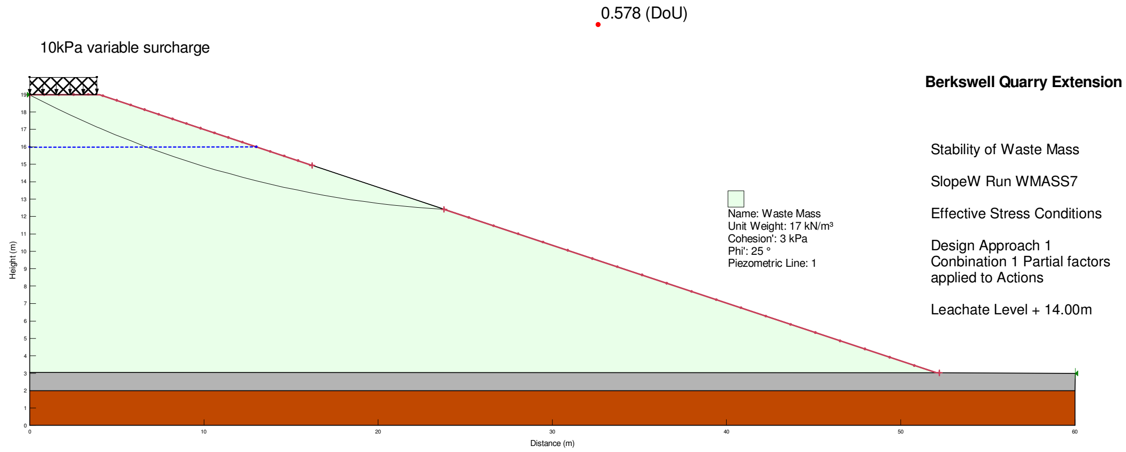

0.188 (DoU)
10kPa variable surcharge
Berkswell Quarry Extension
Stability of Waste Mass
SlopeW Run WMASS2
Total Stress Conditions
Design Approach 1
Conbination 2 Partial factors
applied to Materials &
Varaible Actions
Waste Mass Dry
Name: Waste Mass
Unit Weight: 17 kN/m³
Cohesion': 50 kPa
Phi': 0 °
Height (m)
Distance (m)

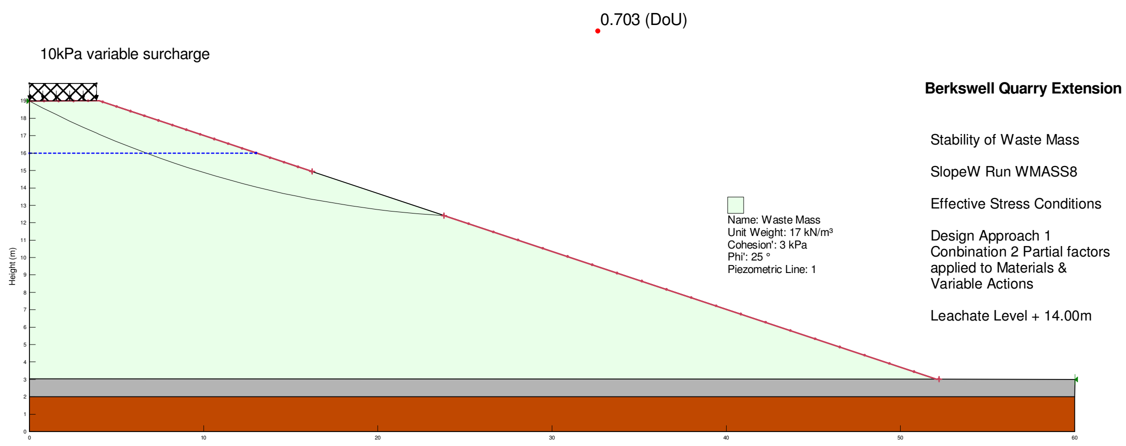

0.539 (DoU)
10kPa variable surcharge
Berkswell Quarry Extension
Stability of Waste Mass
SlopeW Run WMASS3
Effective Stress Conditions
Design Approach 1
Conbination 1 Partial factors
applied to Actions
Leachate Level + 3.00m
Name: Waste Mass
Unit Weight: 17 kN/m³
Cohesion': 3 kPa
Phi': 25 °
Piezometric Line: 1
Height (m)
Distance (m)

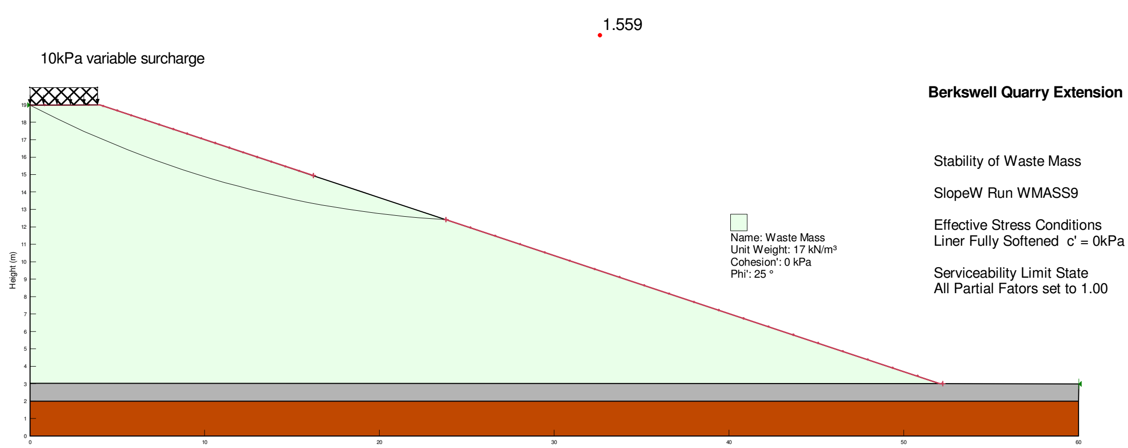

0.643 (DoU)
10kPa variable surcharge
Berkswell Quarry Extension
Stability of Waste Mass
SlopeW Run WMASS4
Effective Stress Conditions
Design Approach 1
Conbination 2 Partial factors
applied to Material &
Variable Actions
Leachate Level + 3.00m
Name: Waste Mass
Unit Weight: 17 kN/m³
Cohesion': 3 kPa
Phi': 25 °
Piezometric Line: 1
Height (m)
Distance (m)


0.539 (DoU)
10kPa variable surcharge
Berkswell Quarry Extension
Stability of Waste Mass
SlopeW Run WMASS5
Effective Stress Conditions
Design Approach 1
Conbination 1 Partial factors
applied to Actions
Leachate Level + 8.00m
Name: Waste Mass
Unit Weight: 17 kN/m³
Cohesion': 3 kPa
Phi': 25 °
Piezometric Line: 1
Height (m)
Distance (m)


0.643 (DoU)
10kPa variable surcharge
Berkswell Quarry Extension
Stability of Waste Mass
SlopeW Run WMASS6
Effective Stress Conditions
Design Approach 1
Conbination 2 Partial factors
applied to Materials &
Variable Actions
Leachate Level + 8.00m
Name: Waste Mass
Unit Weight: 17 kN/m³
Cohesion': 3 kPa
Phi': 25 °
Piezometric Line: 1
Height (m)
Distance (m)


0.578 (DoU)
10kPa variable surcharge
Berkswell Quarry Extension
Stability of Waste Mass
SlopeW Run WMASS7
Effective Stress Conditions
Design Approach 1
Conbination 1 Partial factors
applied to Actions
Leachate Level + 14.00m
Name: Waste Mass
Unit Weight: 17 kN/m³
Cohesion': 3 kPa
Phi': 25 °
Piezometric Line: 1
Height (m)
Distance (m)


0.703 (DoU)
10kPa variable surcharge
Berkswell Quarry Extension
Stability of Waste Mass
SlopeW Run WMASS8
Effective Stress Conditions
Design Approach 1
Conbination 2 Partial factors
applied to Materials &
Variable Actions
Leachate Level + 14.00m
Name: Waste Mass
Unit Weight: 17 kN/m³
Cohesion': 3 kPa
Phi': 25 °
Piezometric Line: 1
Height (m)
Distance (m)


1.559
10kPa variable surcharge
Berkswell Quarry Extension
Stability of Waste Mass
SlopeW Run WMASS9
Effective Stress Conditions
Liner Fully Softened c' = 0kPa
Serviceability Limit State
All Partial Fators set to 1.00
Name: Waste Mass
Unit Weight: 17 kN/m³
Cohesion': 0 kPa
Phi': 25 °
Height (m)
Distance (m)