TETRA TECH LTD.

BUSTA TRIANGLE QUARRY RESTORATION

ENVIRONMENTAL PERMIT APPLICATION

Stability Risk Assessment Report

GEC JOB NO: GE250240605

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1.0 INTRODUCTION

Report Context

1.1 The operator of the installation is the Collard Group Ltd. (CLG).

1.2 Tetra Tech Ltd. have instructed Geotechnical & Environmental Consulting Ltd. (GEC) to undertake a Stability Risk Assessment (SRA) to form part of an Environmental Permit Application for Busta Triangle Quarry Deposit for Recovery restoration scheme.

1.3 In February 2024, planning permission (Ref: HCC/2024/0088) was submitted for the importation of inert materials in order to restore the quarry to high-quality nature conservation habitat and commercial forestry. The proposed importation and land forming will eliminate and mitigate the existing flood issues through raising of the existing site levels.

1.4 The proposal comprises the restoration of the former quarry site to high quality nature conservation habitat and commercial forestry. It is understood that some previous restoration has been undertaken which has left the site liable to widespread flooding. The imported materials and revised topographical levels will be used to direct the flow of water away from the areas subject to flooding and toward the northwestern corner of the application site where seasonally wet heathland habitat will be established.

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

- Busta Triangle, Eversley Deposit for Recovery – Environmental Setting and Site Design Report. TetraTech Report No. 784-B068370 dated January 2025.
- Busta Triangle Quarry Restoration, Proposed Restoration by Inert Landfilling - Hydrogeological Risk Assessment. TetraTech Report No. 784-B068370 dated December 2024.
- Busta Triangle, Eversley Deposit for Recovery – Waste Recovery Plan. TetraTech Report No. 784-B068370 dated January 2025.
- Busta Triangle, Eversley Deposit for Recovery – Operating Techniques. TetraTech Report No. 784-B068370 dated February 2025.
- Busta Triangle, Eversley Deposit for Recovery - Environmental Permit Boundary. Collard Group Ltd. Drawing No. COL/B068370/PER/01 dated 24/09/2024
- FPCR Environment and Design Ltd. - Restoration Plan Drawing No, 1886-FPCR-XX-XX-DR-L-002 dated 11/08/2023.

1.6 This Report has been completed in conjunction with the Environmental Setting and Site Design Report (ESSD) (January 2025). It is not a standalone document and factual data related to the site, its setting and receiving environment are located in the ESSD and referred to in this document. All drawings referred to in this SRA are to be found in the ESSD unless otherwise stated.

1.7 This document has been prepared in accordance with the Stability Risk Assessment Report Template (Version 1 – March 2010) which addresses the guidance presented at: https://www.gov.uk/guidance/landfill-operators-environmental-permits/how-to-do-a-stability-risk-assessment-landfill-sites-for-inert-waste-or-deposit-for-recovery-activities.

Conceptual Stability Site Model

Location

1.8 This Stability Risk Assessment refers to the area that is included within the Environmental Permit Application boundary shown on Drawing No COL/B068370/PER/01 and covers the area known as Busta Triangle Quarry.

1.9 The application site is located approximately 1.50km west of Yately and 2.25km northeast of Hartfordbridge in the county of Hampshire. The site is centred at the approximate National grid Reference (NGR) 478701 159547 (Figure SRA1).

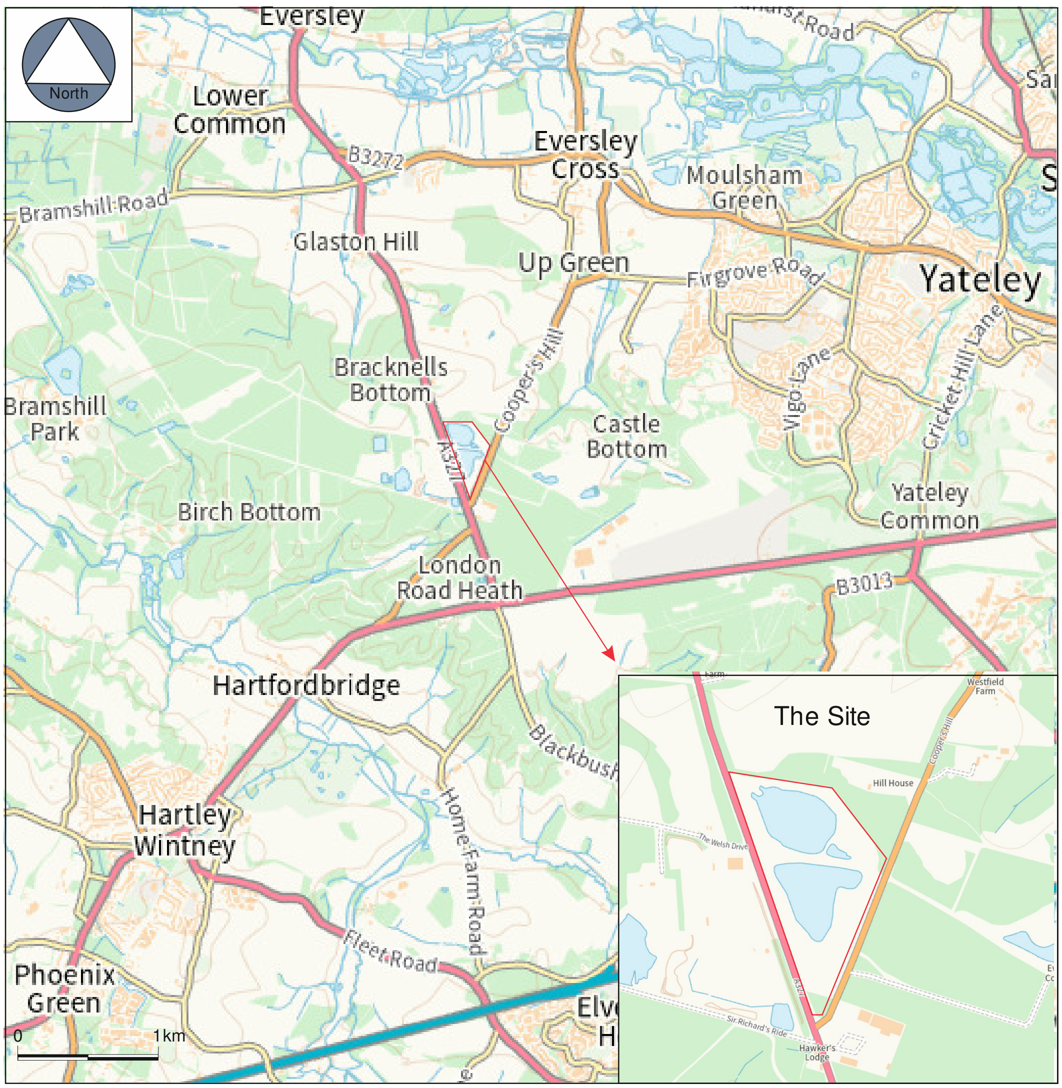


Figure SRA 1 Site location plan

1.10 The site comprises an approximately triangular parcel of land that currently contains two ponds separated by a bridlepath. The application area covers an approximate area of 11.75 hectares.

1.11 The surrounding area comprises: Cemex's Bramshill concrete batching plant and quarry to the west, a thin strip of deciduous woodland with agricultural land to the north and deciduous woodland to the east with a forestry plantation beyond.

1.12 The site gently dips to the north with recorded ground elevations of 93 to 95maOD in the south and 93maOD in the north. The water levels in the two ponds were recorded as 92.8maOD and 93.4maOD in the southern and northern basin respectively. The base level in the two ponds is estimated to be 91maOD.

<u>Regional Geology</u>

Solid Geology

1.13 With reference to British Geological Survey Sheet 284 Basingstoke 1:50000 Sold & Drift, the site is located on the Camberley Sand Formation (CMBS).

1.14 The BGS Lexicon of Named Rock Units describes the CMBS as a fairly uniform sequence of homogeneous, bioturbated, yellow brown, sparsely to moderately glauconitic silty fine-grained sand, or sandy silt, with some ironstone concretions and masses of white sandstone. Sporadic flint gravel or a gravel bed occur near the base.

Superficial Geology

1.15 The geological map records the superficial deposits at the site to comprise River Terrace Deposits (RTD). A generic description provided by the BGS suggests the RTD comprises sand and gravel, locally with lenses of silt, clay or peat.

<u>Structural Geology</u>

1.16 There are no structural features that are likely to affect the stability of the site within 500m.

<u>Local Geology</u>

1.17 Three (3no.) investigative boreholes were undertaken by SLR in 2023 an additional borehole record held by the National Geoscience Database has been used to enhance the coverage. The locations of these exploratory holes are shown on Figure SRA 2 overleaf.

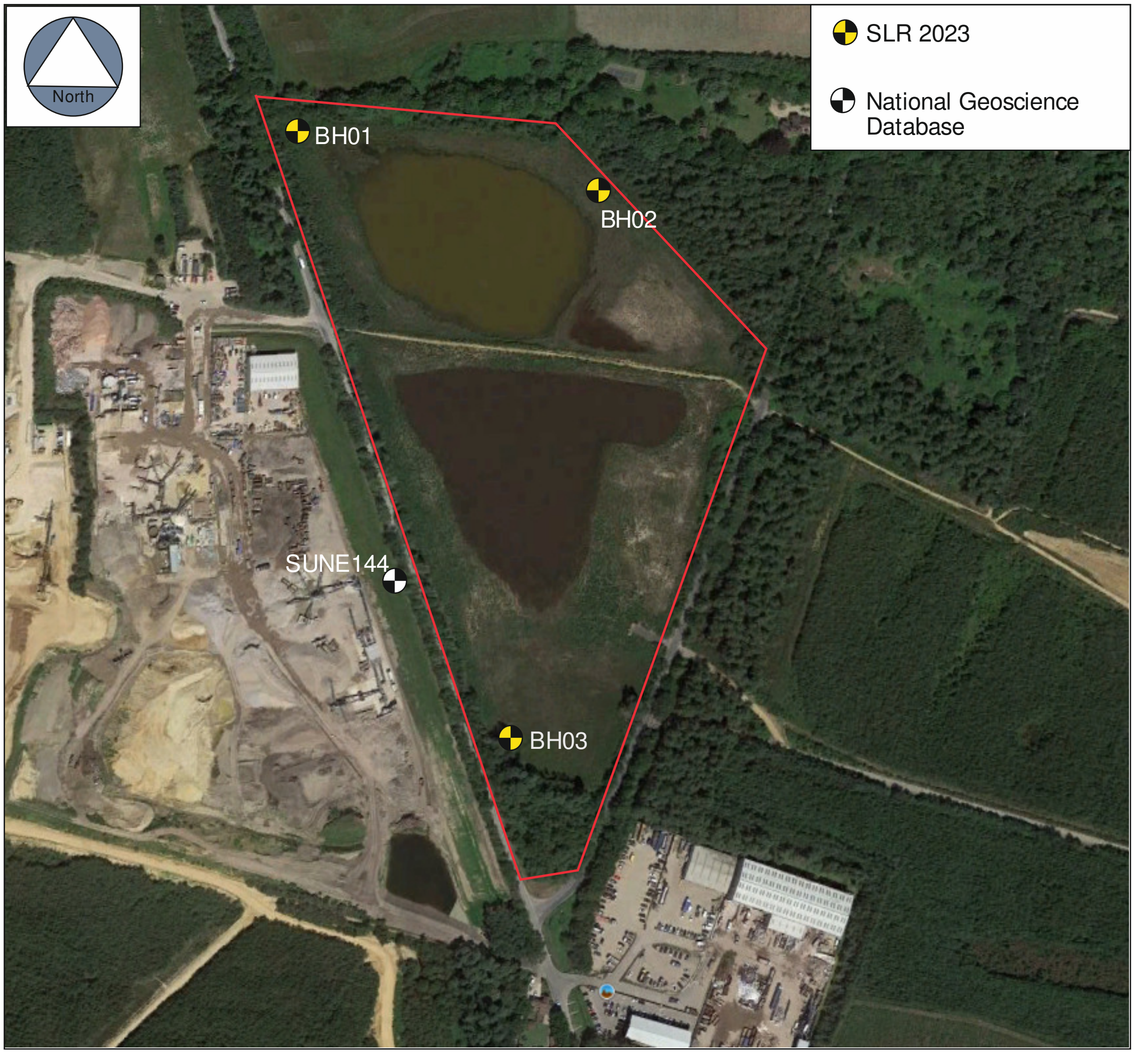


Figure SRA 2 Location of exploratory boreholes

1.18 The stratigraphy encountered in the 4no. boreholes has been interpreted and presented as Table SRA 1 of this Report.

Table SRA 1 – Local stratigraphy of the application area

Location	Topsoil		River Terrace Deposits		Camberly Sand Formation	
	From (mbgl)	Thickness (m)	From (mbgl)	Thickness (m)	From (mbgl)	Thickness (m)
BH01	GL	0.60	0.60	2.80	3.40	>9.10
BH02	GL	0.35	0.35	3.85	4.20	>10.30
BH03	GL	0.20	0.20	5.30	5.50	>9.50
SUNE144	GL	0.60	0.50	4.30	4.90	>0.60

1.19 The interpreted stratigraphy comprises 0.20 to 0.60m of Topsoil over River Terrace Deposits (RTD) comprising sand and gravel in turn overlying the fine to medium sands of the Camberly

Sand Formation (CMBS). The CMBS formed the basal unit of the ground investigation boreholes to a maximum proven depth of 15.00m.

Hydrology

1.20 Excluding the two ponds within the site area. The nearest surface water features comprise flooded quarry workings to the east and west of the site. The closest of these is approximately 110m to the southwest of the site adjacent to "Sir Richards Ride".

1.21 According to the Flood Map for Planning Service (FMPS), the site is not located in a Flood Risk Zone and therefore has a low probability of flooding.

Hydrogeology

1.22 With reference to the Multi Agency Geographic Information for the Countryside's (MAGIC), the aquifer designation for the superficial deposits beneath the site are designated as a Secondary A aquifer. A Secondary A aquifer is defined by the EA as permeable layers that can support local water supplies and may form an important source of base flow to rivers.

1.23 The underlying Camberley Sand Formation is defined as a Secondary A Aquifer for the same reasons as listed above.

1.24 Based on the groundwater strikes recorded during the 2023 SLR ground investigation the shallowest groundwater strike in each of the three boreholes was between 5.3 and 7.2mbgl. The base of the two ponds has previously been estimated at ca 3.00mbgl at 91maOD, which indicates there is no connectivity between the groundwater and the water within the ponds. Therefore, it can be concluded that the ponds are fed via direct precipitation and surface run-off.

Basal Subgrade Model

1.25 After reviewing the historic aerial photography of the site, it is possible to create a timeline from the excavation of mineral and creation of the void to the restoration and first instance of flooding (Figure SRA 3)

2010 prior to the onset of mineral extraction works

2013 Restoration of quarry void underway with stockpiled material present along the western edge of the southern area.

2014 Northern restored area flooded

21017 Southern restored and flooded albeit not to its current extent

Figure SRA 3 Progression of site conditions (after Google Earth)

1.26 Before the onset of quarrying works a spot height recorded on OS maps indicates the ground level to be ca 96mOD. Plate 2 (2013) above shows standing water at the base of the southern workings, given the permeability of the geology (sands and gravels) it is likely that this is the standing groundwater level that was recorded at 5.30 to 6.50mgbl. Assuming extraction works ceased when the groundwater was encountered then the maximum depth of the extraction void would be ca 6mbgl or 89maOD.

1.27 There are many references in various reports to the restoration works not be completed prior to flooding occurring. Therefore, the basal subgrade will comprise restoration materials over in-situ Camberley Sand Formation and the side slope subgrade will consist of the in situ natural stratigraphy. To the south of the ponds the ground level is approximately 94maOD suggesting that approximately 4 to 5m of restoration materials may be present in some areas of the site away from the ponds

Basal and Side Slope Lining System

1.28 Prior to the commencement of landfilling activities, a geological attenuation layer will be constructed in compliance with the 'Landfill Operators: Environmental Permits' guidance (updated 17th February 2022), which specifies a minimum geological barrier of 1m thickness and shall have a hydraulic conductivity less than or equal to $1x10^{-7}$ m/s or its direct equivalent of 0.50m with a hydraulic conductivity of 5×10^{-8} m/s.

Side Slope Subgrade

1.29 The side slope subgrade will comprise the slopes around the perimeter of the site. Based on the stratigraphy identified in the four (4no.) boreholes ground conditions are likely to comprise River Terrace Deposits (RTD) with Camberley Sand Formation (CMBS) potentially daylighting at the base of the side slopes.

1.30 Both the RTD and the CMBS were described as a coarse-grained mixture of sands and gravels. Groundwater strikes were not reported in the upper 5m and therefore will not be present in the side slopes.

1.31 Utilising the Google elevation algorithm, sections have been plotted at four locations around the edge of the site (Figure SRA 4).

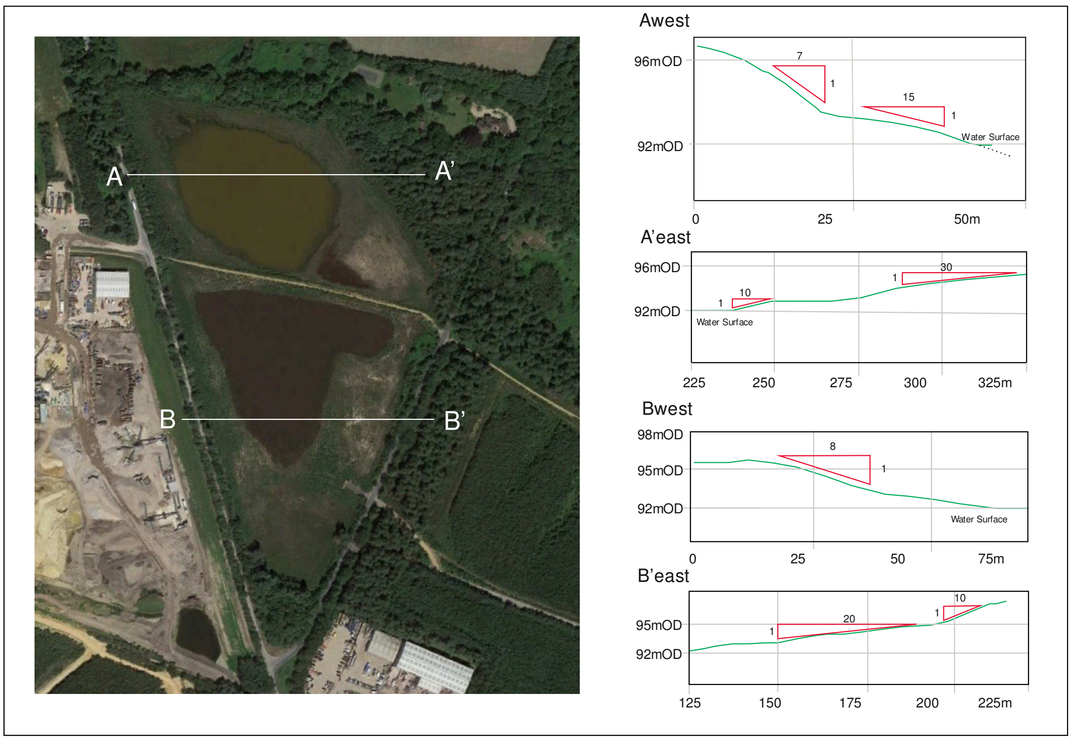


Figure SRA 4 Cross sections through the side slopes

1.32 Close inspection of Figure SRA 4 indicates the steepest side-slopes to be along the western edge of the site where they attain a maximum height of 4.50m (Sect. Awest). The steepest slope section is also located on the western side of the site in Section Awest where a gradient of 1(v) to 7(h) or 8°was identified.

Side Slope Lining Model

1.33 Given the topography of the site the side slope liner will be considered with the basal lining system.

Inert Waste Mass Model

1.34 It is proposed that the Eastern Extension to Carbrooke Quarry will be used for the placement of inert materials only.

1.35 The inert material is liable to comprise locally derived arisings from earthworks; foundation construction works and demolition debris.

1.36 The geology of the local area is variable and comprises both coarse- and fine-grained materials. As most of the inert materials are 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 material 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 SRA 2 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.*

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

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

Capping System Model

1.39 On completion of filling to final levels, the site will be capped with 1.2m of restoration soils comprising not less than 0.30m of topsoil. In accordance with the requirements of the Landfill Directive, an engineered cap (clay or plastic) is not required.

2.0 STABILITY RISK ASSESSMENT

Risk Screening

Basal Subgrade Screening

2.1 The basal subgrade will be formed of the material placed during the previous phase of restoration overlying the Camberley Sand Formation (CMBS). Given the coarse-grained nature of the in-situ CMBS, it has been assumed that all settlement of this stratum is complete. The proposed inert waste placement may instigate further settlement within the CMBS but this will be immediate and largely built out during inert waste placement.

2.2 It has been assumed that the original void attained a maximum depth coincident with the standing groundwater. Therefore, consideration will need to be given to the settlement initiated in the existing restoration fill which is estimated to be 3m thick below the ponds and 4m in other areas of the site. For settlement assessment the thicker sequence of Restoration Fill will be used.

It has been shown that the two surface water ponds on the site are surface fed and are isolated from the standing groundwater. In order to impound the surface water inflows at least the upper ca 3m of the Restoration Fill must be cohesive. For the settlement assessment the worst case of considering the entire thickness of the Restoration Fill as fine-grained will be used.

2.3 The existing ponds will be pumped out prior to the onset of restoration works and the groundwater level will remain below the base of the ponds, such that the site is worked dry throughout all inert waste placement operations.

2.4 A settlement analysis of the existing restoration fill is required.

Basal and side - Slope Lining System Screening

2.5 A basal liner comprising of locally sourced fine-grained material will be placed on the basal subgrade. The basal liner system will comprise either 1.00m of clay with a hydraulic conductivity of 1×10^{-7}m/s or 0.5m of clay with a hydraulic conductivity of 5×10^{-8}m/s.

2.6 Groundwater will remain below the base of the void such that softening of the basal liner or uplift forces on the base of liner will not occur.

2.7 Given the relative shallow gradient (1v : 7h) of the side slopes rotational failure entirely within the side slope liner will not occur. For completeness it will be demonstrated by calculation that the interface between the liner and side slope subgrade will remain stable under a range of water conditions.

Side Slope Subgrade Screening

2.8 The side slope subgrade has been formed by a combination of the original mineral extraction works and the settlement of the earlier phase of restoration. Cross sections through the side slope subgrade show it to attain a maximum height of 4.50m at a maximum gradient of 1(v) to 7(h) or 8°.

2.9 The stratigraphy of the site comprises coarse-grained RTD and CMBS which will have a minimum angle of friction of 30° (BS8004 2015) and therefore will be stable under all foreseeable ground conditions.

2.10 The side slope subgrade can be considered as stable without need for further stability analysis

Waste Mass Screening

2.11 This component is considered to be an issue that will require a detailed geotechnical analysis in order to assess the stability of the waste mass.

Capping / Restoration Soils System Screening

2.12 Based on the finished proposed finished contours, the steepest area of the ground surface will drop a maximum of 1.00m over a distance of 100m creating a maximum gradient of 1(v):100(h). Gradients of this magnitude will remain stable under all foreseeable ground conditions. Therefore, no stability analysis of the restoration soils is considered necessary.

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 Busta Triangle . The method of analysis used in each particular 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 factor of safety against instability for both total stress and effective stress conditions.

2.16 Settlement of the basal subgrade, liner and inert waste instigated by the application of the additional loads placed on the existing ground surface has been determined using a simple finite element analyses.

Justification of Geotechnical Parameters Selected for Analyses

Parameters selected for the Basal subgrade analysis

2.17 The basal subgrade will comprise the previously placed Restoration Fill over units of the Camberley Sand Formation. Typical characteristic geotechnical parameters for these materials are presented in Table SRA 3.

Table SRA 3 Basal subgrade settlement – 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′ (°)
Restoration Fill *	17	50	0	0	23
Camberley Sand Formation	18	Granular		0	30

*worst case saturated fine-grained material

Parameters Selected for Side Slope Subgrade Analyses

2.18 Not required as further stability analysis of the side slope subgrade not required.

Parameters Selected for Side Slope & Basal Liner Analyses

2.19 The side slope and basal 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 SRA 4 Side slope and basal 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′ (°)
Basal / Side Liner	19	50	0	2	23
Side Slope Subgrade	18	Granular		0	30

Parameters Selected for Waste Analyses

2.20 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 SRA 5 Inert waste mass stability - summary of characteristic geotechnical data

Material	Unit Weight	Total Stress		Effective Stress	
	γ_k (kN/m^3)	c_u (kN/m^2)	ϕ_{uk} (°)	c'_k (kN/m^2)	ϕ'_k (°)
Waste Mass	16	50	0	5	25

Selection of Appropriate Factors of Safety

2.21 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 factor of safety of 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 ($tan\phi$)		$\gamma_{\phi'}$	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 ($tan\phi$)		$\gamma_{\phi'}$	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

2.22 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.

2.23 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

Basal Subgrade Analysis

2.24 The settlement of the basal subgrade initiated as a result of the placement of the Inert Waste has been calculated using the Rocscience Settle 3D software programme. For the settlement analysis it is assumed that the settlement is limited to the Restoration Fill.

2.25 The elastic constants used in the settlement analysis are presented in Table SRA 7.

Table SRA 7 Elastic constants and ground model used in the settlement analysis.

Material	Thickness(m)	Unit Weight γ_k (kN/m³)	Total Stress E_u (MN/m²)	Effective Stress E' (MN/m²)	Coefficient of Volume Compression (mvk)
Inert Waste	3.50m	16	25	18	0.25m²/MN
Restoration Fill	4.0m	17	30	23	0.15m²/MN

2.26 The settlement analysis has been carried out in 2 stages: in the first a 55kN/m² surcharge has been applied to the top of the Restoration Fill to represent the 3.5m of Inert Waste; whilst in Stage 2 a 5kN/m² surcharge has been applied to the top of the inert waste to represent post placement loading of the Inert Waste.

2.27 The results of the basal subgrade settlement analyses are shown in Table SRA 8 and the Settle 3D worksheets presented in Appendix 1.

Table SRA 8 Basal subgrade settlement – summary of results

Stage	Surcharge	Settlement (mm)		
		Immediate	Consolidation	Total
1	55kN/m²	8	27	35
2	10kN/m²	3	11	14
Total Settlement at ground surface				**50**

Side Slope Liner Analyses

2.28 The side slope liner will be placed on the existing ground surface after pumping out of the two ponds and will continue up the side slopes to the full height of the proposed inert waste placement. The maximum gradient of the existing side slope subgrade is 1(v) : 7(h). A finite slope model has been used to determine the factor of safety against sliding along the interface between the side slope liner and subgrade.

2.29 The results of the side slope liner stability analyses are shown in Table SRA 9 and the finite slope model calculations are presented in Appendix 2.

Table SRA 9 Side slope liner stability – summary of results

Run	File Name	Liner Thickness (m)	Parallel Submergence Ratio	Factor of Safety	Notes
Side Slope Gradient 8 ° - Sliding along interface between Side Liner and Subgrade					
01	SLINER 1	1	0	4.7	Dry
			0.25	4.2	Unsaturated
			0.50	3.9	Saturated
02	SLINER2	0.5	0	5.2	Dry
			0.25	4.7	Unsaturated
			0.50	4.3	Saturated

Waste Mass Analyses

2.30 The land raise may be up to 3.50m, although it is unlikely that a 3.50m high inert waste face would be created given the phasing and placement of the inert waste in layers. However, for risk assessment purposes a 3.5m high slope will be considered and the waste during placement operations will be 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 can be summarised as follows:

Table SRA9 - Waste Mass Stability – Summary of Results

Run	File Name	Waste Strength	Leachate Level	Degree of Utilisation		Notes
				C1	C2	
1	WMass1	Total	Dry	0.16		Short term waste mass parameters
2	WMass2				0.15	
3	WMass3	Effective	1.00m	0.45		Increasing leachate level measured from base of waste mass
4	WMass4				0.49	
5	WMass5		3.00m	0.58		
6	WMass6				0.68	
7	WMass7		Not Present		0.66	Cohesion = 0kN/m^2

Assessment

Basal Subgrade

2.37 The settlement analysis of the basal subgrade indicates that 50mm of settlement should be expected at the ground surface. As the settlement will commence as soon as the inert waste placement commences much of the forecast settlement will complete at the time when the placemen is complete.

2.38 Based on this estimate of settlement the basal subgrade will not be adversely affected and will remain serviceable during placement without any significant re-engineering.

Basal Liner

2.39 A basal liner comprising of locally sourced fine-grained material will be placed on the basal strata. The basal liner system will comprise either 1.00m of clay with a hydraulic conductivity of 1.0 x 10^{-7}m/s or 0.5m of clay with a hydraulic conductivity of 5 x 10^{-8}m/s.

2.40 Groundwater will remain below the base of the liner and no uplift force will be generated.

2.41 With regards the predicted 35mm of settlement of the basal subgrade, provided the basal liner maintains a water content within its plastic range and is not allowed to dry out the amount of predicted deflection will be easily accommodated without cracking of the basal liner. Therefore the basal liner will remain serviceable in the form set out in herein.

Side Slope Subgrade

2.42 The side slopes gradients of the site area are very shallow with a maximum gradient of 1(v) : 7 (h) being recorded along the western site boundary. Ground investigation boreholes undertaken on the site indicate ground conditions to comprise sands and gravels. A minimum angle of friction of 30° is appropriate for coarse-grained materials. Using a simple stability assessment gives a factor of safety of greater than 4.

2.43 Therefore, it is considered unnecessary to carry out any detailed stability assessment as the side slopes will remain stable under all foreseeable conditions.

Side Slope Liner

2.44 It has been demonstrated that the side slope liner will be stable and will not slide along the interface with the underlying side slope subgrade. Both a 1.00m and a 0.50 m thick liner have been assessed and even when fully saturated return factors of safety of 3.9 and 4.3.

2.45 The results of the side slope liner analyses indicate that the side slope liner will remain stable under all foreseeable conditions in the form presented in this SRA.

Waste Mass

2.46 The stability of the temporary waste face was analysed using the computer programme SLOPE/W to calculate the factor of safety against failure through the waste body for a range of circular failure surfaces using Morgenstern and Price's method.

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

2.48 The waste slope has a degree of utilisation < 1 for all leachate levels up to 3.50m from the base of the waste body. As the thickness of the unbuttressed inert waste is 4.00m a leachate level of 3.50m is extremely unlikely to occur under normal operating conditions.

2.49 The waste slope has a degree of utilisation of 0.66 even if the value of the cohesion intercept of the waste reduces from $5kN/m^2$ to $0kN/m^2$

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

Capping System

2.51 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 lining system at the earliest possible juncture.

Basal Subgrade Monitoring

3.2 It is recommended that monitoring of the basal subgrade is carried out prior to the placement of the basal liner to identify any soft spots. If soft spots are identified appropriate treatments may include excavation and replacement with granular material and proof-rolling.

Basal Liner Monitoring

3.3 The basal liner will comprise locally derived materials which have undergone appropriate permeability testing to ensure they meet the relevant permeability requirements.

3.4 If the basal liner is left exposed for any length of time a programme of routine monitoring should be undertaken to identify cracking as a result of drying and shrinkage or softening as a result of exposure to wet inclement weather. If either of these features are identified, the affected area should be excavated and replaced prior to the placement of inert waste.

Side Slope Subgrade + Lining Monitoring

3.5 The side slopes should be visually monitored for instability both during the mineral extraction works and waste placement operations. It is highly unlikely that any instances of instability will be identified. However, if necessary appropriate action should be taken which may include, buttressing the toe of the slope using inert waste material or reducing the side slope angle.

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.

Capping System Monitoring

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

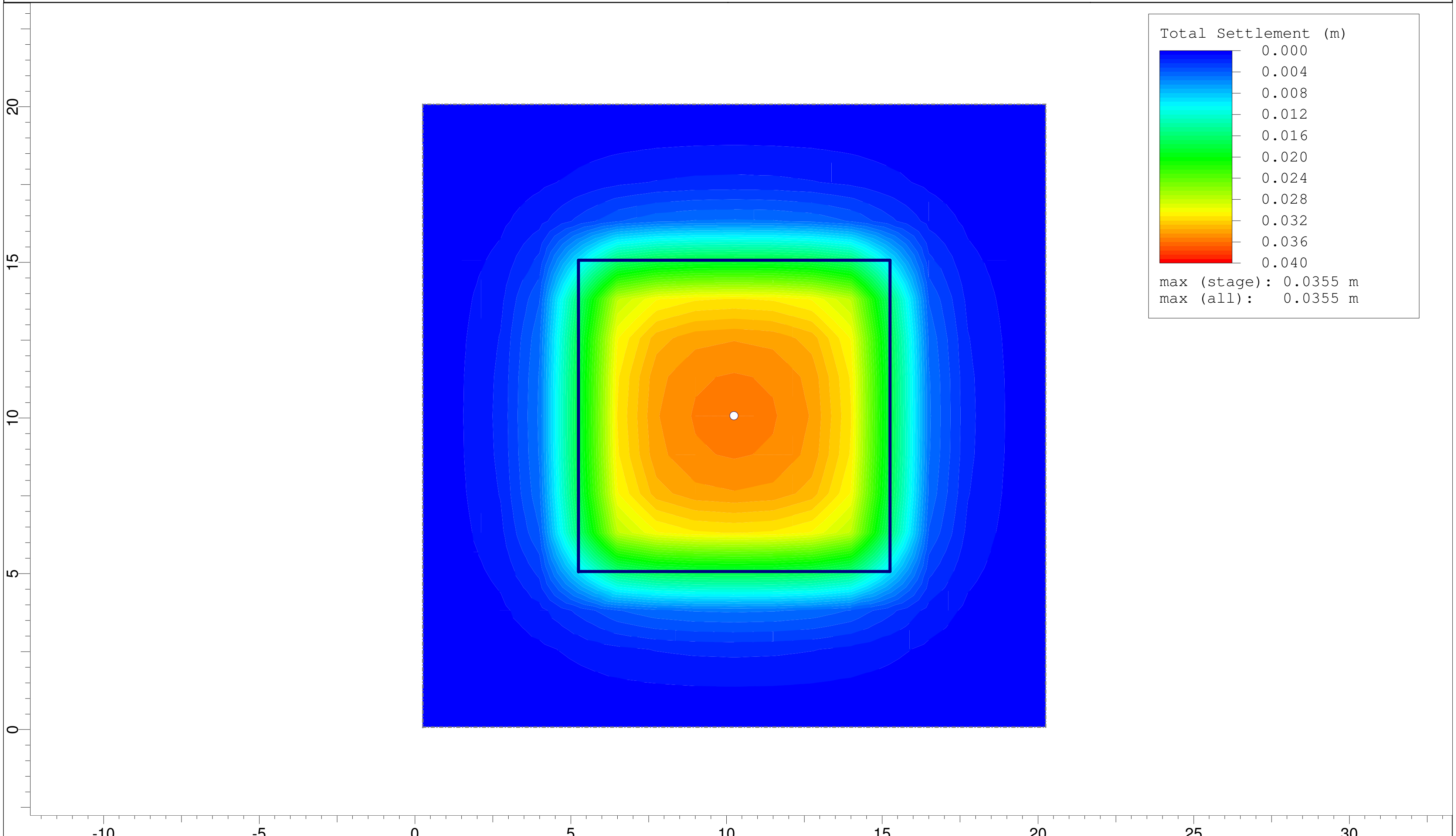
3.8 The surface will be checked for incipient signs of failure that might result from the occurrence of differential settlement within these deposits. These would include cracking, development of depressions or ponding and seepage of water. In the event that any symptom of incipient failure is detected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

Basal Subgrade Settlement

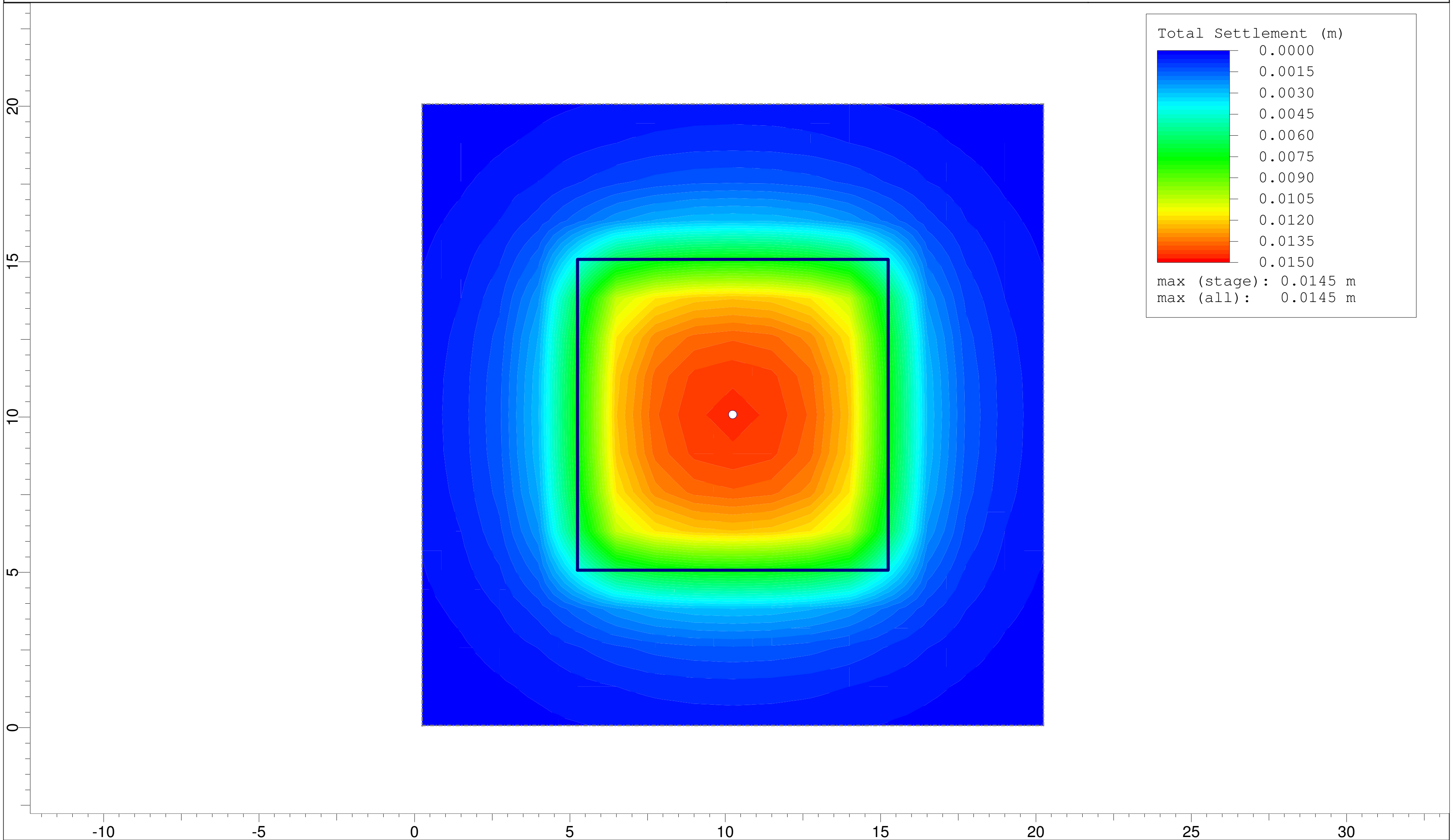
Stage 1 | Data Type: Total Settlement



Project	Butsa Triangle
Analysis Description	Surcharge Applied to Top of Restoration Fill
Drawn By	Dr David Fall
Company	GCC
Date	13/05/2025, 11:16:51
File Name	Project 1

SETTLE3D 2.010

Stage 2 | Data Type: Total Settlement



SETTLE3D 2.010

Project	Butsa Triangle		
Analysis Description	Surcharge Applied to Top of Inert Waste		
Drawn By	Dr David Fall	*Company*	GCC
Date	13/05/2025, 11:16:51	*File Name*	Project 1

Appendix 2

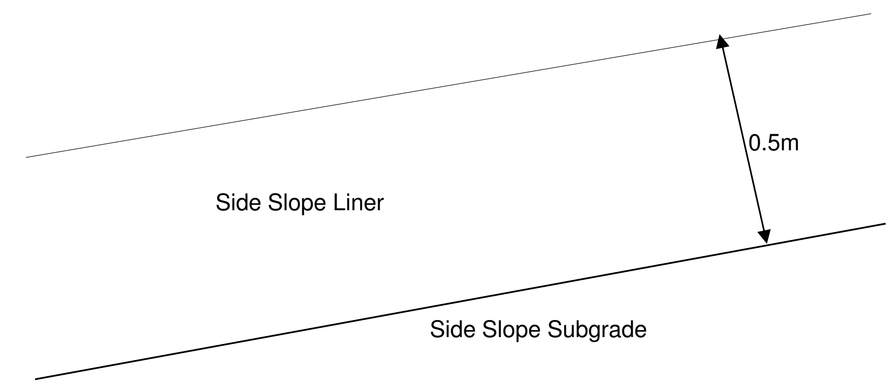
Side Slope Liner Stability

Geotecnical & Environmental Consulting Ltd.				
Calculation Sheet				
Project name	Butsa Triangle	Calc. by	DF	
Design Secton	Side Slope Liner	Date	13/05/2025	

DESCRIPTION **Side Slope Liner Stability** **Section AWest**

Finite Slope Model

GEOMETRY



INPUT PARAMETRS

Side Liner Unit Weight Unit Weight (dry)	γ_{dry}	19	kN/m^3
Side Liner Unit Weight (saturated)	γ_{sat}	21	kN/m^3
Side Liner Internal Shear Strength	ϕ	23	°
Side Liner Soil Cohesion	c	2	kN/m^2
Thickness of Side Liner	h	0.50	m
Height of Slope	H	4.00	m
Slope Angle	β	8	°

Increasing Saturation

Parallel Submergence Ratio	PSR	0	0.25	0.5

Interface Shear Strengths

Side Slope Liner / Side Slope Subgrade	α	2	δ	23
LLDPE Geomembrane / Regulating Layer	α	0	δ	27

Geotecnical & Environmental Consulting Ltd.			
Calculation Sheet			
Project name	Butsa Triangle	Calc. by	DF
Design Secton	Side Slope Liner	Date	13/05/2025

CALCULATED PARAMETERS PSR = 0

Length of Slope	L	28.74	m
Thickness of Water	h_w	0.00	m
Weight of Active Wedge (kN)	W_A	256	kN
Weight of Passive Wedge (kN)	W_p	17	kN
Pore Pressure Perpendicular to Slope	U_n	0	kN
Pore Pressure on Interwedge Surface	U_h	0	kN
Vertical Pore Pressure on Passive Wedge	U_v	0	kN
Force Normal to Active Wedge	N_A	253	kN

FACTOR OF SAFETY

Quadratic Constants	a	35
	b	-180
	c	10

Factor Of Safety 5.2

CALCULATED PARAMETERS PSR = 0.25 Peak Shear Strength

Length of Slope	L	28.74	m
Thickness of Water	h_w	0.13	m
Weight of Active Wedge (kN)	W_A	263	kN
Weight of Passive Wedge (kN)	W_p	17	kN
Pore Pressure Perpendicular to Slope	U_n	35	kN
Pore Pressure on Interwedge Surface	U_h	0.08	kN
Vertical Pore Pressure on Passive Wedge	U_v	0.56	kN
Force Normal to Active Wedge	N_A	225	kN

FACTOR OF SAFETY

Quadratic Constants	a	36
	b	-168
	c	9

Factor Of Safety 4.7

Geotecnical & Environmental Consulting Ltd.			
Calculation Sheet			
Project name	Butsa Triangle	Calc. by	DF
Design Secton	Side Slope Liner	Date	13/05/2025

CALCULATED PARAMETERS PSR = 0.5 Peak Shear Strength

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Length of Slope	L	28.74	m
Thickness of Water	h_w	0.25	m
Weight of Active Wedge (kN)	W_A	270	kN
Weight of Passive Wedge (kN)	W_p	18	kN
Pore Pressure Perpendicular to Slope	U_n	69	kN
Pore Pressure on Interwedge Surface	U_h	0.3125	kN
Vertical Pore Pressure on Passive Wedge	U_v	2	kN
Force Normal to Active Wedge	N_A	198	kN

FACTOR OF SAFETY

Quadratic Constants	a	37
	b	-156
	c	8

Factor Of Safety 4.3

Results

	Factor of Safety against Restoration Soil Sliding
Dry	5.2
PSR=0.25	4.7
PSR=0.50	4.3

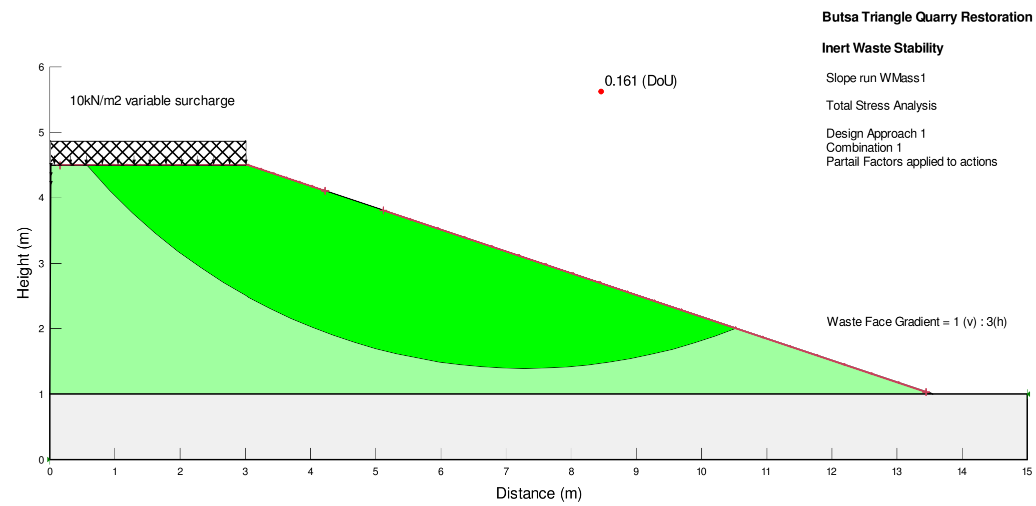
Note - The PSR is the parallel submergance ratio and is 0.5 when the soil layer is full of water

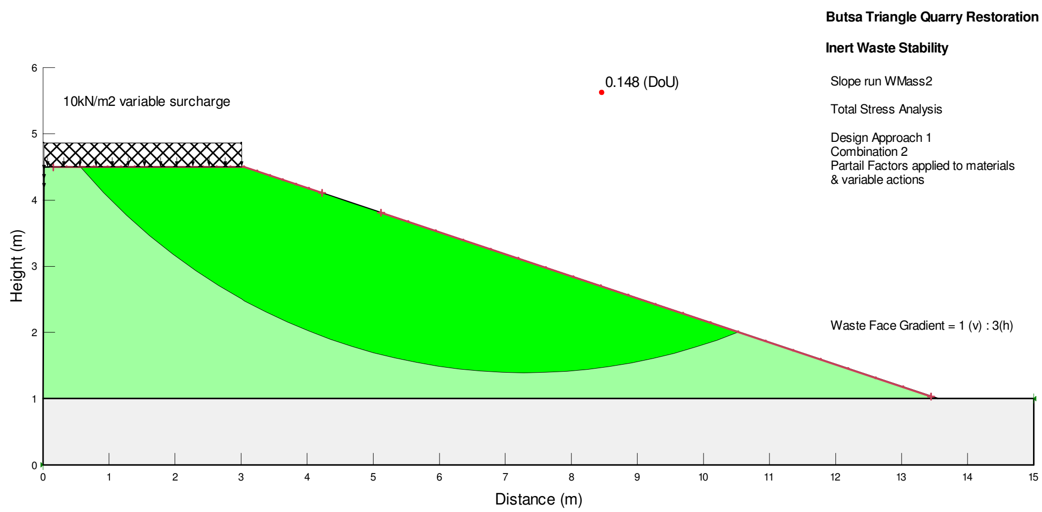
Conclusions

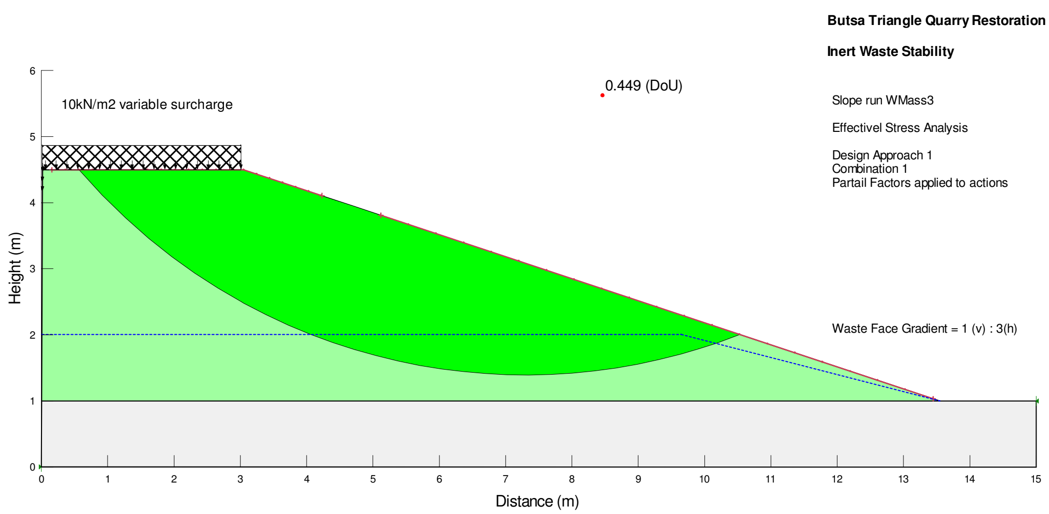
Since all factors of safety are >1.5, it is considered that the stability of the side liner is satifactory

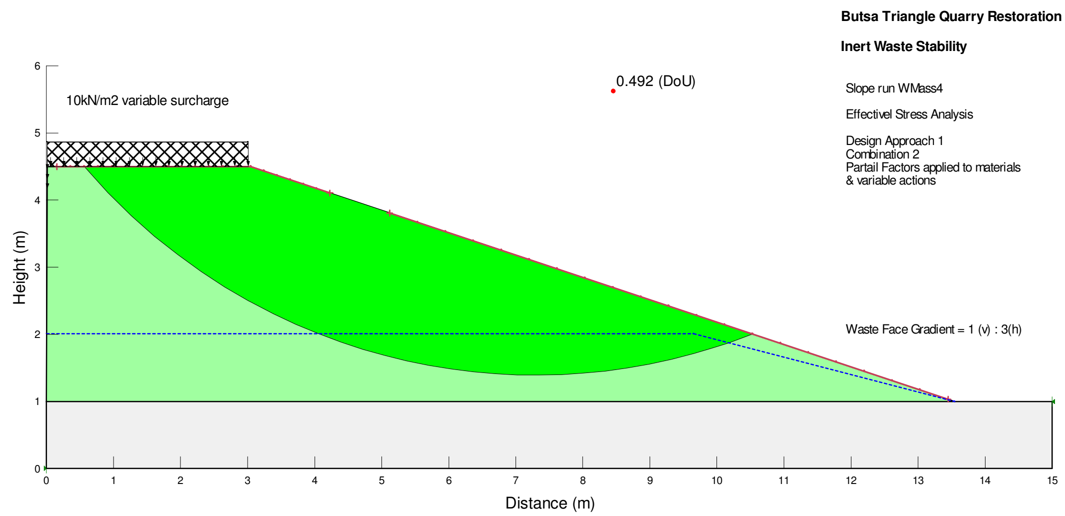
Appendix 3

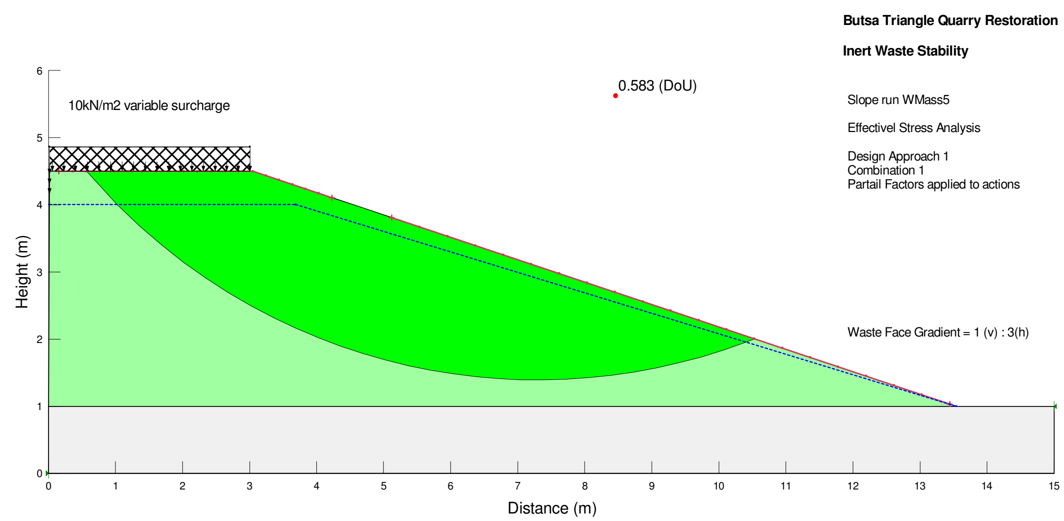
SlopeW Worksheets – Inert Waste Mass

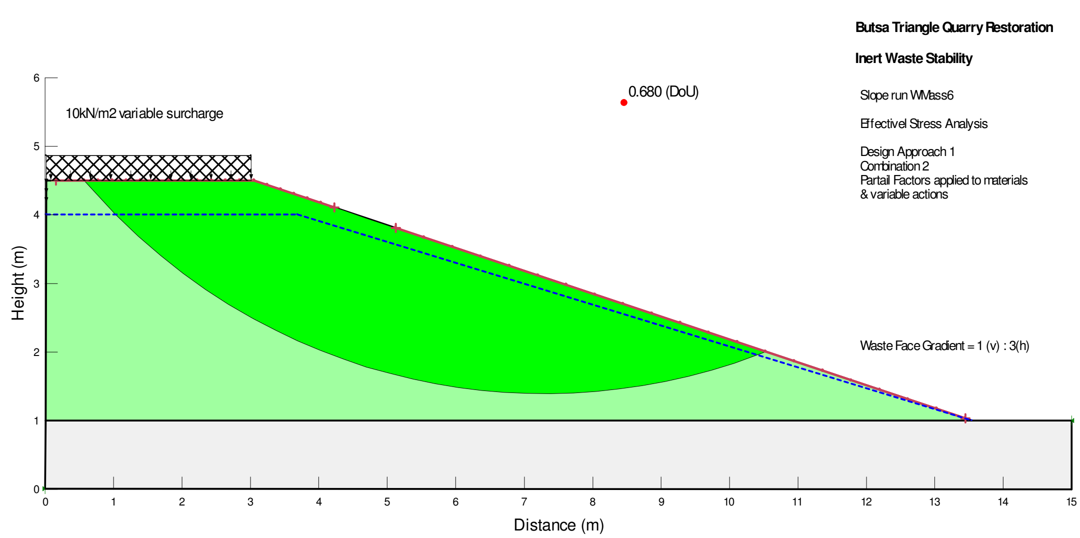

Butsa Triangle Quarry Restoration
Inert Waste Stability
Slope run WMass1
Total Stress Analysis
Design Approach 1
Combination 1
Partail Factors applied to actions
0.161 (DoU)
10kN/m2 variable surcharge
Waste Face Gradient = 1 (v) : 3(h)
Height (m)
Distance (m)

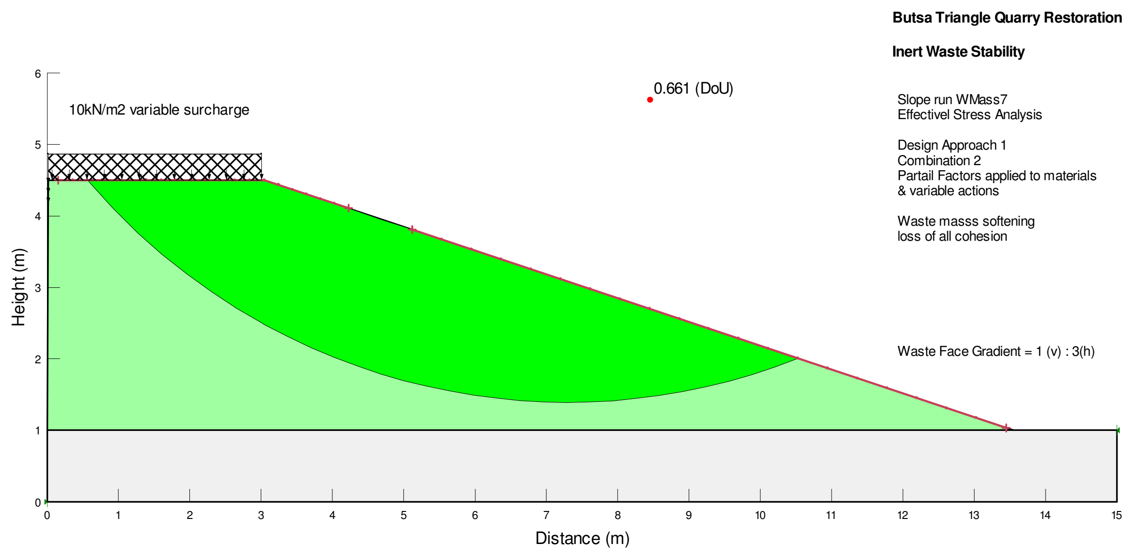

Butsa Triangle Quarry Restoration
Inert Waste Stability
Slope run WMass2
Total Stress Analysis
Design Approach 1
Combination 2
Partail Factors applied to materials
& variable actions
0.148 (DoU)
10kN/m2 variable surcharge
Waste Face Gradient = 1 (v) : 3(h)
Height (m)
Distance (m)


Butsa Triangle Quarry Restoration
Inert Waste Stability
Slope run WMass3
Effectivel Stress Analysis
Design Approach 1
Combination 1
Partail Factors applied to actions
0.449 (DoU)
10kN/m2 variable surcharge
Waste Face Gradient = 1 (v) : 3(h)
Height (m)
Distance (m)


Butsa Triangle Quarry Restoration
Inert Waste Stability
0.492 (DoU)
10kN/m2 variable surcharge
Slope run WMass4
Effectivel Stress Analysis
Design Approach 1
Combination 2
Partail Factors applied to materials
& variable actions
Waste Face Gradient = 1 (v) : 3(h)
Height (m)
Distance (m)


Butsa Triangle Quarry Restoration
Inert Waste Stability
0.583 (DoU)
10kN/m2 variable surcharge
Slope run WMass5
Effectivel Stress Analysis
Design Approach 1
Combination 1
Partail Factors applied to actions
Waste Face Gradient = 1 (v) : 3(h)
Height (m)
Distance (m)


Butsa Triangle Quarry Restoration
Inert Waste Stability
0.680 (DoU)
10kN/m2 variable surcharge
Slope run WMass6
Effectivel Stress Analysis
Design Approach 1
Combination 2
Partail Factors applied to materials
& variable actions
Waste Face Gradient = 1 (v) : 3(h)
Height (m)
Distance (m)


Butsa Triangle Quarry Restoration
Inert Waste Stability
Slope run WMass7
Effectivel Stress Analysis
Design Approach 1
Combination 2
Partail Factors applied to materials
& variable actions
Waste masss softening
loss of all cohesion
Waste Face Gradient = 1 (v) : 3(h)
0.661 (DoU)
10kN/m2 variable surcharge
Height (m)
Distance (m)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15