GEOTECHNICAL
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HILLS QUARRY PRODUCTS LTD.

AIRFIELD QUARRY

APPLICATION FOR WASTE RECOVERY PERMIT

Stability Risk Assessment Report

GEC JOB NO: GE240633010

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1.0 INTRODUCTION

Report Context

1.1 The operator of the installation is Hills Quarry Products Ltd. (HQP).

1.2 Land and Mineral Management have instructed Geotechnical & Environmental Consulting Ltd. (GEC) to undertake a Stability Risk Assessment (SRA) in support of an application for a Waste Recovery Permit in respect to the permanent placement of inert waste at Airfield Quarry, Gally Leaze, Gloucestershire.

1.3 This waste recovery permit application is for the permanent deposit of inert waste to land to facilitate the infilling and restoration of the quarry void that is to be created following mineral extraction activities.

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

- Airfield Quarry, Gally Leaze, Gloucester. Application for Waste Recovery Permit. Environmental Setting and Site Design Report. BCL Report No. B/LMM/AQ_ESSD/22 dated Oct 2022 Ver. 01 (Final).

- Airfield Quarry, Gally Leaze, Gloucester. Proposed sand and gravel extraction and restoration. Hydrogeological Risk Assessment Final Report. BCL Report No. B/HQP/AFLD_HRA/22 dated Apr 2022 Ver. 01 (Final).

1.5 This Report has been completed in conjunction with the Environmental Setting and Site Design Report. 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.

1.6 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

<u>Location</u>

1.7 The application area is located approximately 3km northeast of Cricklade at a former airfield site. The centre of the site is located at NGR 411255 196382 (Figure SRA1).

1.8 This Stability Risk Assessment refers to the area shown in the site layout and phasing plan which is presented in Figure SRA2.

Figure SRA1 Site location plan

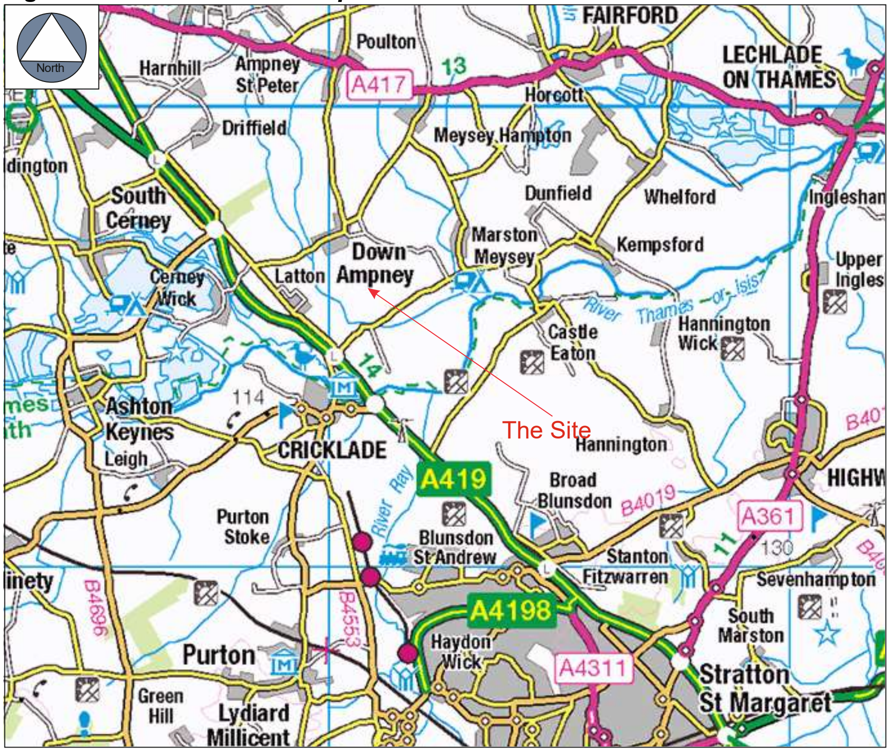
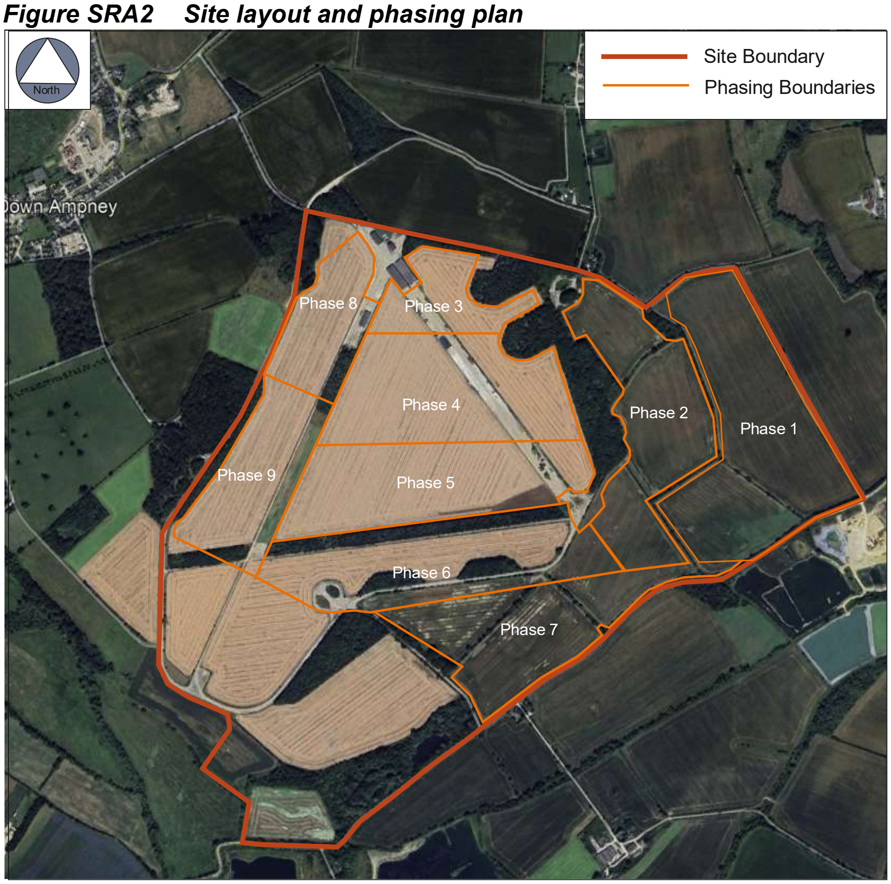


Figure SRA2 Site layout and phasing plan



1.9 The site comprises a former military airfield which maintains some of its former infrastructure including some of the former airfield concrete runways and perimeter tracks.

1.10 The runways form a triangular layout towards the centre of the site with the immediate surroundings within the application site comprising arable farmland with isolated areas of woodland. Outside the site boundary the land is rural, comprising arable and grazing land with isolated areas of woodland and restored mineral extraction works.

1.11 Access to the site is to be via a new entrance along the southern boundary form the adjacent Cricklade – Kempsford Road.

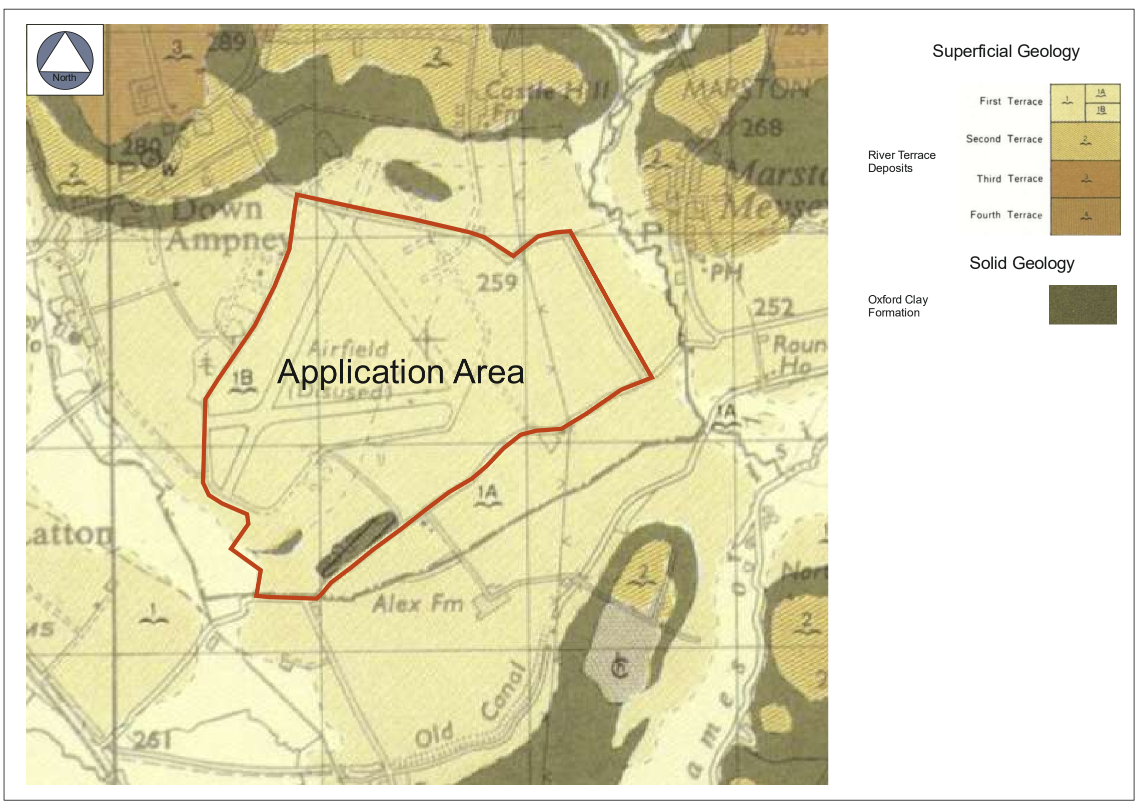
1.12 This application relates to the restoration of a quarry void which will be formed by the phased extraction of sands and gravels. The wider site covers an area of 236ha of which 178ha will be subject to mineral extraction works.

Regional Geology

Solid Geology

1.13 With reference to British Geological Survey Sheet 252 Swindon 1:50,000 Solid and Drift (1997), the site is located in an area underlain by solid geology of Upper Jurassic Oxford Clay Formation.

Figure SRA3 Geology of the site area – after NERC 1997



1.14 The BGS Lexicon of Named Rock Units describes the Upper Jurassic Oxford Clay Formation (OXC) as being grey silicate-mudstone generally smooth to slightly silty with sporadic beds of argillaceous limestone nodules.

Superficial Geology

1.15 The BGS mapping shows superficial deposits comprising River Terrace Deposits to be present across the entire Application Area. The Lexicon of Named Rock Units gives a generic description of the RTD as sand and gravel, locally with lenses of silt, clay or peat.

Structural Geology

1.16 There are no structural features shown within the area of the site. BGS Sheet 295 indicates the strata in the area of the site to be flat lying.

Local Geology

1.17 An extensive drilling program has been undertaken at the site to determine the nature and thickness of the extractable sand and gravel deposits (RTD). The drilling data shows the thickness of sand and gravel to vary within the Application Area, with the thickest sequence of sand and gravel in the northwest of the site where it attains 5m. The RTD generally thins to the south and within the eastern section of the site, with areas of less than 0.50m thickness.

1.18 The drilling logs identified a systematic stratigraphy below the site comprising 0.20 - 0.30m of Topsoil and 0.10 -1.20m of fine – grained RTD collectively termed Overburden, overlying the sand and gravel deposit.

1.19 The Oxford Clay Formation (OXC) comprising a sequence of compacted clays and shales formed the basal stratum across the site. The OXC reduces in thickness to the northeast, eventually pinching out against the underlying Kellaway Clay Member some 1.5km from the site boundary.

1.20 Deeper drilling, reported in the HRA, indicates a minimum thickness for the OXC beneath the site of 11m in the west increasing to 30m in the east.

Hydrology

1.21 Two named watercourses, Ampney Brook and Marston Meysey Brook, drain the area to the west, east and south of the Site.

Table SRA1 Surface watercourses within 1km of the site

Name	Direction from Site	Closest Distance	Observations
Ampney Brook	Southwest	170m	Can cease to flow under extreme conditions last recorded cessation (2011).
Marston Meysey Brook	Northeast	300m	Can cease to flow under extreme conditions last recorded cessation (2018).

1.22 In addition to the two named watercourses the site is currently drained by a series of managed ditches especially in the lower lying areas in the southern and eastern areas of the site.

1.23 A total of eight water features were identified in the scheme specific HRA within 1km of the site. The majority were recorded as either being dry at the time of survey, waterbodies relating to the ongoing extraction operations in the locality or manmade lined tanks.

1.24 Two natural ponds were identified as present within the search radius, a large garden pond at a property south of Marston Meysey and the series of ponds at Ampney Pits LWS, located within the southern section of the Site.

Hydrogeology

1.25 According to the Multi-Agency Geographic Information for the Countryside's (MAGIC) website, the superficial sand and gravel deposits (underlying and encompassing the Site) are designated as a 'Secondary A Aquifer' (formerly referred to as 'minor aquifers'). These are defined as permeable layers capable of supporting local abstraction and in some cases providing a component of baseflow to local watercourses.

The underlying solid geology of the Oxford Clay Formation is regarded as non-aquifer ("unproductive strata" under the EA classification scheme), possessing low permeability and negligible potential for water supply or river base flow.

1.26 The Hydrogeological Risk Assessment indicates that groundwater levels will be between 2.00 and 3mbgl in the area of the application site. The ESSD states that all the sands and gravels of the RTD will be extracted to a maximum depth of 5.00mbgl (73 to 77mOD) which means in order to work in a dry environment dewatering of the void will be required.

Deposition Models

1.27 The inert waste placement will comprise the importation of inert waste for infilling the quarry void that will be created from mineral extraction activities at the site.

1.28 Extraction and progressive restoration of the Airfield Site will commence from in the east, where the thickness of the recoverable mineral is at its thinnest and progress in a south westerly direction in 9 Phases (as shown Figure SRA2). The thickest sequence of sand and gravel (RTD) will be encountered during Phases 8 and 9 in the west of the site where the basal subgrade (OXC) of the void is expected to be at 5.00mbgl.

Basal Subgrade Model

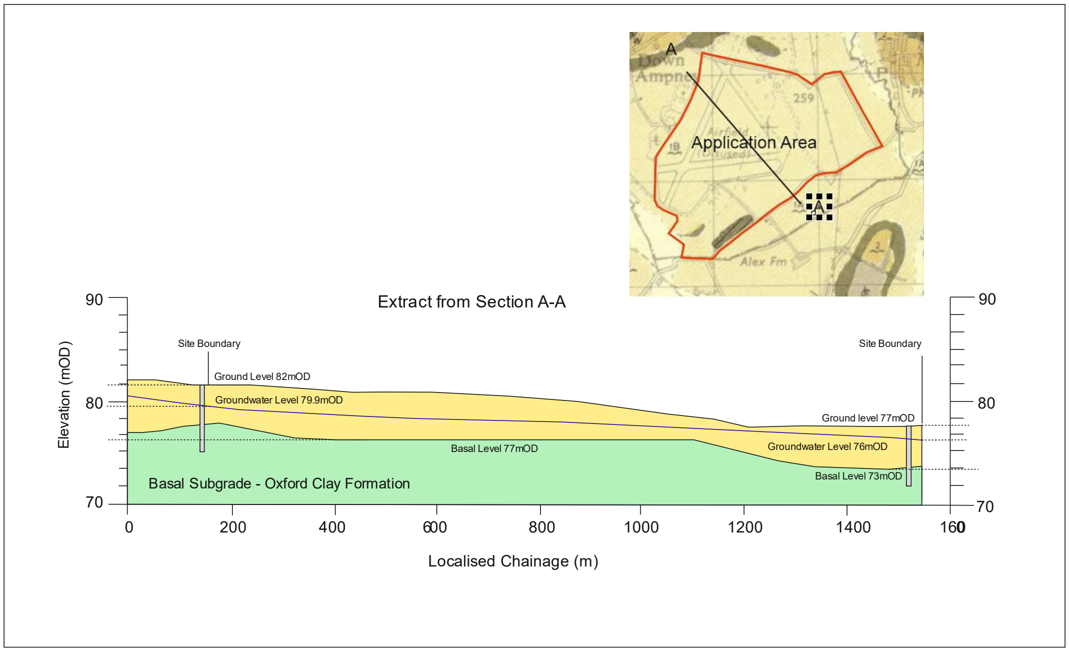
1.29 The void associated with this permit application will be created by the extraction of sands and gravels from the River Terrace Deposits (RTD).

1.30 The basal subgrade will comprise the in-situ clays and silts of the Oxford Clay Formation, which is considered, subject to pre-placement inspection, a competent stratum.

1.31 The ESSD indicates the base of the extraction void will achieve a maximum depth of 5.00mbgl along the western edge of the extraction void.

1.32 Groundwater monitoring reported in the Hydrogeological Risk Assessment indicates that the groundwater will be above the base of the extraction void by up to 3.50m in some areas of the site if all the sand and gravel are to be excavated. To demonstrate this, the central portion of Section A-A (HRA Figure 6) has been reproduced as SRA Figure 4 and shows the groundwater to be 3m above the void base.

Figure SRA 4 Cross-section across site



1.33 Dewatering will be undertaken to ensure that all the extraction works are carried out in a dry environment. The dewatering will be continued until the pressure from the placed inert waste is sufficient to overcome the hydrostatic uplift forces which will manifest themselves on the base of the inert waste after the cessation of dewatering.

Basal Lining System

1.34 A geological barrier (attenuation layer) is a requirement for all landfills according to the Landfill Directive (1999/31/EC) and must provide sufficient attenuation to prevent a risk to soil and groundwater.

1.35 All the sands and gravels of the RTD are to be removed leaving the in-situ OXC to be exposed at the base of the void. The Landfill Directive states that any material used in the construction of a geological barrier will have a hydraulic conductivity of less than 1 x 10^{-7} m/s and a minimum thickness of 1m. The in-situ OXC has been described as a fine-grained series of clays and silts with a minimum thickness of 11.00m and therefore the in-situ basal subgrade will meet this requirement.

Side Slope Subgrade Model

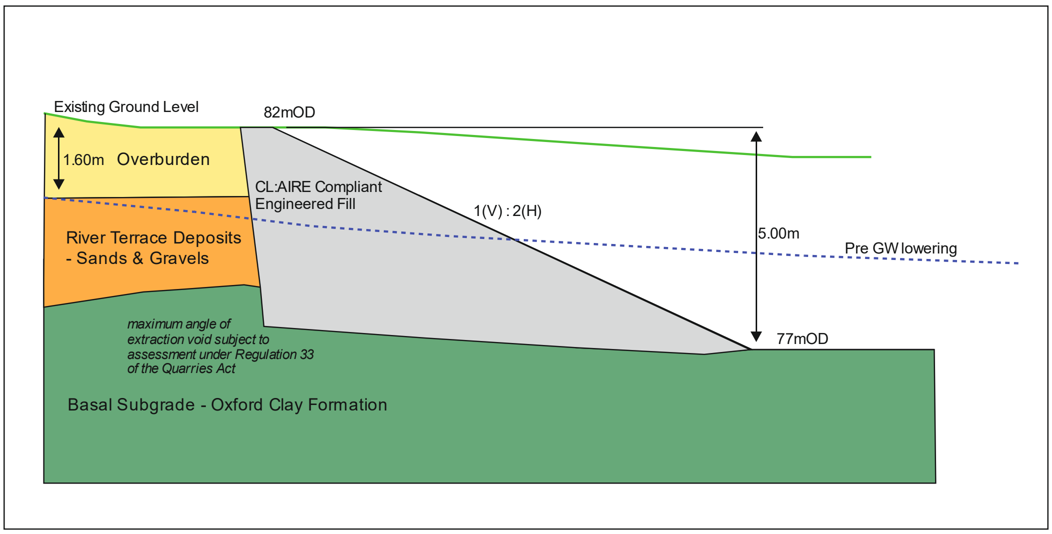
1.36 The side slope subgrade model will comprise the sands and gravels of the RTD. Local boreholes have shown the RTD to comprise an upper layer of up to 1.60m of Topsoil and fine-grained RTD.

1.37 Based on information supplied by the Client the highest side slope will achieve a maximum height 5m and slope batter of 26.5° (1V : 2H) which will be formed by the placement of a CL:AIRE compliant Engineered Fill comprising the rejects from the mineral extraction process.

1.38 Dewatering will maintain groundwater a minimum of 0.50m below the base of the extraction void across the different phases of extraction and inert waste placement and therefore will not act to destabilise the side slope subgrade.

1.39 A geological section, compiled from information supplied in the HRA and ESSD, is presented as Figure SRA5.

Figure SRA5 Section through side slope subgrade



Side Slope Lining Model

1.40 The Environmental Permitting Regulations (England and Wales) 2016 (as amended) specify that an attenuation layer to prevent leachate migration must be present at the base and sides of sites which accept inert materials for deposition. Therefore, a geological barrier (attenuation layer) will be installed on top of the CL:AIRE Engineered Fill across the side slope subgrade of the extraction void.

1.41 The barrier will be constructed using suitable site won OXC which will either be 1m in thickness with a permeability no greater than $1x10^{-7}$m/s or its EA approved equivalent of 0.5m with a permeability of no greater than $1x10^{-8}$m/s. In situ testing and sampling will be undertaken to ensure that the OXC is suitable for this purpose.

1.42 The proposed construction of the clay liner would be to the specification detailed in the Construction Quality Assurance (CQA) Plan that will be submitted to the Agency for approval prior to engineering taking place.

Inert Waste Mass Model

1.43 It is proposed that the Airfield Quarry will be used for the placement of inert materials only.

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

1.45 The geology of the local area is variable and comprises both coarse- and fine-grained materials. 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 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.

1.46 The maximum inert waste slope will be restricted to 1(v):2(h).

1.47 The waste will be compacted in horizontal layers across the base of each of the phases to the approved pre-settlement restoration level.

Capping System Model

1.48 On completion of filling to final levels, the site will be capped with restoration soils and 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 in-situ Oxford Clay Formation. This Stratum is considered to be a competent engineering soil which will not undergo any noticeable settlement during or post placement of the inert waste.

2.2 Provided careful inspection of the basal subgrade is carried, with particular attention to any cracking or soft spots, prior to the placement and compaction of the inert waste, further consideration of this component is not considered necessary.

Basal Lining System Screening

2.3 The function of the basal liner will be fulfilled by the in-situ Oxford Clay Formation which has an estimated minimum thickness of 11m in the area of the site.

2.4 No further analysis of this component is considered necessary.

Side Slope Subgrade Screening

2.5 The side slopes will be formed as part of the extraction process which will be carried out by a competent quarrying contractor. These works will be subject to ongoing inspection (Regulation 33) part of which would be to assess the stability of the side slope subgrade. Therefore, the side slope subgrade will be in a stable configuration prior to the placement of CL:AIRE Compliant Engineered Fill. It is unlikely that these 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 to determine a safe long term angle of the repose of the Engineered Fill .

2.6 Side slope subgrade instability is likely to be limited to the upper overburden layers where the buttressing Engineered Fill is at its thinnest.

Side Slope Lining System Screening

2.7 An artificially established side-slope lining system, comprising either 1.00m of locally sourced fine-grained material with a hydraulic conductivity of less than 10^{-7}m/s or its Environment Agency approved equivalent, is to be placed on the side slopes of the extraction void. Given maximum height of the side slope subgrade, it is probable that the side slope lining system will be placed in one lift.

2.8 Groundwater outflows into the void are not expected as dewatering is to be undertaken to lower it to a minimum of 0.50m below the base of the extraction void.

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

Waste Mass Screening

2.10 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.

2.11 Consideration should be given to the standing groundwater level once the dewatering has stopped to ensure sufficient Inert Waste is in place to overcome any hydrostatic uplift forces.

Capping System Screening

2.12 The land surrounding the proposed infill areas is extremely flat and there is to be no raising of land above surrounding ground levels. It is therefore apparent that placed material and capping soils will be contained by the adjacent land, with no side slopes that could give rise to potential for instability. Therefore, there is no need for a stability assessment of the restoration soils

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 landfill facility at Coombefield North Quarry. 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 Degree of Utilisation against instability for 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 both the fine-grained RTD (Overburden) and the sands and gravels of the coarse-grained RTD.

2.17 Considering the worst case, where 1.60m of overburden is present above the sand and gravel, the following characteristic geotechnical parameters are considered appropriate (Table SRA3).

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

Material	Description	Unit Weight	Total Stress		Effective Stress	
		γ (kN/m^3)	c_u (kN/m^2)	ϕ_u (°)	c' (kN/m^2)	ϕ' (°)
CL:AIRE Engineered Fill	Rejects from the extraction process	18	40	0	5	28
Overburden	Silty sandy CLAY	18	20	0	2	25
RTD	Sand & Gravel	18	Coarse-Grained		0	35

Parameters Selected for Side Slope Liner Analyses

2.18 The side slope liner is to be constructed using locally sourced OXC. Typical values for a fine-grained material 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 Weight	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

Parameters Selected for Waste Analyses

2.19 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	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	17	50	0	5	25

Selection of Appropriate Factors of Safety

2.20 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 Degree of Utilisation must be less than 1.00.

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*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

2.21 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.

2.22 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 and Basal Liner

2.23 No stability analysis of this component is considered necessary

Side Slope Subgrade

2.24 The side slopes of the void will be formed during the mineral extraction phase of the works and will be subject to ongoing stability assessment and inspection. On completion of the extraction works the exposed side slopes will be buttressed with CL:AIRE Engineered Fill to a batter angle of 11(V) : 2(H).

2.25 Groundwater monitoring has shown the maximum height of standing groundwater to be ca3.50m above the base of the void as shown on the cross-section reproduced as (Figure SRA 4).

2.26 Groundwater dewatering will be carried out to control the level of the standing groundwater and place it below the base of the void throughout the extraction phase and up until sufficient inert waste is placed to overcome any hydrostatic uplift forces.

2.27 Therefore, provided dewatering is maintained groundwater will not adversely affect the stability of the side slope subgrade.

2.28 The highest side slope subgrade will be ca 5m formed at a maximum gradient of 1(V) : 2(H) after placement and compaction of the Engineered Fill.

2.29 The results of the side slope subgrade 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	
Upper Slope Only				
01	SSG1	0.331		Upper Slope Only Effective Stress Conditions
02	SSG2		0.338	
Entire Side Slope				
03	SSG3	0.569		Entire Slope Effective Stress Conditions
04	SSG4		0.645	

<u>Side Slope Liner Analyses</u>

2.30 A side slope liner will be placed against the CL:AIRE Engineered Fill. 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) : 2(H). The liner will be modelled as a 1.00m thick layer applied to the side slope subgrade as this poses a more critical case than the 0.50m thick option.

2.31 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		
Rotational Failure Entirely within Side Slope Liner							
01	SSL1	50	0	0.171		1.00	Total stress
02	SSL2				0.158		
03	SSL3	5	25	0.616		1.00	Full effective stress conditions
04	SSL4				0.671		
05	SSL5	0	25		1.151	1.00	Liner fully softened

<u>Waste Mass Analyses</u>

2.32 The post extraction void may be up to 5m deep. Although it is considered unlikely that a 5m high temporary waste face would be created given the phasing and placement of the inert waste in layers, to represent the worst case, a 5m high temporary waste slope will be considered in this analysis with waste faces during placement operations being restricted to 1(v) : 2(h).

2.33 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.

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

2.35 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.

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

2.37 The effects of saturation of the waste mass have been modelled by reducing the cohesion to 0kN/m^2 and representing the waste mass as fully softened.

2.38 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 Condition	Degree of Utilization		Notes
				C1	C2	
1	WM1	Total	Dry	0.251		Total Stress
2	WM2				0.232	
3	WM3	Effective	Dry	0.632		Effective Stress
4	WM4				0.707	
5	WM5		Saturated	0.842		Cohesion = 0kN/m^2
6	WM6				1.011	

2.39 Groundwater levels presented in the Hydrogeological Risk Assessment indicate that standing groundwater level may be up to 3.50m above the base of the extraction void.

2.40 Using a simple hydrostatic balance equation, if dewatering was to cease the uplift force on the underside of the basal liner will be :

height of groundwater above base of void x unit weight of water

$$3.50 \times 9.81 = 35\text{kN/m}^2$$

The thickness of material required to overcome the hydrostatic uplift would be:

thickness of inert waste x unit weight > 35kN/m^2.

Assuming worst case:

$$35/17 = 2.10\text{m}$$

2.41 Therefore, it is recommended that to avoid uplift at the base of the inert waste dewatering of the void should continue until a minimum of 2.10m of inert waste is in place.

Assessment

Basal Subgrade

2.42 The basal subgrade is to comprise the in-situ OXC which is considered a competent engineering soil and no settlement other than short term elastic recompression is expected, which will be built out during inert waste placement.

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

Basal Liner

No basal liner is proposed at the site.

Side Slope Subgrade

2.44 The side slopes of the void have been formed as part of the mineral extraction works. It is appropriate to assume that the extraction works will be subject to geotechnical appraisal. The side slopes will be buttressed by the placement of CL:AIRE Engineered Fill prior to the construction of the side slope liner. This appraisal will demonstrate that the CL:AIRE Engineered Fill is stable in the long term at a gradient of 1(V) : 2(H).

2.45 The results of the stability assessment of the upper slope indicate the side slope subgrade will be stable with a maximum Degree of Utilisation of 0.338 under effective stress conditions and combination 2 factoring. It should be noted that only effective stress conditions have been analysed as this offers the most critical condition.

2.46 Considering the entire side slope including the natural material behind the CL:AIRE Engineered Fill the side slope remains stable under all foreseeable conditions with a maximum Degree of Utilisation of 0.645 under effective stress conditions and combination 2 factoring.

2.47 The side slope stability analysis has shown that 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

2.48 For the purposes of this stability assessment, the full height of the side slope liner has been modelled.

2.49 The 1.00m thick side slope liner has been analysed and shown to be stable in the short term under total stress conditions with a maximum degree of utilisation of 0.171 being returned under Combination 1 factoring.

2.50 If left unsupported in the long-term such that fully drained effective stress conditions are achieved the liner remains stable with a degree of utilisation of 0.671 under Combination 2 factoring. However, it left unsupported for such a period to allow it to become fully saturated and lose any apparent cohesion the liner is liable to become unstable (SSL5). Therefore, it is recommended that the liner is placed in advance of the inert waste placement and not left unsupported for long periods without buttressing with inert waste.

2.51 Dewatering will lower the groundwater below the base of the extraction void such that hydrostatic forces on the back of low permeability liner will not occur.

2.52 It can be concluded that side slope liner will remain stable under operational conditions provided it is not left exposed to become fully saturated. Visual monitoring of the side slope liner will be required in the form laid out in Section 3 of this SRA.

Waste Mass

2.53 The stability of the inert 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.

2.54 The waste slope has a Degree of Utilisation of <1.00 (<100%) for both short term total stress conditions and long term effective stress conditions.

2.55 If the inert waste becomes fully saturated such that the apparent cohesion of the material reduces to 0kN/m^2 the waste slope may become unstable as the reported Degree of Utilisation of 1.011 suggests. Under these very improbable conditions it may become necessary to slacken the waste slope to 1(V) : 2.5(H).

2.56 It is concluded that under all normal operating conditions a 1(V) : 2(H) waste slope will be stable for the range of conditions anticipated.

Capping System

2.57 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 any inert waste, it is recommended that the basal subgrade is carefully inspected. Special attention should be paid to the presence of any cracking as a result of long term exposure and soft areas if left exposed during long periods of inclement weather.

3.3 To avoid shrinkage and cracking in hot weather a layer of inert waste should be placed over the basal liner or in the absence of suitable waste material a protective geotextile could be used.

Basal Liner Monitoring

3.4 The function of the basal liner will be performed by the in-situ subgrade which will be inspected as detailed in the previous section.

Side Slope Subgrade + Lining Monitoring

3.5 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 fine-grained Overburden is present behind the CL:AIRE Engineered Fill. In the event of any instances of instability, appropriate action should be taken which may include battering back the upper slopes or buttressing the slope using inert waste material or undertaking minor dentition works.

3.6 Provided the side slope liner is properly compacted and not left exposed for extended periods of time the side slope lining system will remain stable in the short term. 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

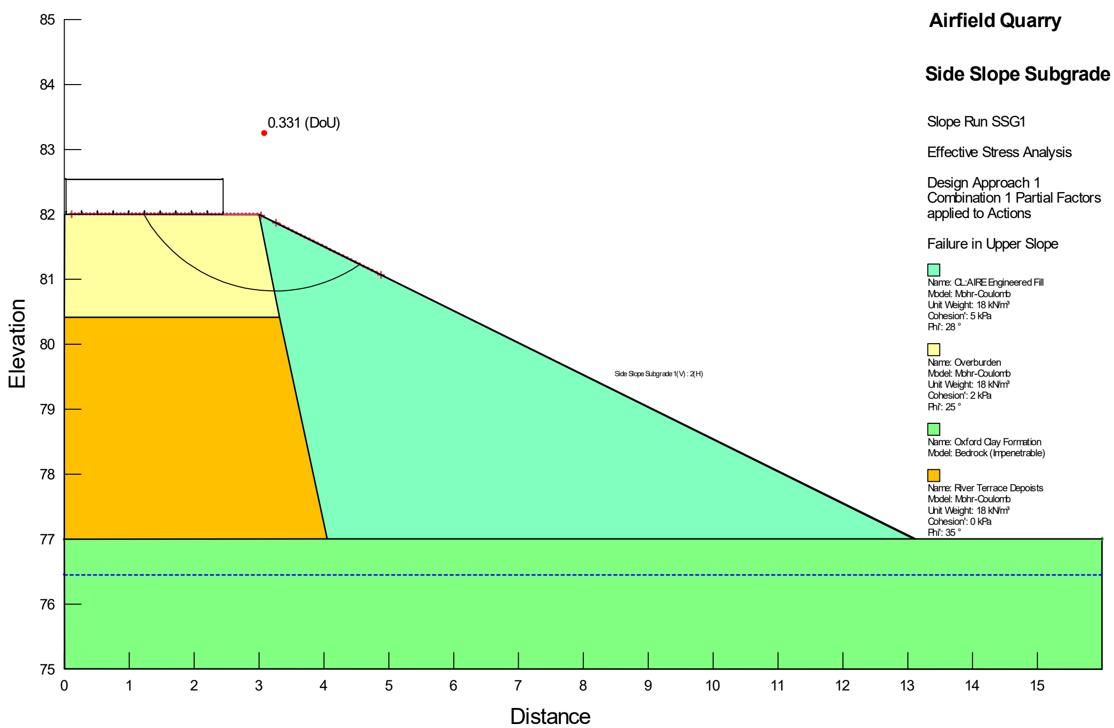
3.7 The temporary slopes in the waste should be visually monitored and appropriate actions taken on any sign of instability. This would typically include a reduction in slope angle of the temporary waste slopes.

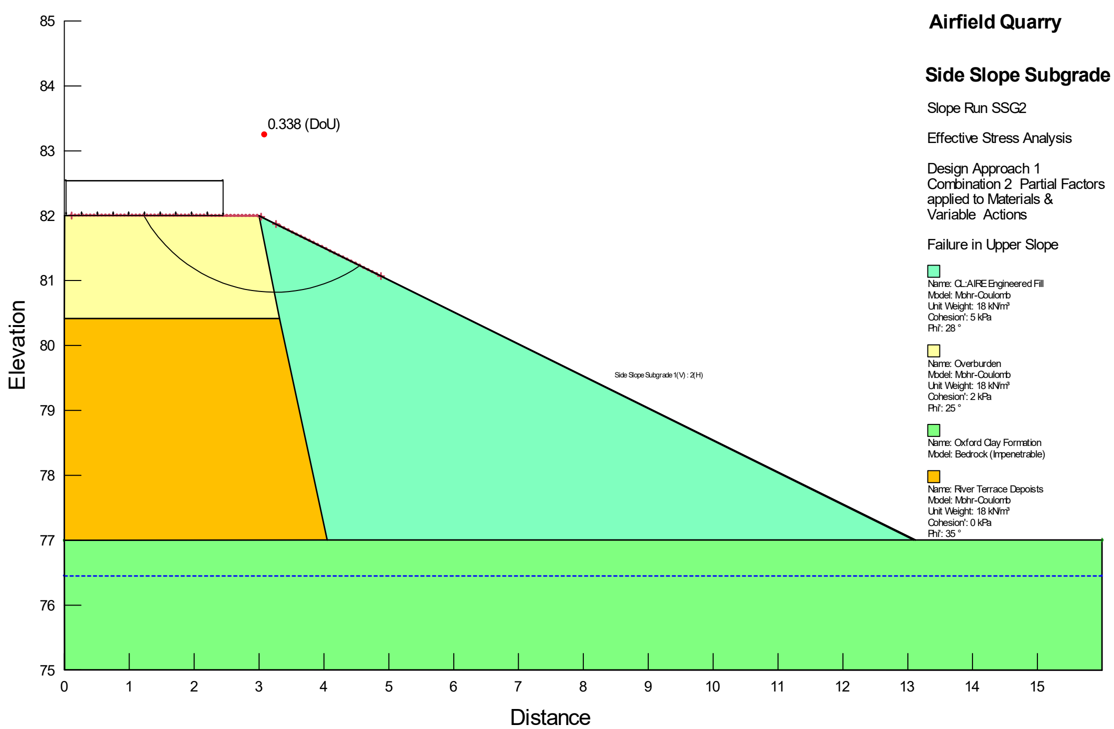
Restoration Soils and Finished Surface Monitoring

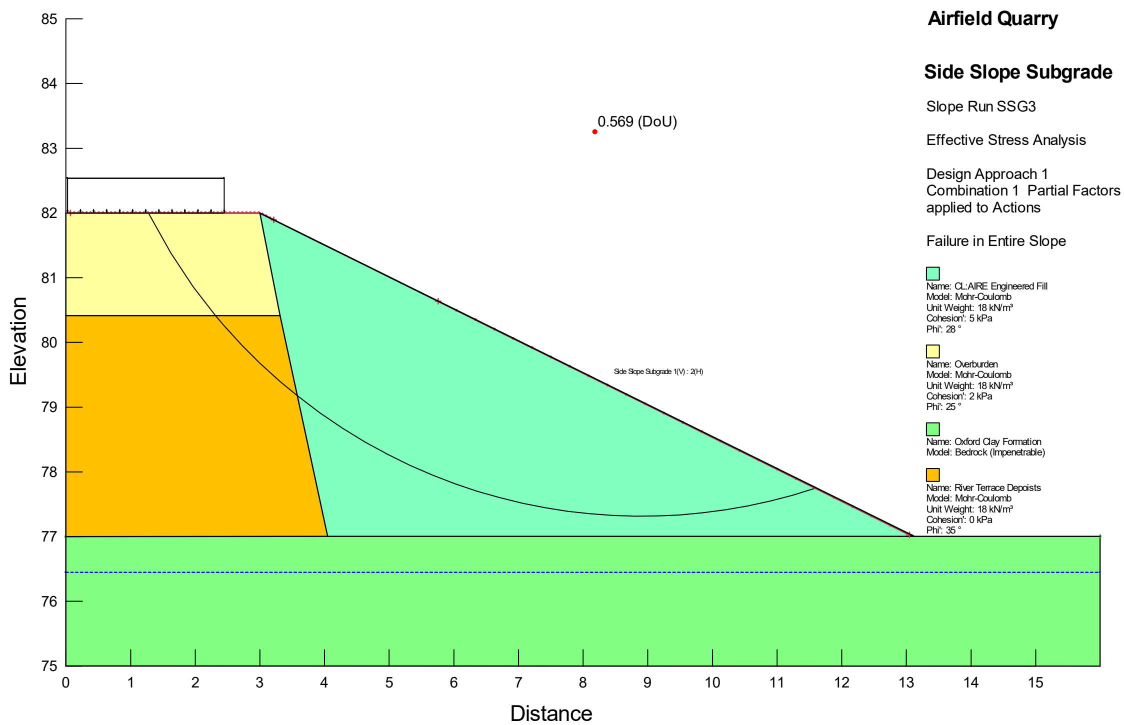
3.8 EA Guidance 'Landfill and deposit for recovery: aftercare and permit surrender' indicates that where records demonstrate that a recovery site has accepted only inert wastes during its lifetime, the site is applicable for a low risk surrender based on records alone. As such no further monitoring or post closure monitoring is deemed necessary.

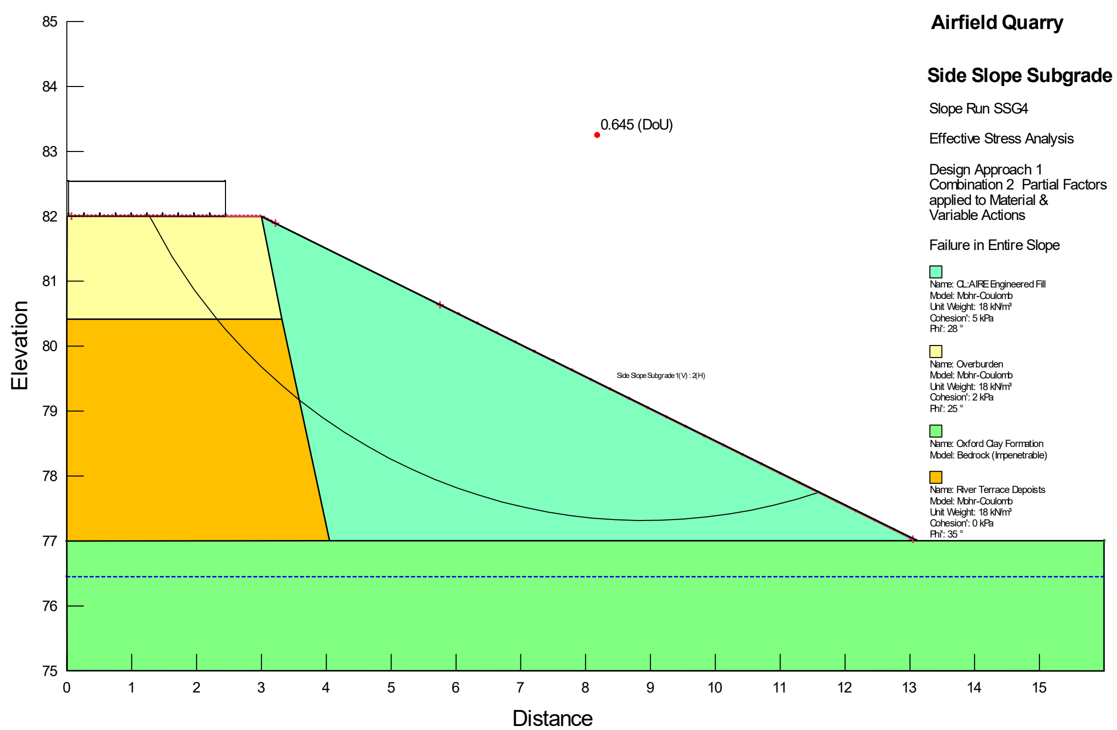
Appendix 1

SlopeW Worksheets – Side Slope Subgrade


Airfield Quarry
Side Slope Subgrade
Slope Run SSG1
Effective Stress Analysis
Design Approach 1
Combination 1 Partial Factors
applied to Actions
Failure in Upper Slope
Name: CL:AIRE Engineered Fill
Model: Mohr-Coulomb
Unit Weight: 18 kN/m³
Cohesion': 5 kPa
Phi': 28 °
Name: Overburden
Model: Mohr-Coulomb
Unit Weight: 18 kN/m³
Cohesion': 2 kPa
Phi': 25 °
Name: Oxford Clay Formation
Model: Bedrock (Impenetrable)
Name: River Terrace Depoists
Model: Mohr-Coulomb
Unit Weight: 18 kN/m³
Cohesion': 0 kPa
Phi': 35 °
0.331 (DoU)
Side Slope Subgrade 1(V) : 2(H)
Elevation
Distance
85
84
83
82
81
80
79
78
77
76
75
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15


Airfield Quarry
Side Slope Subgrade
Slope Run SSG2
Effective Stress Analysis
Design Approach 1
Combination 2 Partial Factors
applied to Materials &
Variable Actions
Failure in Upper Slope
Name: CL:AIRE Engineered Fill
Model: Mohr-Coulomb
Unit Weight: 18 kN/m³
Cohesion': 5 kPa
Phi': 28 °
Name: Overburden
Model: Mohr-Coulomb
Unit Weight: 18 kN/m³
Cohesion': 2 kPa
Phi': 25 °
Name: Oxford Clay Formation
Model: Bedrock (Impenetrable)
Name: River Terrace Depoists
Model: Mohr-Coulomb
Unit Weight: 18 kN/m³
Cohesion': 0 kPa
Phi': 35 °
0.338 (DoU)
Side Slope Subgrade 1(V) : 2(H)
Elevation
Distance
85
84
83
82
81
80
79
78
77
76
75
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15


Airfield Quarry
Side Slope Subgrade
Slope Run SSG3
Effective Stress Analysis
Design Approach 1
Combination 1 Partial Factors
applied to Actions
Failure in Entire Slope
Name: CL:AIRE Engineered Fill
Model: Mohr-Coulomb
Unit Weight: 18 kN/m³
Cohesion': 5 kPa
Phi': 28 °
Name: Overburden
Model: Mohr-Coulomb
Unit Weight: 18 kN/m³
Cohesion': 2 kPa
Phi': 25 °
Name: Oxford Clay Formation
Model: Bedrock (Impenetrable)
Name: River Terrace Depoists
Model: Mohr-Coulomb
Unit Weight: 18 kN/m³
Cohesion': 0 kPa
Phi': 35 °
0.569 (DoU)
Side Slope Subgrade 1(V) : 2(H)
Elevation
Distance
85
84
83
82
81
80
79
78
77
76
75
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15


Airfield Quarry
Side Slope Subgrade
Slope Run SSG4
Effective Stress Analysis
Design Approach 1
Combination 2 Partial Factors
applied to Material &
Variable Actions
Failure in Entire Slope
Name: CL:AIRE Engineered Fill
Model: Mohr-Coulomb
Unit Weight: 18 kN/m³
Cohesion': 5 kPa
Phi': 28 °
Name: Overburden
Model: Mohr-Coulomb
Unit Weight: 18 kN/m³
Cohesion': 2 kPa
Phi': 25 °
Name: Oxford Clay Formation
Model: Bedrock (Impenetrable)
Name: River Terrace Depoists
Model: Mohr-Coulomb
Unit Weight: 18 kN/m³
Cohesion': 0 kPa
Phi': 35 °
0.645 (DoU)
Side Slope Subgrade 1(V) : 2(H)
Elevation
Distance
85
84
83
82
81
80
79
78
77
76
75
0
1
2
3
4
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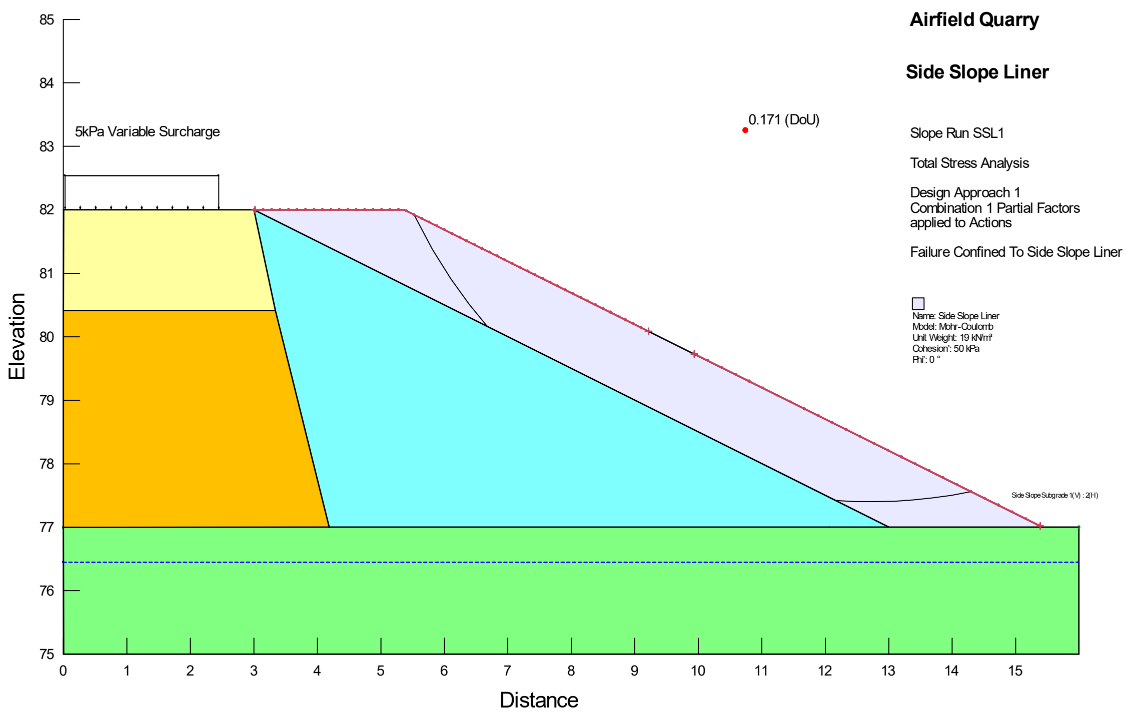
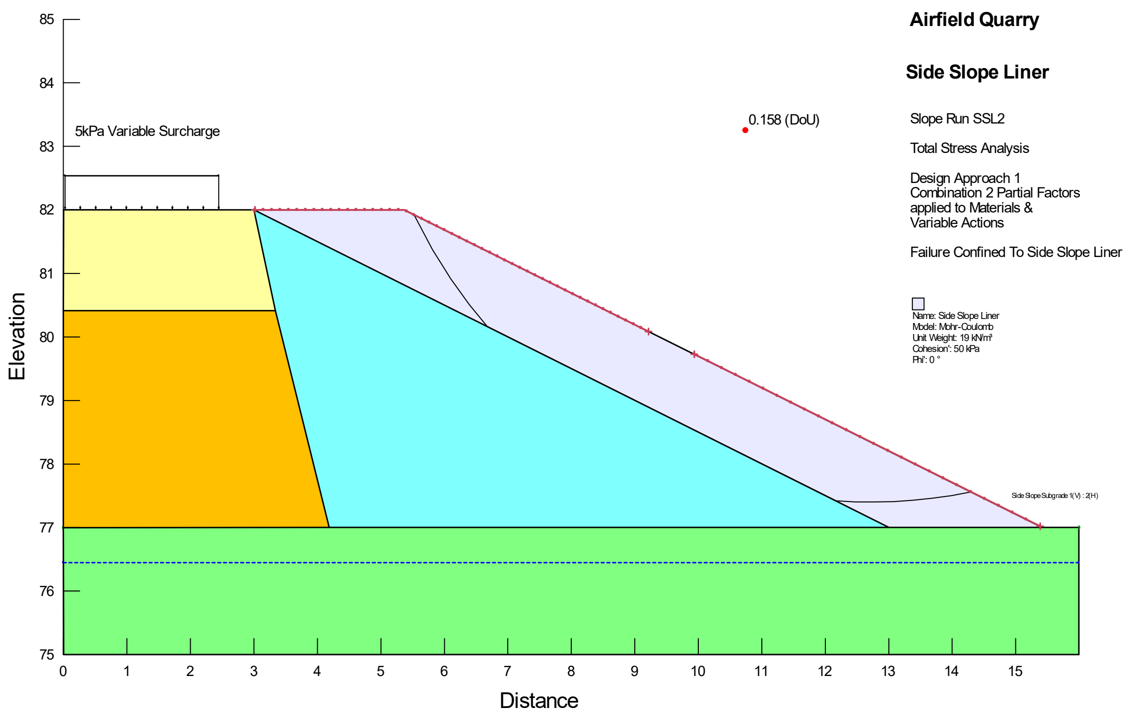
12
13
14
15

Appendix 2

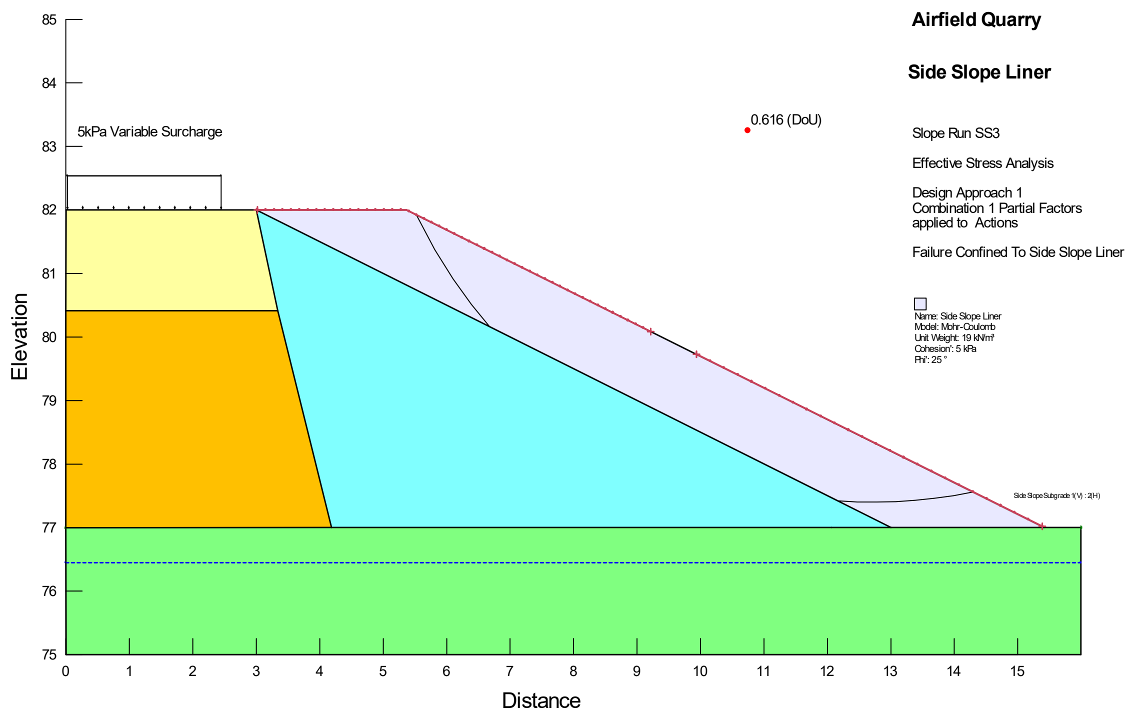
SlopeW Worksheets - Side Liner Stability

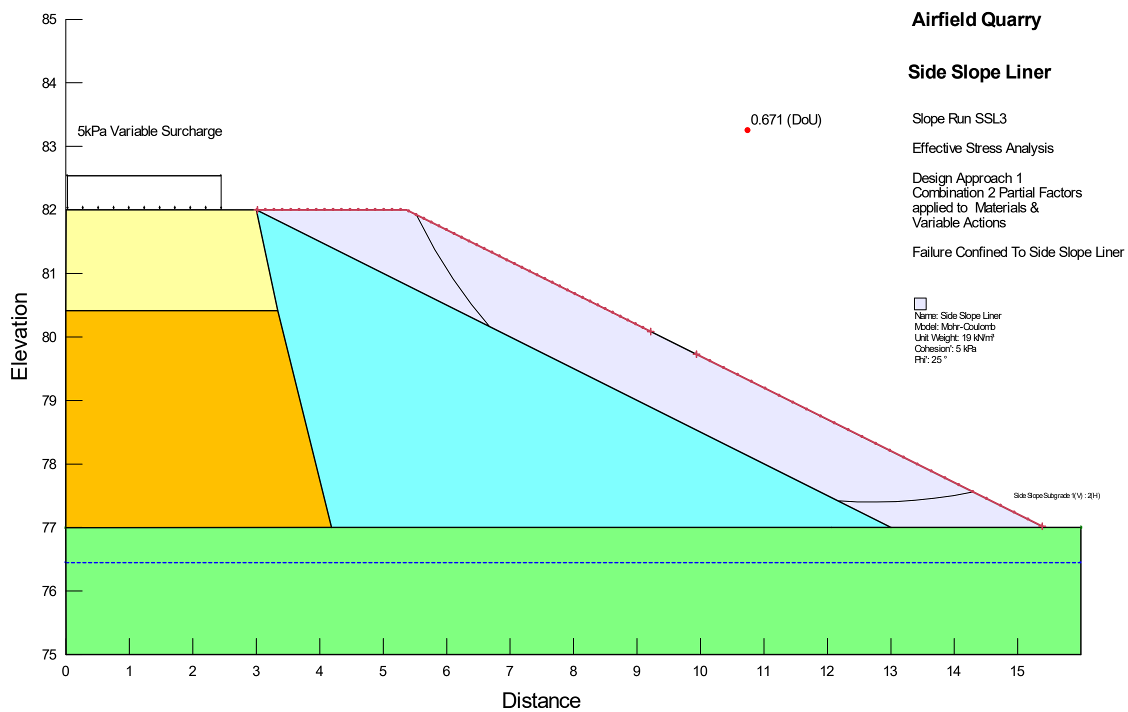


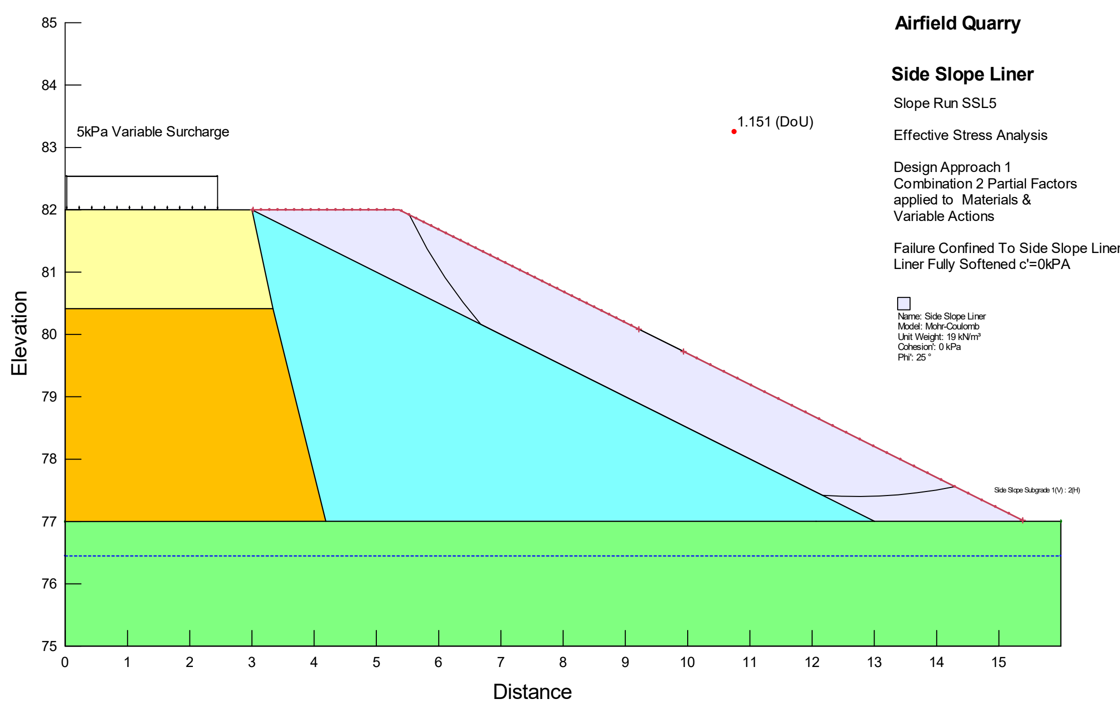
Airfield Quarry
Side Slope Liner
Slope Run SSL1
Total Stress Analysis
Design Approach 1
Combination 1 Partial Factors
applied to Actions
Failure Confined To Side Slope Liner
Name: Side Slope Liner
Model: Mohr-Coulomb
Unit Weight: 19 kN/m³
Cohesion': 50 kPa
Phi': 0 °
0.171 (DoU)
5kPa Variable Surcharge
Side Slope Subgrade 1(V) : 2(H)
Elevation
Distance



Airfield Quarry
Side Slope Liner
Slope Run SSL2
Total Stress Analysis
Design Approach 1
Combination 2 Partial Factors
applied to Materials &
Variable Actions
Failure Confined To Side Slope Liner
Name: Side Slope Liner
Model: Mohr-Coulomb
Unit Weight: 19 kN/m³
Cohesion': 50 kPa
Phi': 0 °
0.158 (DoU)
5kPa Variable Surcharge
Side Slope Subgrade 1(V) : 2(H)
Elevation
Distance


Airfield Quarry
Side Slope Liner
0.616 (DoU)
Slope Run SS3
Effective Stress Analysis
Design Approach 1
Combination 1 Partial Factors
applied to Actions
Failure Confined To Side Slope Liner
Name: Side Slope Liner
Model: Mohr-Coulomb
Unit Weight: 19 kN/m³
Cohesion': 5 kPa
Phi': 25 °
5kPa Variable Surcharge
Side Slope Subgrade 1(V) : 2(H)
Elevation
Distance


Airfield Quarry
Side Slope Liner
0.671 (DoU)
Slope Run SSL3
Effective Stress Analysis
Design Approach 1
Combination 2 Partial Factors
applied to Materials &
Variable Actions
Failure Confined To Side Slope Liner
Name: Side Slope Liner
Model: Mohr-Coulomb
Unit Weight: 19 kN/m³
Cohesion': 5 kPa
Phi': 25 °
5kPa Variable Surcharge
Side Slope Subgrade 1(V) : 2(H)
Elevation
Distance


Airfield Quarry
Side Slope Liner
Slope Run SSL5
Effective Stress Analysis
Design Approach 1
Combination 2 Partial Factors
applied to Materials &
Variable Actions
Failure Confined To Side Slope Liner
Liner Fully Softened c'=0kPA
Name: Side Slope Liner
Model: Mohr-Coulomb
Unit Weight: 19 kN/m³
Cohesion': 0 kPa
Phi': 25 °
1.151 (DoU)
5kPa Variable Surcharge
Side Slope Subgrade 1(V) : 2(H)
Elevation
Distance
85
84
83
82
81
80
79
78
77
76
75
0
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14
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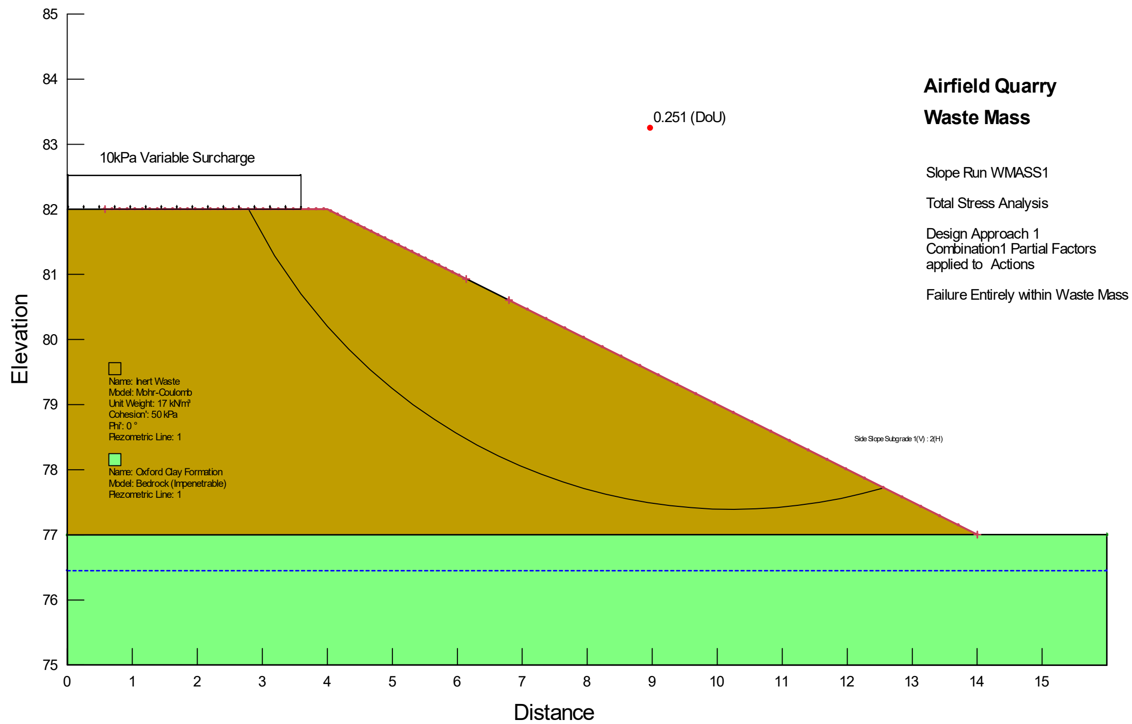
Appendix 3

SlopeW Worksheets – Waste Mass


Airfield Quarry
Waste Mass
Slope Run WMASS1
Total Stress Analysis
Design Approach 1
Combination1 Partial Factors
applied to Actions
Failure Entirely within Waste Mass
0.251 (DoU)
10kPa Variable Surcharge
Side Slope Subgrade 1(V) : 2(H)
Name: Inert Waste
Model: Mohr-Coulomb
Unit Weight: 17 kN/m³
Cohesion': 50 kPa
Phi': 0 °
Piezometric Line: 1
Name: Oxford Clay Formation
Model: Bedrock (Impenetrable)
Piezometric Line: 1
Elevation
Distance
85
84
83
82
81
80
79
78
77
76
75
0
1
2
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5
6
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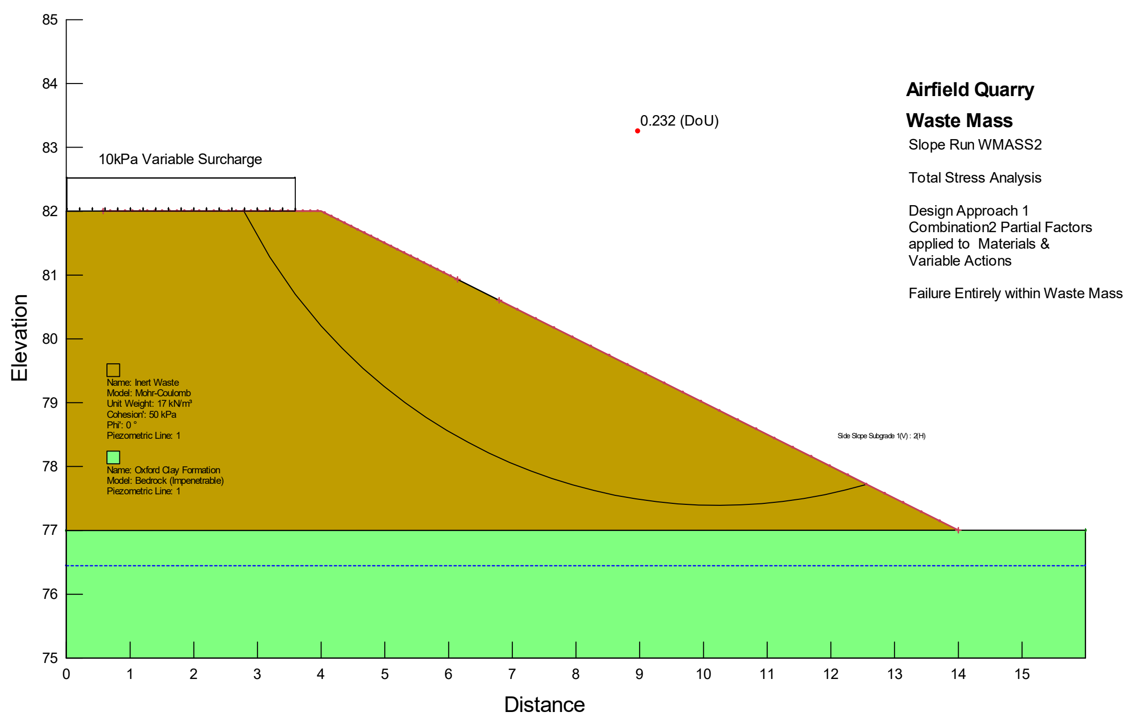
Airfield Quarry
Waste Mass
Slope Run WMASS2
Total Stress Analysis
Design Approach 1
Combination2 Partial Factors
applied to Materials &
Variable Actions
Failure Entirely within Waste Mass
0.232 (DoU)
10kPa Variable Surcharge
Side Slope Subgrade 1(V) : 2(H)
Name: Inert Waste
Model: Mohr-Coulomb
Unit Weight: 17 kN/m³
Cohesion': 50 kPa
Phi': 0 °
Piezometric Line: 1
Name: Oxford Clay Formation
Model: Bedrock (Impenetrable)
Piezometric Line: 1
Elevation
Distance
85
84
83
82
81
80
79
78
77
76
75
0
1
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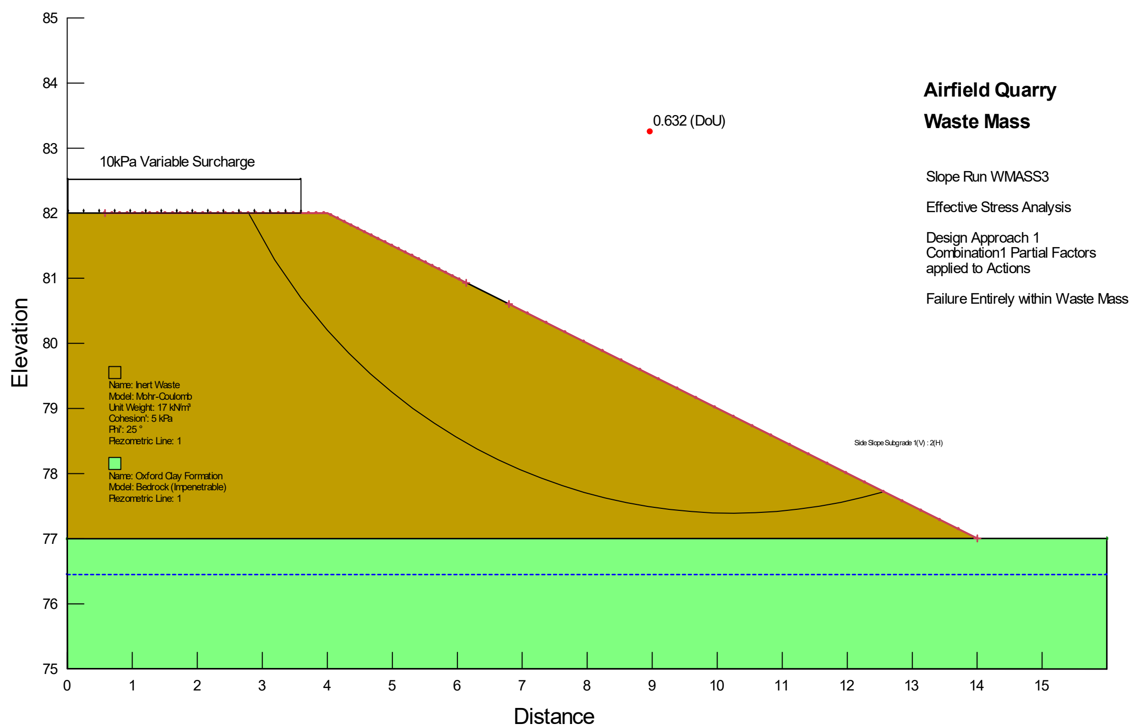
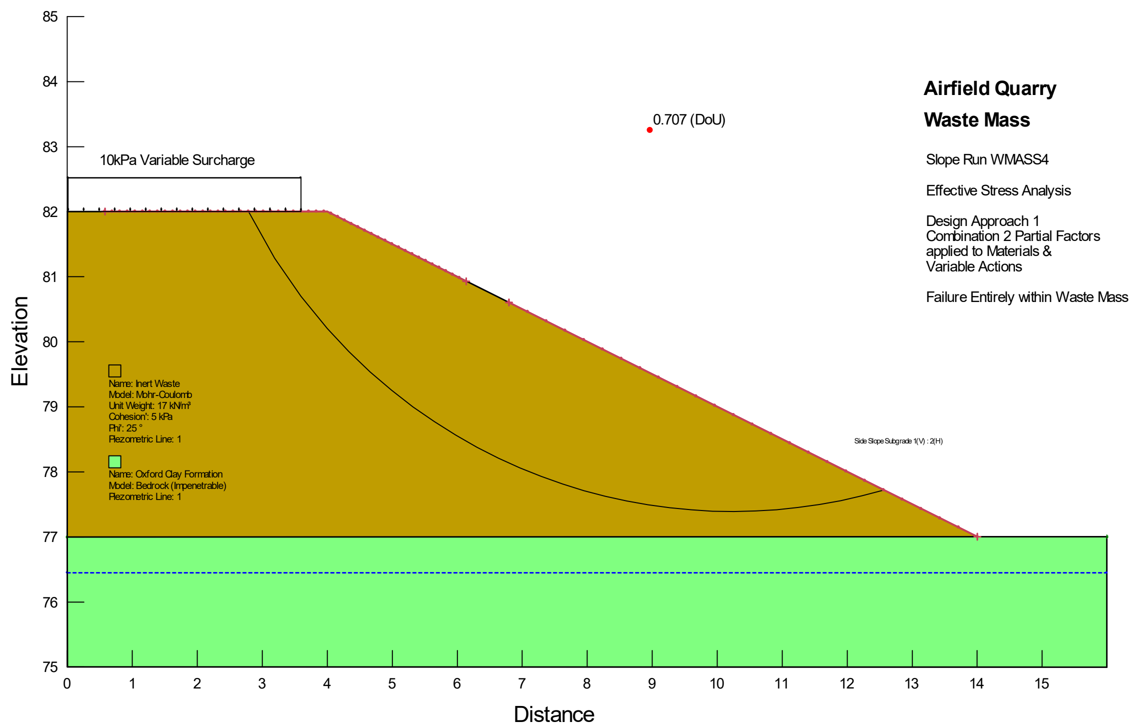
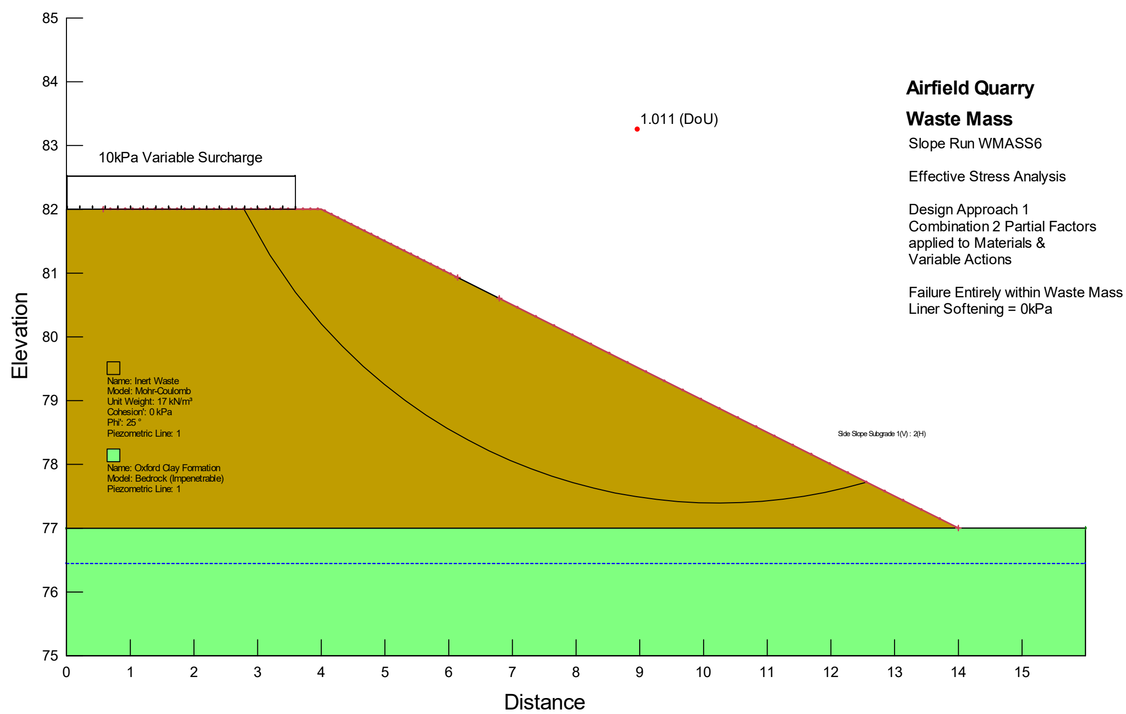

Airfield Quarry
Waste Mass
0.632 (DoU)
10kPa Variable Surcharge
Slope Run WMASS3
Effective Stress Analysis
Design Approach 1
Combination1 Partial Factors
applied to Actions
Failure Entirely within Waste Mass
Side Slope Subgrade 1(V) : 2(H)
Name: Inert Waste
Model: Mohr-Coulomb
Unit Weight: 17 kN/m³
Cohesion': 5 kPa
Phi': 25 °
Piezometric Line: 1
Name: Oxford Clay Formation
Model: Bedrock (Impenetrable)
Piezometric Line: 1
Elevation
Distance


Airfield Quarry
Waste Mass
0.707 (DoU)
10kPa Variable Surcharge
Slope Run WMASS4
Effective Stress Analysis
Design Approach 1
Combination 2 Partial Factors
applied to Materials &
Variable Actions
Failure Entirely within Waste Mass
Side Slope Subgrade 1(V) : 2(H)
Name: Inert Waste
Model: Mohr-Coulomb
Unit Weight: 17 kN/m³
Cohesion': 5 kPa
Phi': 25 °
Piezometric Line: 1
Name: Oxford Clay Formation
Model: Bedrock (Impenetrable)
Piezometric Line: 1
Elevation
Distance


Airfield Quarry
Waste Mass
Slope Run WMASS6
Effective Stress Analysis
Design Approach 1
Combination 2 Partial Factors applied to Materials & Variable Actions
Failure Entirely within Waste Mass
Liner Softening = 0kPa
1.011 (DoU)
10kPa Variable Surcharge
Name: Inert Waste
Model: Mohr-Coulomb
Unit Weight: 17 kN/m³
Cohesion': 0 kPa
Phi': 25 °
Piezometric Line: 1
Name: Oxford Clay Formation
Model: Bedrock (Impenetrable)
Piezometric Line: 1
Side Slope Subgrade 1(V) : 2(H)
Elevation
Distance