MELTON ROSS WESTERN QUARRY AREA RESTORATION

Environmental Permit Variation
Stability Risk Assessment
Prepared for: Singleton Birch Limited
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APPENDICES

1.0 Introduction

SLR Consulting Limited (SLR) has been instructed by Singleton Birch Limited (SBL) to prepare an environmental permit variation application to add the restoration of the Western Quarry Area of the Melton Ross Quarry Complex, hereafter referred to as 'the Site', to SBL's Melton Ross Lime Works permit (ref. EPR/BL8805IZ).

As part of the permit application, SLR has undertaken a Geotechnical Stability Risk Assessment (SRA). This document describes the manner in which the assessment has been carried out and presents the overall findings of the work.

Relevant background information describing the site setting (including geological, hydrological, site monitoring data and development proposals) is detailed within the site's Environmental Setting and Site Design (ESSD) in Section 5 of this Application.

The methodology adopted for this Stability Risk Assessment generally follows the principles outlined in the Environment Agency R&D Technical Report P-385, volumes TR1 and TR2[1] (from here on referred to as the guidance). Where additional analytical techniques have been used, these are described within the text.

1.1 Conceptual Stability Site Model

The Melton Ross Quarry Complex is located within a predominantly agricultural landscape, approximately 17km to the east of Scunthorpe, within North Lincolnshire. It is located west of the village of Croxton, and north of the village of Melton Ross. Access to the complex is gained from the B1211 to the southeast.

The complex is bisected by the A180(T), which runs east – west between parts of the complex. The original quarry workings lie to the south of the A180(T) and a more recent quarry extension is being developed to the north of this road. The Western Quarry comprises the western part of the original quarry area to the south of the A180(T), centred on national grid reference TA 07288 11446. The Camp Wood landfill lies in the eastern part of the original quarry area, immediately to the east of the site.

The site has been quarried to an elevation of approximately 30m AOD in the north of the site. In the south of the site, mineral has been extracted to a depth of approximately 18m AOD. Prior to the commencement of restoration works, the southern area will be backfilled with site sourced material to raise the level to 30m AOD, i.e. the same level as the northern area of the site. Restoration will be through backfilling a combination of mining waste material and imported inert waste to a maximum height of 60m AOD.

The SRA considers the restoration of the site using suitable site-derived stockpiled overburden and imported inert waste.

1.2 Geology

A review of the BGS Geoindex website[2] confirms that there are no superficial deposits present across or adjacent to the site, with bedrock present at or near the surface.

The site is underlain by the Welton Chalk Formation, typically described as a '*White, massive or thickly bedded chalk with common flint nodules'*. The base of the Welton Chalk is marked by the Black Band, a distinctive dark grey, and locally black, laminated thick marl horizon, reported locally to be the Plenus Marl. The Black Band rests on a well-developed erosion surface at the top of the Lower Chalk succession. Beneath the Black Band is the Ferriby Chalk which is less flinty and contains reddened basal beds of impure limestone, lithologically

[1] Environment Agency R&D Technical Report P1-385/ TR1 and TR2, 'Stability of Landfill Liner Systems', March 2003.
[2] BGS Website (accessed 19/08/20) http://mapapps2.bgs.ac.uk/geoindex/home.html

indistinguishable from the bulk of the Lower Chalk. These strata rest unconformably on the Ancholme Clay Group, which is of Upper Jurassic Age.

The Welton Chalk Formation extends a significant distance uninterrupted to the north and east of the site but has limited extent to the west and south-west where the Ferriby Chalk outcrops. The chalk dips steeply to the east and north-east beneath the site and consequently thickens significantly across the Melton Ross site, from c. 25m in thickness to the west of the western quarry to c.40m thick to the east of Camp Wood. It is noted that the Welton Chalk has been largely excavated from across the western quarry with between 1m and 5m thickness left in-situ beneath the base of the quarry.

The Ferriby Chalk Formation outcrops approximately 160m to the south-west of the site as a relatively thin band. The chalk subsequently dips steeply beneath the Welton Chalk beneath the site.

To the west of the Ferriby Chalk outcrop the chalk is overlain by Carstone Sandstone and Kimmeridge Clay formations, neither of these are present beneath the application site.

1.3 Conceptual Site Model

The following sections provide further details of the principal components of the landfill development.

1.3.1 Basal Subgrade Model

The basal subgrade of the site will be formed of in-situ chalk of the Welton Chalk Formation in the north of the site and by backfilled material in the south of the site. The top of the basal subgrade will be at an elevation of 28m AOD.

1.3.2 Side Slope Subgrade Model

The side slope subgrade will be formed by the extraction side slopes of the in-situ Welton Chalk. The side slopes are typically 30m high and cut vertically within the Chalk bedrock.

1.3.3 Basal Attenuation Layer Model

As the site is not classified as an inert landfill it is not proposed to construct a formal geological barrier, however it is proposed that the existing and future mining waste material will be used as an attenuation layer for the site.

The attenuation layer will comprise mining waste material placed to a minimum 1m thickness across the base of the site. The material will be compacted as placed but would not comprise of formal engineering.

1.3.4 Side Slope Attenuation Layer Model

As the site is not classified as an inert landfill it is not proposed to construct a formal geological barrier, however it is proposed that the existing and future mining waste material will be used as an attenuation layer for the site.

The attenuation layer will comprise mining waste material placed to a minimum 1m thickness over the full height of the side slope.

1.3.5 Waste Mass Model

The site will only accept inert waste and non-reactive non-hazardous waste mainly from construction projects. Strict waste acceptance procedures will be in place at the site to ensure that only authorised waste is accepted.

Restoration will also include the placement of mining waste material from the limeworks. This material is not chemically classified as inert waste; however, it is understood to have similar physical / geotechnical properties to inert waste.

1.3.6 Capping System Model

There is no requirement for an engineered cap, imported inert fill and the mining waste will be placed to the approved levels with the uppermost levels formed of topsoil which was originally removed when quarrying works commenced within the northern quarry area.

2.0 STABILITY RISK ASSESSMENT

Each of the six principal components of the conceptual stability site model has been considered and the various elements of that component have been assessed with regard to stability.

The principal components considered are:

- The basal subgrade.
- The side slope subgrade.
- The basal geological barrier.
- The side slope geological barrier.
- The waste.
- The capping system.

2.1 Risk Screening

Issues relating to stability and integrity for each principal component of the proposed development have been subject to a preliminary review to determine the need to undertake further detailed geotechnical analyses. The following sections present the results of this screening exercise.

2.1.1 Basal Subgrade Screening

The base of the site will be formed of the in-situ chalk or within the backfilled material at an elevation of approximately 30m AOD.

Table 2-1
Stability Components for Basal Subgrade

Excessive Deformation	Compressible subgrade	The basal subgrade will be partially formed by the in-situ chalk. The chalk is considered effectively incompressible under the limited weight imparted by the waste mass. This does not require further consideration. The basal subgrade formed within the backfilled material has the potential to compress. This element requires further consideration.
	Basal heave	The base of the site is to be formed above the maximum recorded groundwater level and therefore there is no potential for basal heave. This element does not require further consideration.
	Cavities in subgrade	It is possible that cavities will exist within the chalk formation; but any cavities would be observed and recorded during extraction and it is unlikely that any unrecorded cavities will be present. The subgrade will be inspected prior to any fill being placed. This does not require further consideration
Filling on Waste	Compressible waste	Not applicable.
	Cavities in waste	Not applicable.

Given the foregoing, it is considered that the basal subgrade system requires further assessment.

2.1.2 Side Slope Subgrade Screening

The controlling factors that will affect the stability and deformability of the side slope subgrade are detailed in Table 2-2 below.

Table 2-2
Stability/Integrity Components of Side Slope Subgrade

Cut slope	Rock	Stability	Side slopes will be formed of the in-situ chalk. The site has been subject to regular Geotechnical Assessment under the requirements of the Quarries Regulations 1999. These assessments will have identified any issues with the stability of the side slopes during extraction. The latest assessment report should be reviewed prior to any fill placement takes place. This element does not require further consideration.
		Cavities in subgrade	It is possible that cavities will be present within the in-situ chalk. The site will be subject to regular Geotechnical Assessment under the requirements of the Quarries Regulations 1999. These assessments will identify any issues with the presence of cavities within the side slopes during extraction. The latest assessment report should be reviewed prior to any fill placement takes place. This element does not require further consideration.
		Deformability	The side slope subgrade will be formed by the in-situ chalk. The chalk is considered effectively incompressible under the limited weight imparted by the waste mass. This does not require further consideration.
	Cohesive soils	Stability	Not applicable
		Deformability	Not applicable
		Time dependent stability	Not applicable.
		Groundwater	Not applicable
	Granular soils	Stability	Not applicable
		Deformability	Not applicable
		Groundwater	Not applicable
Fill Slope	Cohesive soils	Stability	Not applicable.
		Time dependent stability	Not applicable.
		Groundwater	Not applicable.
	Granular soils	Stability	Not applicable.
		Deformability	Not applicable.
		Groundwater	Not applicable.

Given the foregoing, it is considered that the side slope subgrade does not require further assessment.

2.1.3 Basal Attenuation Layer Screening

The controlling factors that influence the stability and integrity of the basal geological barrier system are given in Table 2-3 below.

Table 2-3
Stability/Integrity Components of Basal Attenuation Layer

Mineral only	Stability and Integrity	The basal attenuation layer will comprise engineered low permeability material. In terms of potential for movements along the basal geological barrier, the development of the site will result in the generation of temporary waste slopes. The presence of temporary slopes may result in instability within the waste and the along basal geological barrier system. Since this issue is largely dependent upon the geometry of the waste mass, this aspect of the stability review is covered under Section 2.1.5, Waste Mass Stability.
	Compressible subgrade	The basal attenuation layer will comprise engineered low permeability material which is considered to be effectively incompressible under the stresses imposed by the waste height proposed. This component does not require further consideration.
	Cavities	Natural cavities could potentially be present in the basal subgrade; this issue is discussed as part of the basal subgrade assessment and therefore not considered further here.
	Basal heave	The base of the site is to be formed above the maximum recorded groundwater level and therefore there is no potential for basal heave. This component does not require further assessment.
Geosynthetic / clay geological barrier	Stability and Integrity	Not applicable.
	Compressible subgrade	Not applicable.
	Cavities	Not applicable.
	Basal heave	Not applicable.

Given the foregoing, it is considered that the basal attenuation layer will require further assessment.

2.1.4 Side Slope Attenuation Layer Screening

Unconfined	Mineral only	Stability	The side slope attenuation layer will be constructed in lifts of low permeability material placed immediately ahead of waste mass placement. The attenuation layer will be 1m thick. As the attenuation layer will always be immediately buttressed by inert waste, further assessment is not necessary as it will not be in an unconfined state long enough for the stability of the material to be a problem. This aspect of the assessment does not require further consideration.
		Integrity	The integrity of the side slope attenuation layer will not be compromised as the liner will be immediately buttressed through waste placement; and so will not be in the unconfined condition for long enough for the integrity to become a problem. This aspect of the assessment does not require further consideration.
	Geosynthetic / mineral	Stability	Not applicable.
		Integrity	Not applicable.
Confined	Mineral only	Stability	This issue is considered as being separate from the Waste Mass Analysis, which examines the influence of the confined side slope attenuation layer system on the overall stability of the waste mass. The issue of confined side slope attenuation layer stability is therefore considered as part of the Waste Mass Analysis.
		Integrity	If the integrity in the unconfined condition is satisfactory, it is clear that the integrity of the side slope attenuation layer in the confined condition will be greater due to the buttressing effect of the waste and will therefore be satisfactory.

	Geosynthetic / mineral	Stability	Not applicable
		Integrity	Not applicable

Given the foregoing, it is considered that the basal attenuation layer will require further assessment.

2.1.5 Waste Mass Screening

The controlling factors that influence the stability of the waste mass are presented in Table 2-4 below.

Table 2-4
Stability Components of Waste Slopes

Failure wholly in waste	Stability		Inert and non-reactive non-hazardous waste will be placed in phases within the void. Temporary waste slopes will be generated through progressive filling. Temporary waste slopes will require further assessment.
Failure involving geological barrier and waste	Mineral only	Stability	The development of the void by progressive infilling will result in the generation of a single temporary waste slope in the short term. The proposed method of working has the potential to shear through the basal attenuation layer. This element requires further assessment.
		Integrity	Not applicable
	Geosynthetic / Mineral	Stability	Not applicable
		Integrity	Not applicable

Given the foregoing, it is considered that the waste mass requires further assessment.

Leachate Collection System

Due to the nature of the inert and non-reactive non-hazardous waste to be deposited at the site, a significant volume of leachate will not be generated. Consequently, a specific leachate collection system will not be installed.

Gas Collection System

Due to the nature of the waste to be deposited at the site, landfill gas will not be generated. Therefore, a gas extraction system is not warranted and will not be installed.

2.1.6 Capping System Screening

No formal capping is proposed at the site, analysis of the capping system is not required.

2.2 Lifecycle Phases

This aspect of the assessment identifies the critical phases during the development of the site.

The site will be filled in phases; material will be placed in the void to form the proposed waste profile and result in a worst case with a waste slope formed from formation level up to the restoration level.

To ensure the SRA fully addresses the key issues throughout the life of the site, temporary waste slope stability will be considered.

2.3 Data Summary

The following data are required as input for the analyses undertaken for this Stability Risk Assessment

- Material unit weight.
- Drained and undrained shear strength of soils and waste.

It should be noted that there is limited laboratory test data relating to the shear strength of the materials available on the site or those proposed for import to site. However, some basic laboratory testing of the material proposed to be used to construct the attenuation layer is available including particle size distribution and permeability data. The information from this test data has been used to determine typical shear strength parameters for this material type.

There is limited available information on appropriate effective stress shear strength parameters for the in-situ material. Where no direct measurement of a particular property is available, reference has been made to on site and regional borehole logs, literature references and relevant experience from within SLR in the same or similar materials.

The geotechnical parameter values adopted are discussed in more detail in Section 2.6.

2.4 Selection of Appropriate Factors of Safety

The factor of safety is the numerical expression of the degree of confidence that exists, for a given set of conditions, against a particular failure mechanism occurring. It is commonly expressed as the ratio of the load or action which would cause failure against the actual load or actions likely to be applied during service. This is readily determined by limit equilibrium slope stability analyses, which are the only type of analyses required for the current study.

Prior to determining appropriate factors of safety for the various components of the model, it is necessary to identify key 'receptors' and evaluate the consequences in the event of a failure (relating to both stability and integrity). Consideration of the following receptors is required:

- Groundwater
- Property - relating to site infrastructure, third party property
- Human beings (i.e. direct risk)

The factor of safety adopted for each component of the model would be related to the consequences of a failure.

2.4.1 Factor of Safety for Basal Subgrade

The assessment carried out in relation to basal subgrade does not require an absolute factor of safety.

2.4.2 Factor of Safety for Side Slope Subgrade

An assessment is not required on this component as it has been screened out in Section 2.1.2.

2.4.3 Factor of Safety for Basal Attenuation Layer

An assessment is not required on this component as it has been screened out in Section 2.1.3.

2.4.4 Factor of Safety for Side Slope Attenuation Layer

An assessment is not required on this component as it has been screened out in Section 2.1.4.

2.4.5 Factor of Safety for Waste Mass

There are no waste shear strength parameters available in the Guidance, therefore effective stress shear strength parameters have been used, based on the likely materials accepted at the site. In this case it is considered appropriate to adopt a factor of safety of 1.3.

2.4.6 Factor of Safety for Capping System

An assessment is not required on this component as it has been screened out in Section 2.1.6.

2.5 Justification for Modelling Approach and Software

In order to perform a comprehensive Stability Risk Assessment, the components of the site development, as previously described in Section 1.3 of this document, must be considered not only individually but also in conjunction with one another where relevant. Any analytical techniques adopted for such an assessment should adequately represent all the considered scenarios, i.e. the different modelled phases of the lifecycle, for both confined and unconfined conditions (where appropriate). The methodology and the software should also achieve the desired output parameters for the assessment, e.g. determination of limit equilibrium factor of safety or calculation of strains within geological barrier components.

The analytical methods used in this Stability Risk Assessment include:

- Limit equilibrium stability analyses for the derivation of factors of safety for the side slope geological barrier and temporary waste slopes.

The limit equilibrium analyses have been undertaken using the package Slope/W 2018, version 9.1.0 (Geo-Slope International). The Morgenstern-Price[3] non-circular methods of analysis have been used.

[3] Morgenstern, N.R and Price, V.E. (1965), 'The analysis of stability of general slip surfaces' Geotechnique.

2.6 Justification of Geotechnical Parameters Selected for Analysis

The following sections present a justification for the various parameters used in the stability analyses based on the following criteria:

- An assessment of the suitability of non-site-specific data, where used;
- Methods for the derivation of the parameters adopted.

A summary of the geotechnical parameters used in the design and analysis of the development are presented in tabular form for each component of the site in Table 2-5.

The parameters used in the analysis have been:

- Adapted from similar work undertaken by SLR;
- Inferred from site specific data or other relevant published data.

It should be noted that the geotechnical parameters for limit equilibrium analysis include the shear strength and unit weight of each material within the model, plus pore water or gas pressure assumptions. Shear strength has been defined using total or undrained (s_u), and effective shear strength parameters of cohesion, (c′), and the angle of shearing resistance, (ø′).

2.6.1 Parameters Selected for Basal Subgrade Analysis

Parameters required to inform the assessment of basal subgrade stability are discussed in the analysis, Section 2.7.1.

2.6.2 Parameters Selected for Side Slopes Subgrade Analysis

Analysis of the Side Slope subgrade is not necessary as it has been screened out in Section 2.1.2.

2.6.3 Parameters Selected for Basal Attenuation Layer Analysis

The parameter required for the basal attenuation layer analysis (undertaken as part of the Waste Mass Analysis) is the typical angle of shearing resistance of low permeability clay. The adopted parameters are presented in Table 2-5.

2.6.4 Parameters Selected for Side Slope Attenuation Layer Analyses

Analysis of the Side Slope attenuation layer is not necessary as it has been screened out in Section 2.1.2.

2.6.5 Parameters Selected for Waste Analyses

In terms of the waste strength, SLR has adopted conservative values of effective shear strength parameters, with the values presented in Table 2-5. These have been adopted based on assumptions made from SLR's recent experience.

2.6.6 Parameters Selected for Capping Analyses

Analysis of the capping is not necessary as it has been screened out in Section 2.1.6

Table 2-5
Geotechnical Material Parameters for Analysis

Material		Unit Weight, γ (kN/m3)	Effective cohesion, c′ (kPa)	Angle of Shearing Resistance, ø' (º)	Shear Strength, Su (kPa)	Typical Description
Inert and similar non-reactive non-hazardous Waste		16	0.5	26	-	Inert and similar non-reactive non-hazardous waste.
Attenuation Layer		16	0.5 (0)*	26 (18)	50	Low permeability site sourced material
Side Slope Subgrade	Weathered Chalk	16	0	31	-	In-situ chalk. Weathered at shallow depths
	Chalk	18	10	39	-	In-situ chalk.

* Values in parentheses are residual or fully softened parameters

2.7 Analyses

Details of the various Stability Risk Assessment analyses undertaken for the site are presented in the following sections.

2.7.1 Basal Subgrade Analysis

As the basal subgrade is to be partially formed within backfilled material comprising site sourced material of both coarse and fine grained material there is a possibility that the subgrade may consolidate and settle over time.

The maximum depth of fill required to achieved the desired level is approximately 12m (vertical). A conservative assessment of the degree of settlement that may take place in material of this composition would be 10%; it is therefore reasonable to assume that there could be up to 1.2m of settlement of the basal sub grade in the south of the site.

Given the amount of possible settlement which could occur in the basal subgrade, it is recommended that that basal attenuation layer is thickened to 2.2m, in the southern area of the site. This should also be extended to a zone 5m into the northern area of the site where the basal subgrade is formed in in-situ rock.

Therefore, if the basal subgrade does settle by 10% there will still be a minimum of 1m thickness of the attenuation layer.

2.7.2 Side Slope Subgrade Analysis

Analysis of the basal subgrade is not necessary, as it has been screened out in Section 2.1.2.

2.7.3 Basal Attenuation Layer Analysis

Analysis of the basal subgrade is not necessary, as it has been screened out in Section 2.1.3.

2.7.4 Side Slope Attenuation Layer Analysis

Analysis of the basal subgrade is not necessary, as it has been screened out in Section 2.1.3.

2.7.5 Waste Analysis

In considering the stability of the waste mass, the stability and integrity of the geological barrier system would normally be considered as they are intrinsically linked.

Analyses have been dealt with in terms of circular and non-circular 2-D limit equilibrium using the computer program Slope/W. Stability analysis outputs are presented in Appendix SRA2.

Pore fluid pressure is the combined effect of water and gas pressures. The distribution of pore fluid pressure varies within the waste mass due to a number of factors, including the nature and variability of the waste and the presence of perched water tables.

In order to model the pore fluid pressures in the waste mass a pore water pressure ratio (r_u) of 0.1 will be applied to the waste mass to represent a worst-case condition.

A worst-case situation will be used by placing waste to a maximum height of 30m

Mode 1 Waste Mass Stability

Mode 1 analysis has been carried out on 30m high waste slope with an overall gradient of 1V:3H. The results of the Mode 1 analyses are summarised Table 2-6 below.

Mode 1B considers partial saturation of the waste mass through the application of pore water ratio (r_u) within the waste mass. Figures SRA1-2 and SRA2-1 within Appendix SRA1 demonstrates that in order to maintain an acceptable factor of safety temporary waste slopes should be constructed at a gradient of 1V:3H and a maximum height of 30m.

Table 2-6
Summary of Waste Stability Analysis for Mode 1

Figure	File	Method	Factor of Safety	r_u	Comments
SRA2-1	SRA2	Drained Circular	1.909	0	30m high slope at 1V:3H gradient. Failure solely within waste mass. Acceptable (FOS >1.3)
SRA2-2	SRA2	Drained Circular	1.750	0.1	30m high temporary slope at 1V:3H gradient. Failure solely within waste mass. Acceptable (FOS >1.3)

Figures SRA1-1 to SRA1-2 demonstrates a factor of safety in excess of 1.3, which is considered to be acceptable.

Mode 2 Waste Mass Stability

Mode 2 considers a potential failure mechanism that passes through the waste and into the basal attenuation layer. A 30m high waste mass has been analysed with a waste slope gradient of 1V:3H.

Output drawings from Slope/W, detailing the slope profiles and the critical slip planes analysed for Mode 2, are presented in Appendix SRA2. The factors of safety reported for peak and softened interface analyses are summarised in Table 2-7 below.

Modes 2B and 2D consider partial saturation of the waste mass through the application of pore water ratio (r_u) within the waste mass.

Under peak shear strength conditions for the basal attenuation layer acceptable factors of safety are achieved under both favourable and unfavourable pore pressure conditions, as shown in Figures SRA2-3 and SRA2-4.

Table 2-7
Summary of Waste Stability Analysis for Mode 2

Figure	File	Method	FoS	Geological Barrier		r_u	Comments
				ø' (°)	c' (kPa)		
SRA1-3	SRA1	Drained Non-circular	1.938	26	0.5	0	Mode 2A: Peak shear strength in basal geological barrier. Acceptable (FOS >1.3)
SRA1-4	SRA1	Drained Non-circular	1.733	26	0.5	0.1	Mode 2B: Peak shear strength in basal geological barrier. Acceptable (FOS >1.3)
SRA1-5	SRA1	Drained Non-circular	1.937	18	0	0	Mode 2C: Residual shear strength in basal geological barrier. Acceptable (FOS > 1.0)
SRA1-6	SRA1	Drained	1.731	18	0	0.1	Mode 2D: Residual shear strength in basal geological barrier.

Figure	File	Method	FoS	Geological Barrier		r_u	Comments
				ø' (°)	c' (kPa)		
		Non-circular					Acceptable (FOS > 1.0)

Figure SRA1-5 and SRA1-6 assume the angle of shearing resistance in the attenuation layer is in a long-term softened condition, with a value of ø'=18° and c'=0kPa. Since softened shear strength values have been assumed, the allowable factor of safety has been reduced to greater than 1.0, in line with the recommendations made in the Guidance.

Mode 3 Waste Mass Stability

Mode 3 considered a potential, non-circular slip surface passing down through the side slope attenuation layer system and along the attenuation layer.

The analysis considers the following scenarios:

- Peak shear strength conditions in the attenuation layer with softened shear strength conditions in the side slope attenuation layer; and,
- Softened shear strength conditions in both the basal and side slope attenuation layers.

The results are presented in Table 2-8 below and the analysis sections are presented in Appendix SRA2.

Table 2-8
Summary of Waste Stability Analysis for Mode 3

Figure	File	Method	FoS	Side Slope Attenuation Layer		Basal Attenuation Layer		Comments
				ø' (°)	c' (kPa)	ø' (°)	c' (kPa)	
SRA1-7	SRA1	Drained Non-circular	3.403	18	0	26	0.5	Peak shear strength for attenuation layer. Acceptable (FOS >1.3)
SRA21-8	SRA1	Drained Non-circular	2.256	18	0	18	0	Softened shear strength for attenuation layer. Acceptable (FOS >1.0)

Both scenarios return an acceptable factor of safety as shown in Figures SRA2-7 and SRA2-8.

2.7.6 Capping Stability Analysis

An assessment is not required on this component as it has been screened out in Section 2.1.6.

2.8 Assessment

2.8.1 Basal Subgrade Assessment

This Stability Risk Assessment has assessed the proposed basal subgrade including the requirement to place backfill to raise the level to the required formation level. The assessment has established that there is a potential for settlement of the backfilled material to occur and therefore placement of additional material to form the attenuation layer is required to ensure the minimum thickness of attenuation is maintained.

2.8.2 Side Slope Subgrade Assessment

Assessment of this component is not required as it was eliminated from consideration by the screening process (Section 2.1.2).

2.8.3 Basal Attenuation Layer Assessment

Assessment of this component is not required as it was eliminated from consideration by the screening process (Section 2.1.3).

2.8.4 Side Attenuation Layer Assessment

Assessment of this component is not required as it was eliminated from consideration by the screening process (Section 2.1.4).

2.8.5 Waste Assessment

Waste Mass Stability

This Stability Risk Assessment incorporates analyses of basal and side slope attenuation layer stability since this component plays a role in waste mass stability. The assessment considers temporary waste slopes within the inert and non-hazardous waste.

The site will be in filled in a number of phases. The models produced consider the worst-case scenario, with temporary waste slopes constructed to a maximum height of 30m, including the basal and side slope attenuation layer, at a gradient of 1V:3H.

The stability assessment demonstrated that the waste slopes maintain an adequate factor of safety in all modelled conditions.

2.8.6 Capping Assessment

Assessment of this component is not required as it was eliminated from consideration by the screening process (Section 2.1.6).

3.0 MONITORING

3.1 The Risk Based Monitoring Scheme

Based upon the foregoing Stability Risk Assessment, a simple risk-based monitoring scheme is considered appropriate for the future development of the landfill. The monitoring is limited to ensuring compliance with the tipping rules and monitoring of groundwater levels.

3.2 Basal Subgrade Monitoring

No additional instrumentation is deemed as being required during construction or post closure.

3.3 Side Slope Subgrade Monitoring

Monitoring during construction will comprise construction quality assurance to ensure compliance with the construction specification.

No additional instrumentation is deemed as being required during construction or post closure.

3.4 Basal Geological Barrier System Monitoring

Monitoring during construction will comprise construction quality assurance to ensure compliance with the construction specification.

No additional instrumentation is deemed as being required during construction or post closure.

3.5 Side Slope Geological Barrier System Monitoring

Monitoring during construction will comprise construction quality assurance to ensure compliance with the construction specification.

No additional instrumentation is deemed as being required during construction or post closure.

3.6 Waste Mass Monitoring

Tip faces and surrounding areas should be inspected daily for signs of failure.

No other specific monitoring is required for the waste other than to record waste elevations across the site.

3.7 Capping Monitoring

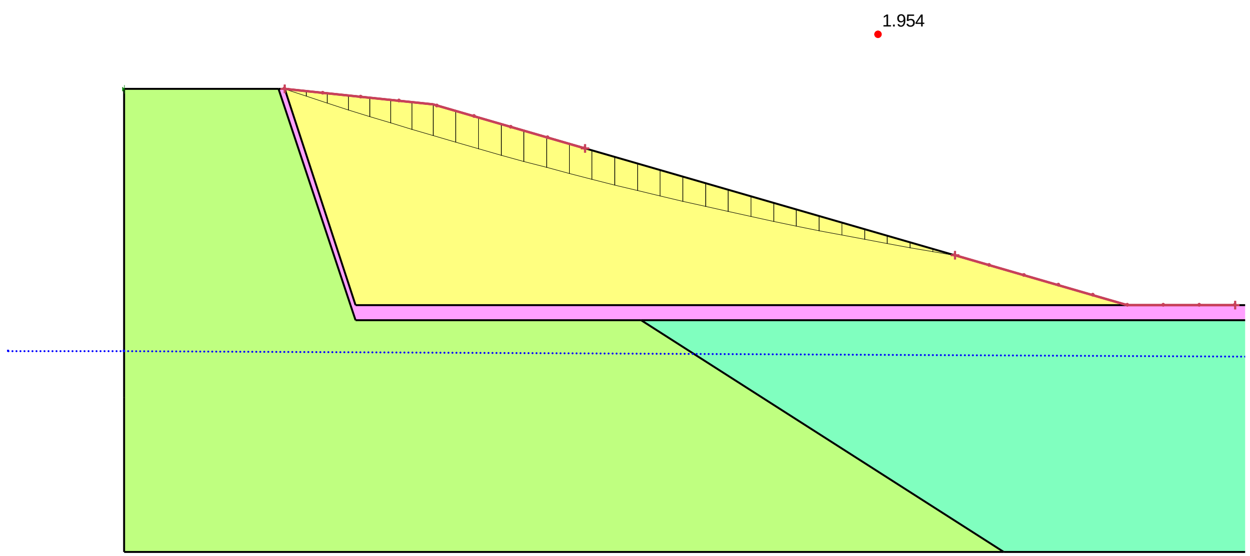
Monitoring during construction will comprise construction quality assurance to ensure compliance with the construction specification.

No additional instrumentation is deemed as being required during construction or post closure.

APPENDIX 01

Waste Mass Analysis

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line	Include Ru in PWP
Pink	Attenuation layer	Mohr-Coulomb	18	0.5	26	0	1	No
Aqua	Backfill	Mohr-Coulomb	18	2	32	0	1	No
Green	Chalk	Bedrock (Impenetrable)					1	No
Yellow	Waste	Mohr-Coulomb	18	0.5	26	0	1	No



Notes:

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Site: MELTON ROSS WESTERN QUARRY

Project: STABILITY RISK ASSESSMENT

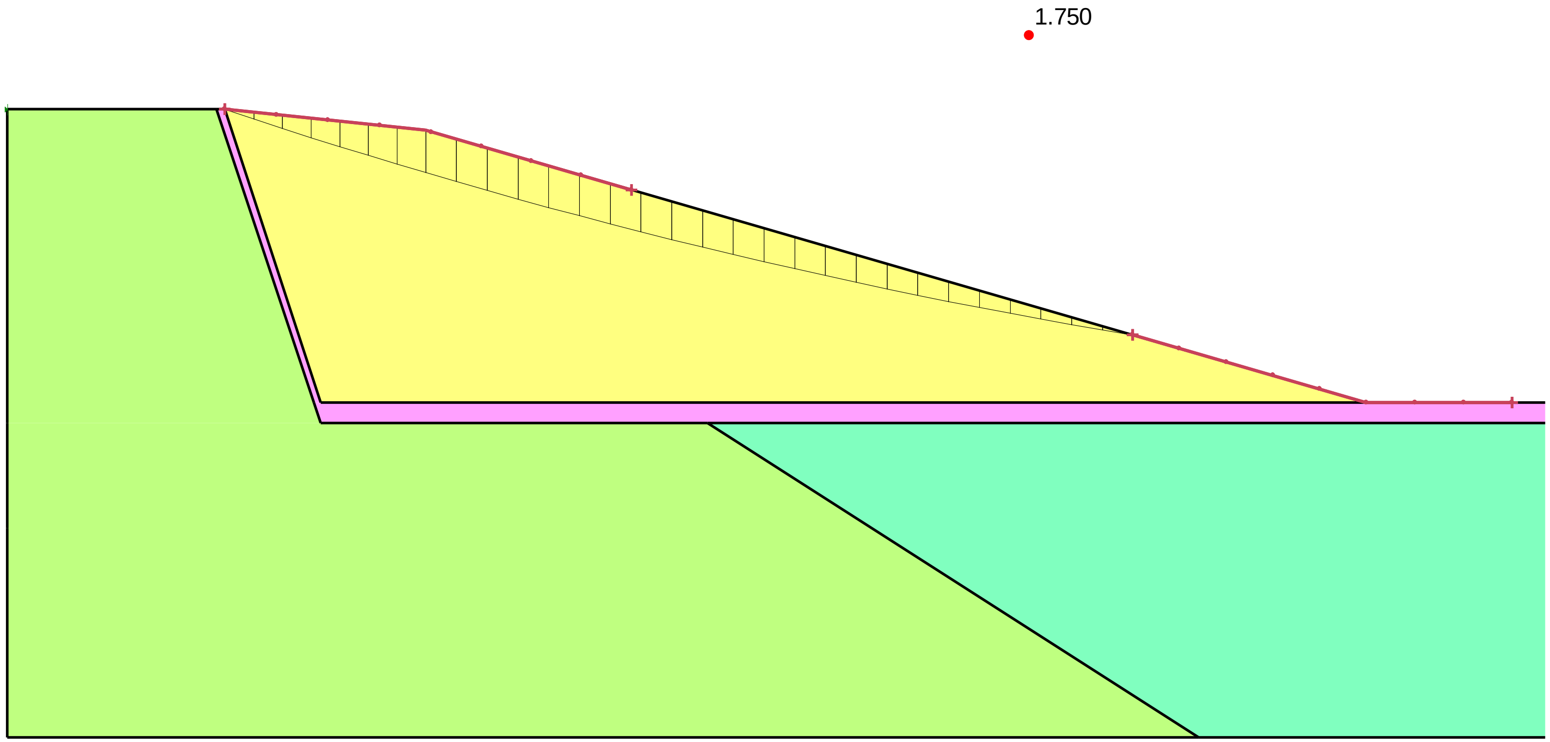
Date: OCTOBER 2020

SCALE: NTS

Drawing: **SRA 1-1**

Appendix **1**

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Ru
	Attenuation layer	Mohr-Coulomb	18	0.5	26	0	0
	Backfill	Mohr-Coulomb	18	2	32	0	0
	Chalk	Bedrock (Impenetrable)					0
	Waste	Mohr-Coulomb	18	0.5	26	0	0.1



Notes:

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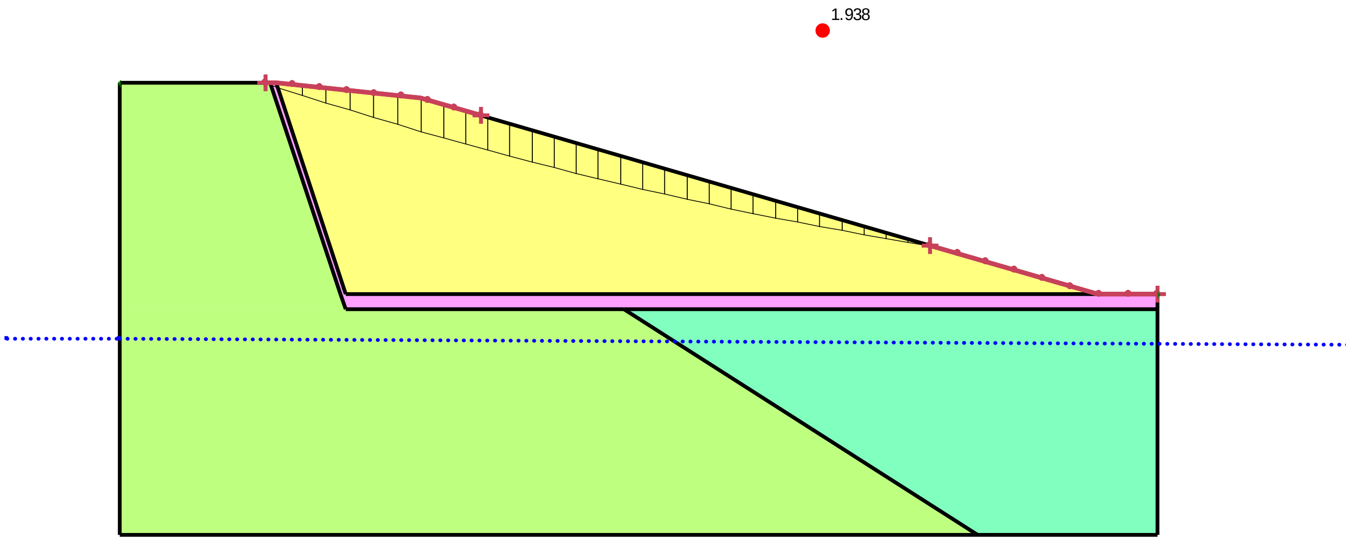
Site:	MELTON ROSS WESTERN QUARRY
Project:	STABILITY RISK ASSESSMENT
Date:	OCTOBER 2020 — SCALE: NTS
Drawing:	**SRA 1-2**

Appendix

1

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line	Include Ru in PWP
	Attenuation layer	Mohr-Coulomb	18	0.5	26	0	1	No
	Backfill	Mohr-Coulomb	18	2	32	0	1	No
	Chalk	Bedrock (Impenetrable)					1	No
	Waste	Mohr-Coulomb	18	0	26	0	1	No



Notes:

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Site: Melton Ross Western Quarry

Project: Stability Risk Assessment

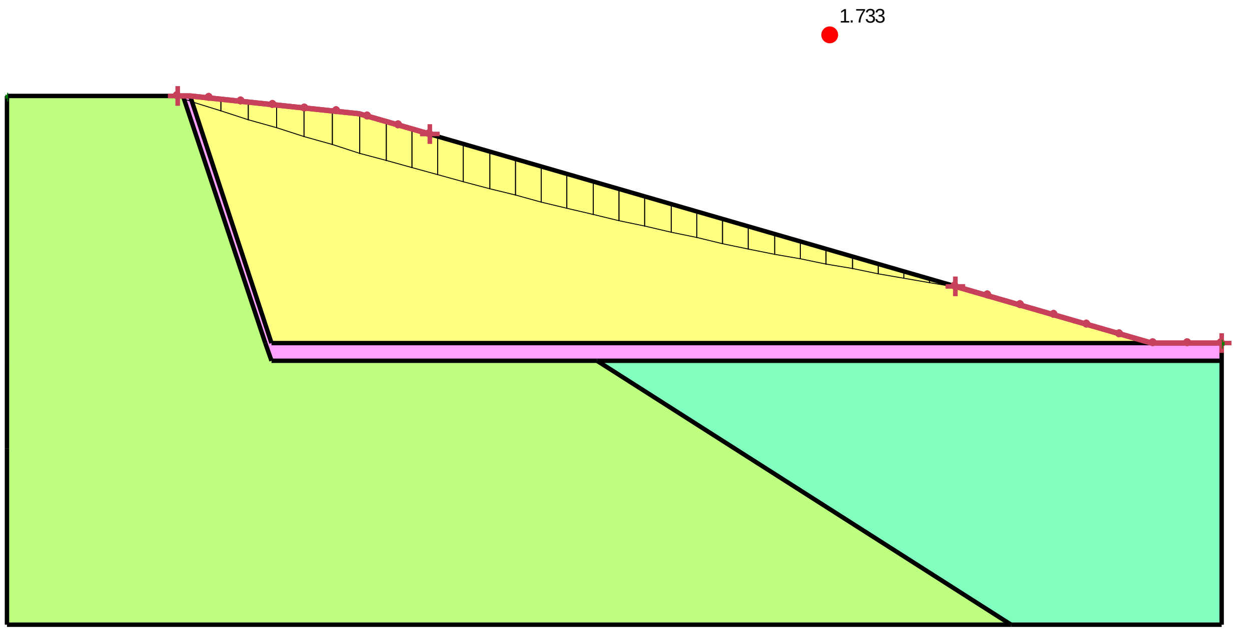
Date: October 2020

Scale: NTS

Drawing: **SRA 1-3**

Appendix **1**

Color	Name	Model	Unit Weight (kN/m^3)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Ru
	Attenuation layer	Mohr-Coulomb	18	0.5	26	0	0
	Backfill	Mohr-Coulomb	18	2	32	0	0
	Chalk	Bedrock (Impenetrable)					0
	Waste	Mohr-Coulomb	18	0	26	0	0.1



Notes:

SLR

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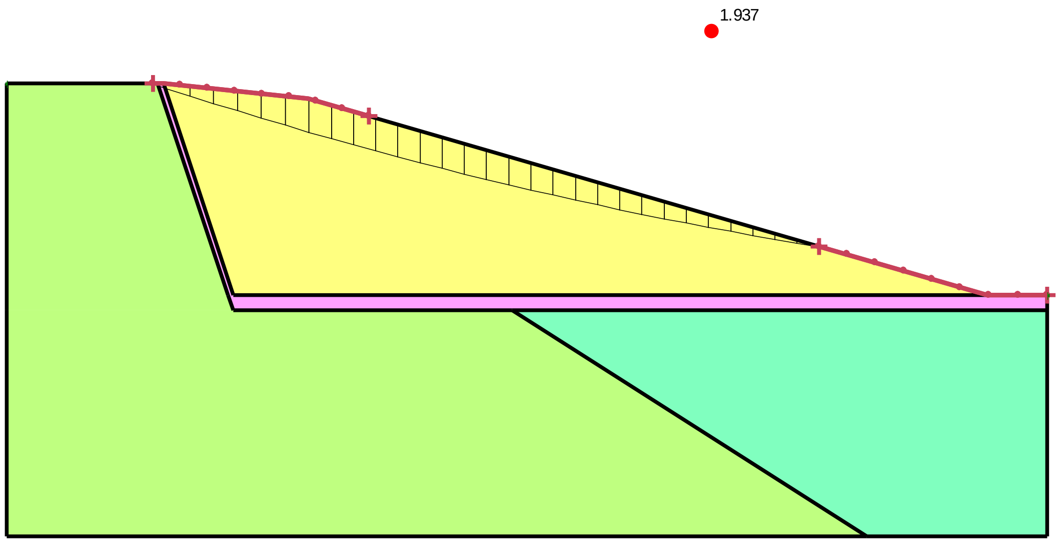
Site:	Melton Ross Western Quarry
Project:	Stability Risk Assessment
Date:	October 2020 — Scale: NTS
Drawing:	**SRA 1-4** — Appendix **1**

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Ru
Pink	Attenuation layer	Mohr-Coulomb	18	0	18	0	0
Green	Backfill	Mohr-Coulomb	18	2	32	0	0
Light green	Chalk	Bedrock (Impenetrable)					0
Yellow	Waste	Mohr-Coulomb	18	0	26	0	0



Notes:

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Site: MELTON ROSS WESTERN QUARRY

Project: STABILITY RISK ASSESSMENT

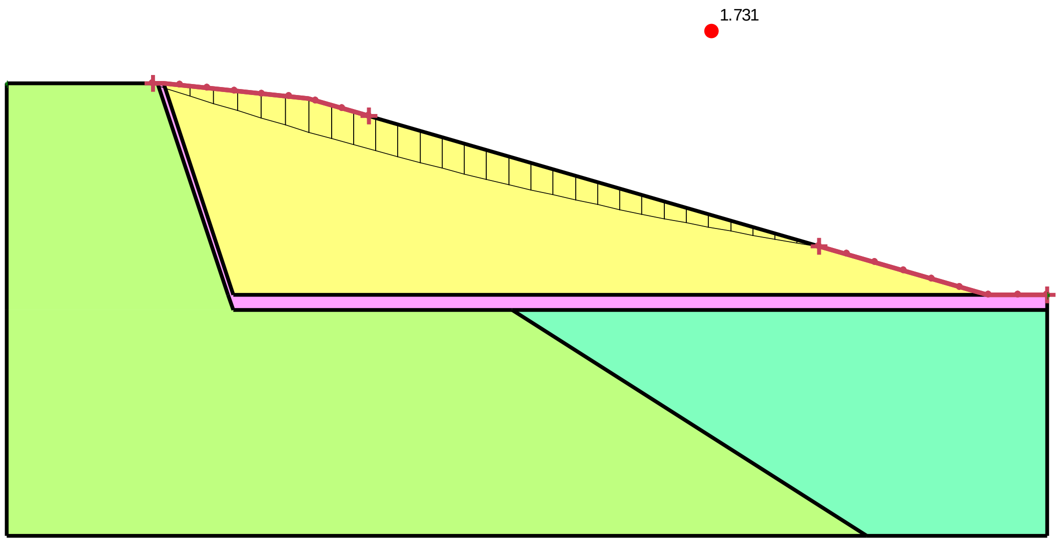
Date: OCTOBER 2020

SCALE: NTS

Drawing: **SRA 1-5**

Appendix **1**

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Ru
	Attenuation layer	Mohr-Coulomb	18	0	18	0	0
	Backfill	Mohr-Coulomb	18	2	32	0	0
	Chalk	Bedrock (Impenetrable)					0
	Waste	Mohr-Coulomb	18	0	26	0	0.1



Notes:		Site:	MELTON ROSS WESTERN QUARRY
		Project:	STABILITY RISK ASSESSMENT
		Date:	OCTOBER 2020 — SCALE: NTS
		Drawing:	**SRA 1-6** — Appendix **1**

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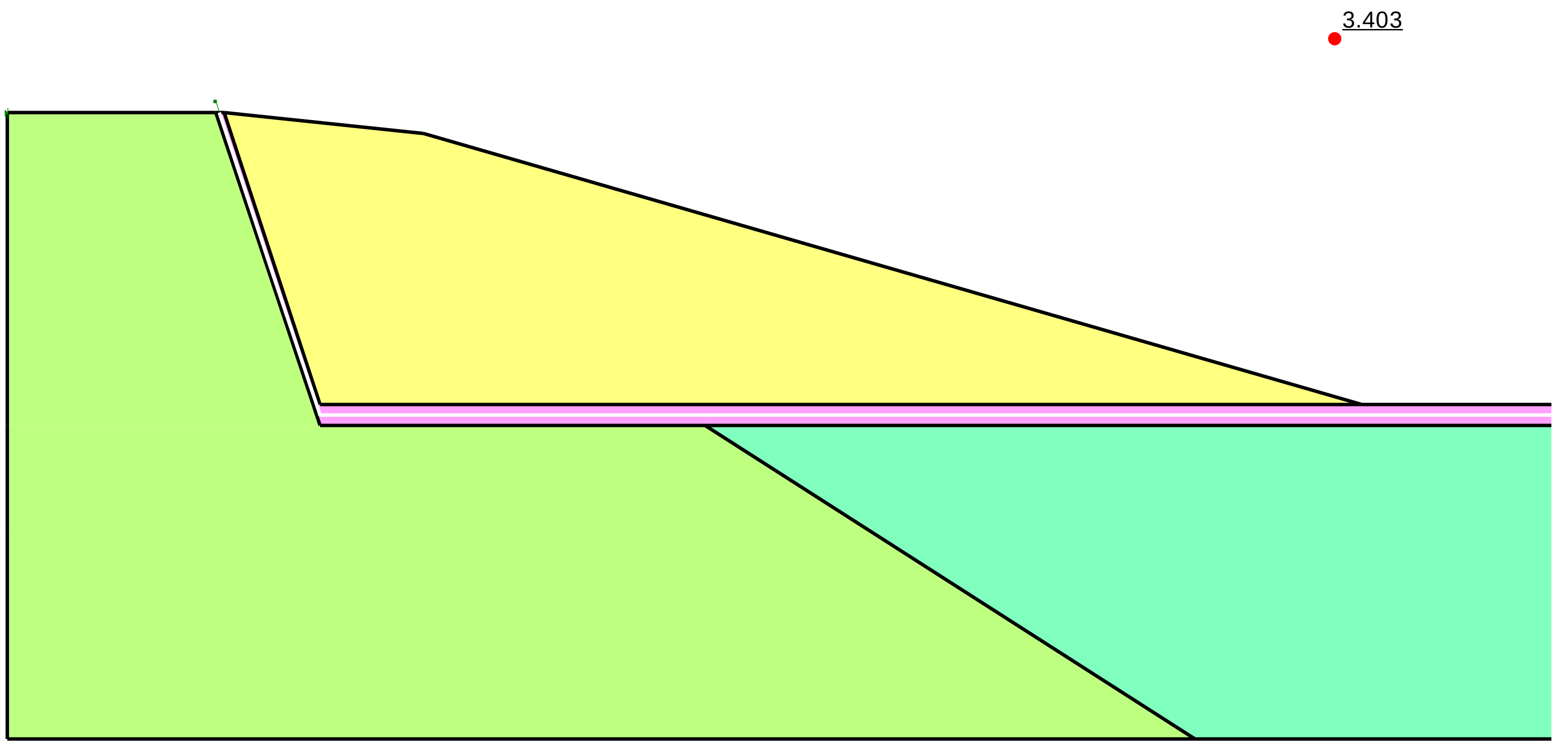
Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Ru
	Attenuation layer	Mohr-Coulomb	18	0.5	26	0	0
	Backfill	Mohr-Coulomb	18	2	32	0	0
	Chalk	Bedrock (Impenetrable)					0
	Waste	Mohr-Coulomb	18	0.5	26	0	0.1



Notes:

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Site: MELTON ROSS WESTERN QUARRY

Project: STABILITY RISK ASSESSMENT

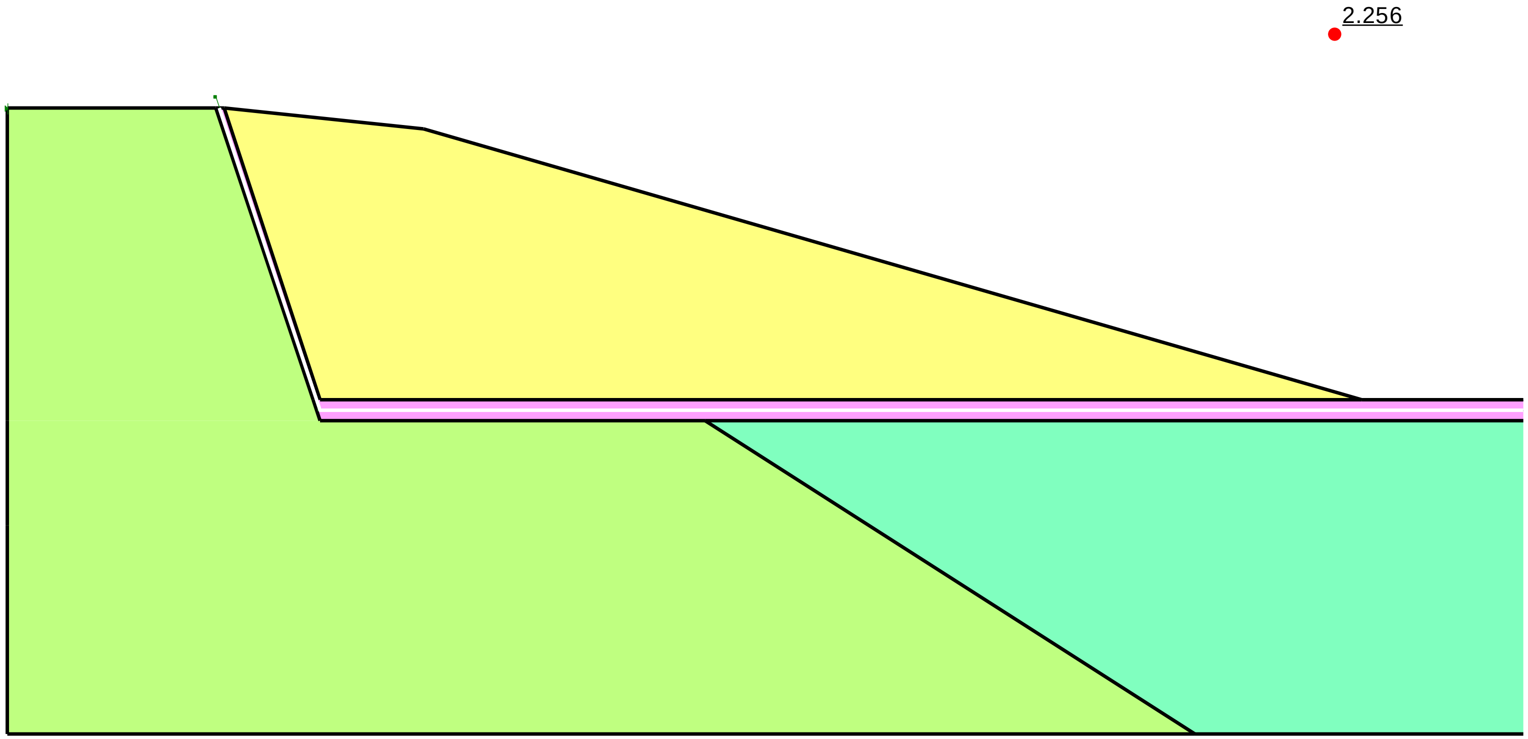
Date: OCTOBER 2020

SCALE: NTS

Drawing: **SRA 1-7**

Appendix **1**

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Ru
	Attenuation layer	Mohr-Coulomb	18	0	18	0	0
	Backfill	Mohr-Coulomb	18	2	32	0	0
	Chalk	Bedrock (Impenetrable)					0
	Waste	Mohr-Coulomb	18	0.5	26	0	0.1



Notes:

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Site: MELTON ROSS WESTERN QUARRY

Project: STABILITY RISK ASSESSMENT

Date: OCTOBER 2020

SCALE: NTS

Drawing: **SRA 1-8**

Appendix **1**

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