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# WYG ENVIRONMENTAL LTD.

## RIDING COURT FARM, DATCHET, BERKSHIRE

## Stability Risk Assessment Report

## GEC JOB NO: GE160270908

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# CONTENTS



**LIST OF TABLES**

## LIST OF APPENDICES

# 1.0 INTRODUCTION

## Report Context

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

1.2 WYG Environmental Ltd. (WYG) has instructed Geotechnical & Environmental Consulting Ltd. (GEC) to undertake a Stability Risk Assessment (SRA) to form part of an Environmental Permit Application for Riding Court Farm, Datchet, Berkshire.

1.3 It is understood that the void, to be backfilled with inert waste, will be formed by sand and gravel extraction works. Systematic filling with inert waste will commence on completion of mineral extraction work provided the necessary regulatory permissions are received.

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

- Volume 1 – Planning Application Statement. Extraction of Sand & Gravel and Importation of Restoration Material at Riding Court Farm, Datchet, Berkshire.
- Riding Court Farm, Datchet, Berkshire Review of 1995 Geological Investigation Data. CEMEX UK Operations Ltd. Dated 28/10/11.
- Response to Schedule 5 Notice, CEMEX Kingsmead Landfill Application no. EPR/BB3102/A001. Dated 27/05/2014.

1.5 It is understood that planning restrictions prevent dewatering of the site during either the mineral extraction or inert waste placement phases of the works meaning both mineral extraction and waste placement will take place both above and below standing groundwater level.

## Conceptual Stability Site Model

Location

1.6 This Stability Risk Assessment refers to the area that is included within the Environmental Permit Application boundary shown on Drawing No. (A097237_LOC_01) and covers the area of 43.8 hectares.

1.7 The site is located immediately to the north of the M4 Motorway and separated from it by a two lane unclassified road which runs parallel and adjacent to the M$ for some of its length. The site is centred on the Riding Court Farm office complex which is located approximately 600m northeast of the town of Datchet. The centre of the site is located at National Grid Reference (NGR) 499092 177757 (Drawing No. A097237_LOC_01).

1.8 The site is generally level and lies within the middle part of the valley of the River Thames. Some areas of the application area lie within the floodplain of the River Thames.

Regional Geology

1.9 With reference to British Geological Survey Sheet 269 Windsor and Bracknell 1:50000 Sold & Drift, the site is located on Shepperton Gravel Member (SHGR) overlying London Clay Formation (LCF). A band of Alluvium is shown to cross the site coincident with its northern boundary.

1.10 The BGS Lexicon of Named Rock Units describes the SHGR as Devensian age comprising gravel with subordinate amounts of sand and clay. The SHGR forms part of the Maidenhead Formation present below the Thames floodplain Alluvium. The London Clay Formation, which forms the bedrock in the area, is described as a Palaeogene deposit of Clay, Silt and Sand.

1.11 2no. boreholes available from the British Geoscience Database are located within the boundary of the site and show the geology to comprise 4.0ft (1.2m) Topsoil over 15.0ft (4.6m) of Gravel in turn overlying > 2.0ft (>0.6m) of Clay.

1.12 A borehole carried out by Fugro-McCelland as part of the M4 Gantries investigation adjacent to the western boundary of the site indicates the ground condition to comprise 0.75m of road construction materials overlying 7.85m of sandy fine to coarse Gravel in turn overlying stiff closely fissured London Clay.

Local Geology

1.13 A mineral resource assessment was carried out by CEMEX during 1995 comprising 54No. power auger boreholes drilled on a 100m grid. A review of this ground investigation is presented in CEMEX UK Review Report dated 28/10/2011 and in brief showed the site to typically comprise 0.30m of Topsoil overlying 0.70m of Clay in turn overlying 4.50m of Sand and Gravel with London Clay Formation forming the basal unit in the investigation.

1.14 A précis of the ground conditions encountered during this investigation is presented in Table SRA1.

**Table SRA1 Local Stratigraphy in Riding Court Farm, Datchet**

| Stratum | Stratigraphy | | | | | | Notes |
|---|---|---|---|---|---|---|---|
| | From (mbgl) | | To (mbgl) | | Thickness (m) | | |
| | Min | Max | Min | Max | Min | Max | |
| Topsoil/Subsoil | GL | | 0.30 | 1.00 | 0.30 | 1.00 | |
| Clay / Sand (Possibly Thames Floodplain Alluvium) | 0.30 | 1.00 | NP | 2.10 | NP | 1.80 | Recorded as not being present (NP) at 10 locations |
| Shepperton Gravel Member | 0.30 | 2.10 | 4.10 | 10.80 | 3.20 | 9.70 | Thicker sequences of Gravel located towards the south of the site. |
| London Clay Formation | 4.10 | 10.80 | >0.90 | | | | Maximum proven thickness |

*GL – Ground Level*

<u>Hydrogeology</u>

1.15 The Environment Agency website indicates the Riding Court Farm overlies a principal aquifer interpreted as the Shepperton Gravel Member. The London Clay Formation is considered as a Non Aquifer.

1.16 A tributary of the River Thames flows to the east of the site before turning and running along the northern boundary of the application area. The River Thames flows 800m to the south of the site at its nearest point; whist the Queen Mother Reservoir is located approximately 300m to the southeast on the southern side of the M4 Motorway.

1.17 Groundwater levels reported in the CEMEX Review Report indicates a perched groundwater table to be present within the Shepperton Gravel at between 2.50 and 4.50mbgl. No groundwater strikes were reported in the limited thickness of the London Clay Formation investigated.

## Basal Subgrade Model

1.18 In the area of Riding Court, Datchet the underlying Shepperton Gravel Member is to be excavated as part of the mineral extraction works. Therefore the basal subgrade will comprise the London Clay Formation.

1.19 The London Clay Formation is described locally as stiff blue clay and is considered to be of medium compressibility.

1.20 Groundwater has been recorded within the Shepperton Gravel Member at between 2.50 and 4.50mbgl. No groundwater strikes have been recorded within the London Clay Formation.

1.21 The full thickness of the London Clay Formation has not been encountered in any of the local boreholes; however published sources indicate a minimum thickness of 50m should be expected beneath the site.

## Basal Lining System

1.22 No basal lining system will be incorporated into the facility design as the basal subgrade will comprise the low permeability London Clay Formation.

## Side Slope Subgrade Model

1.23 The side slope subgrade model will comprise Shepperton Gravel Member overlying London Clay Formation. There is a discontinuous layer of superficial Clay / Sand, interpreted as Thames Floodplain Alluvium, above the Shepperton Gravel Member (Table SRA1) but this stratum will be removed during the site stripping phase of the works.

1.24 Perched groundwater has been recorded between 2.50 and 4.50mbgl within the Shepperton Gravel Member. A piezometric surface at 2.50mbgl will be included in the side slope stability model and a porewater coefficient ($r_u$) of 0.2 will be applied to the upper 1.00m of the London Clay Formation to represent long term percolation of groundwater and associated decrease in shear strength.

1.25 A mineral base isopachyte drawing presented as Figure 3 in the CEMEX Review Report indicates the base of the extractable sands and gravel to dip toward the south with the thickest sequence being identified in the area of Riding Court Farm Complex. Across other areas of the site the typical thickness of the Shepperton Gravel Member is between 4.50 and 5.00m. Therefore the side slope subgrade will be modelled with a maximum side slope gradient of 1(v):2(h) and a typical height of 6.00m including 1.00m overdig into the London Clay Formation. Additional analyses will be carried out to assess the effect of deeper extraction works should thicker sequences of gravel be encountered.

## Side Slope Lining Model

1.26 The side slope liner will placed against the 1(v):2(h) side slope subgrade.

1.27 The side slope liner shall be formed using selected imported fine-grained material. It is unlikely that a single source material for the construction of the side slope liner will be available; therefore a selection protocol will be used to ensure the appropriateness of any material.

1.28 The side slope liner will be constructed in each phase of working maintaining a distance of at least 25m ahead of waste tipping. Liner material for placement below standing water level will be dozed over an advancing face and allowed to consolidate at their natural angle of repose under gravity alone. Liner material placed above the standing water level will be compacted by multiple passes of earth moving plant.

1.29 A minimum thickness of side slope liner with a permeability of $1x10^{-6}$m/s of 10m is required to achieve equivalence with the Landfill Directive. However, a minimum thickness of 15.00m is envisaged at the crest of the side slope liner.

1.30 The thickness of the sides slope liner at the base of the void is dependent on the materials natural angle of repose. However, based on typical geotechnical data it is likely to be in excess of 20m.

## Waste Mass Model

1.31 It is proposed that the waste deposited at the Riding Court facility will be from known sources largely comprising London Clay and other materials from large earthwork contracts. Based on data collected from other CEMEX operated inert landfill sites it is estimated that 99% of the imported waste will comprise naturally occurring soils and 1% comprising concrete, bricks, tiles and ceramics.

1.32 Inert waste material for disposal below standing water level will be placed at approximately original ground level before being dozed over an advancing waste face into the water. Waste slopes below standing water level will form at a natural angle of repose.

1.33 Inert waste material for placement above the standing water level will be placed to achieve the final landform during a second phase of landfilling. The toe of the advancing upper face will be maintained at least 20m from the crest of the lower submerged slope. Fill above the water level will be compacted by repeated passes of earthmoving equipment and slopes above the water table will be restricted to a maximum gradient of 1 (v):2(h).

## Restoration Soils Model

1.34 In accordance with the requirements of the Landfill Directive, an engineered cap (clay or plastic) is not required.

1.35 On completion of filling to final levels, the site will be restored to a mixture of agricultural land restored back to original ground levels and two small lakes in a framework of woodland belts and parkland.

1.36 Due to the nature of the waste gas monitoring and control systems are not required.

# 2.0 STABILITY RISK ASSESSMENT

## Risk Screening

Basal Subgrade Screening

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

2.2 Therefore a full stability analysis of the basal subgrade is not required but the material will be included in the analysis of both the Waste Mass and the Side Slope Subgrade.

Basal Lining System Screening

2.3 No basal liner is to be constructed at this site

Side Slope Subgrade Screening

2.4 The side slopes will be formed as part of the sand and gravel extraction process and will comprise Shepperton Gravel Member overlying the London Clay Formation.

2.5 The presence of groundwater within the Shepperton Gravel Member at between 2.5 and 4.5m below existing ground level means that the lower side slope subgrade will be formed below standing groundwater levels.

2.6 The side slopes will be formed at a maximum gradient of 1(v):2(h) above standing water level and will form at their natural angle of repose below standing water level.

2.7 A full stability analysis of the subgrade model is considered necessary.

Side Slope Lining System

2.8 An artificially established side lining system will be constructed at the Riding Court Farm site. The liner will be constructed using selected fine-grained materials from different sources.

2.9 The liner material will be placed below standing water by dozing over the exposed face created by the mineral extraction works and allowed to consolidate under its own weight to form a final face gradient equal to its natural angle of repose. Above the standing water level the material will be place and compacted by repeated passes of earth moving plant. The minimum liner thickness at the crest will be 15m but maybe considerably thicker at the toe dependant on its angle of repose.

2.10 A full investigation of this component is considered necessary.

2.11 Characteristic geotechnical values are presented in Table SRA4.

Waste Mass Screening

2.12 Inert waste placed at the site will largely comprise natural soils from local earthwork projects.

2.13 The inert waste will be placed both above and below the standing groundwater level. Below the standing groundwater level the waste will be allowed to consolidate under its own weight whilst above the standing groundwater level the inert waste will be compacted by multiple passes of earthmoving plant.

2.14 A full stability analysis of both the temporary and permanent waste faces will be carried out as part of this stability risk assessment.

Capping System Screening

2.15 There is no requirement for an engineered cap as this site. Restoration soils will be placed to achieve a landform similar to the pre-extraction levels. Due to the type of the waste to be placed at the site no gas or uplift pressures will be generated within the waste mass.

2.16 Based on the above no detailed analysis of the restoration landform is considered necessary.

### Justification of Modelling Approach and Software

2.17 Two dimensional limit equilibrium stability analyses were used in the assessment of the stability of the subgrade and subgrade liner. The method of analysis used in each particular case was determined from an examination of the form of failure being considered.

2.18 The stability analyses of the slopes were carried out using the Slope/W computer programme.

2.19 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.

2.20 No explicit analysis of likely settlement will be carried out although reference will be made to areas where settlements may need to be considered.

### Justification of Geotechnical Parameters Selected for Analyses

Parameters Selected for Basal Subgrade Analyses

2.21 The basal subgrade will be included the analysis of both the side subgrade and waste mass. The characteristic properties of the basal subgrade are presented in Table SRA2.

**Table SRA2 Basal Subgrade Stability – Summary of Geotechnical Data**

| Parameter | | | Characteristic Value | | Source |
|---|---|---|---|---|---|
| Unit Weight | | $\gamma_k$ | 19kN/m$^3$ | | BS8002 Table 1 |
| Shear Strength | Total | $c_{uk}$ , $\phi_{uk}$ | 75kN/m$^2$ | 0˚ | Lower bound value for stiff clays |
| | Effective | $c'_k$ , $\phi'_k$ | 5kN/m$^2$ | 23˚ | Published values for London clay |
| Coefficient of Compression | | $m_{vlk}$ | 0.20m$^2$/MN | | Published value for medium compressibility clay |
| Modulus of Deformation | Undrained | $E'_k$ | 30MN/m$^2$ | | 400 x $c_{uk}$ |
| | Drained | $E_{uk}$ | 23MN/m$^2$ | | 0.75 x $E_{uk}$ |

Parameters Selected for Side Slopes Subgrade Analyses

2.22 Side Slope Subgrade analyses will be carried out on the side slopes formed in the Shepperton Gravel Member and London Clay Formation. The characteristic geotechnical parameters to be used in the analysis subgrade are presented in Table SRA3.

**Table SRA 3 Side Slope Subgrade Stability – Summary of Characteristic Geotechnical Data**

| Stratum | Parameter | | | Characteristic Value | | Source |
|---|---|---|---|---|---|---|
| Topsoil / Thames Floodplain Alluvium | Not included in Side Slope Stability Model | | | | | |
| Shepperton Gravel Member | Unit Weight | | $\gamma_k$ | 20kN/m$^3$ | | BS8002 Table 1 |
| | Shear Strength | | $c_k$, $\phi_k$ | 0kN/m$^2$ | 35˚ | Published values |
| London Clay Formation | Unit Weight | | $\gamma_k$ | 19kN/m$^3$ | | BS8002 Table 1 |
| | Shear Strength | Total | $c_{uk}$ , $\phi_{uk}$ | 75kN/m$^2$ | 0˚ | Lower bound value for stiff clays |
| | | Effective | $c'_k$ , $\phi'_k$ | 5kN/m$^2$ | 23˚ | Published values for London clay |

Parameters Selected for Side Slopes Liner Analyses

2.23 The side slopes liner is to be constructed using appropriate fine-grained material. Typical values for clay materials have been used to define the characteristic geotechnical values of the side slope liner material. It should be noted that liner material placed above and below the standing water level have been assigned different geotechnical characteristic values to represent saturation and softening (Table SRA 4).

**Table SRA 4 Side Slopes Liner Stability – Summary of Characteristic Geotechnical Data**

| Stratum | | Parameter | | | Characteristic Value | | Source |
|---|---|---|---|---|---|---|---|
| Selected Fine Grained | Above Standing Water | Unit Weight | | $\gamma_k$ | 18kN/m$^3$ | | BS8002 Table 1 |
| | | Shear Strength | Total | $c_{uk}$ , $\phi_{uk}$ | 40kN/m$^2$ | 0˚ | Selection Protocol |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Material | | | Effective | $c_k$, $\phi_k$ | 10kN/m$^2$ | 23˚ | Published values |
| | Below Standing Water | Unit Weight | | $\gamma_k$ | 17kN/m$^3$ | | Loosely placed |
| | | Shear Strength | Total | $c_{uk}$ , $\phi_{uk}$ | 40kN/m$^2$ | 0˚ | Selection Protocol |
| | | | Effective | $c'_k$ , $\phi'_k$ | 0kN/m$^2$ | 23˚ | Softened due underwater placement |

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

2.24 The waste will largely comprise fine-grained materials from known sources with minor amounts of concrete and other demolition debris. The material will be placed both above and below standing water level therefore two sets of characteristic geotechnical values are presented for the Waste Mass.

**Table SRA 5 Waste Mass Stability – Summary of Characteristic Geotechnical Data**

| Stratum | | Parameter | | | Characteristic Value | | Source |
|---|---|---|---|---|---|---|---|
| Waste Mass | Above Standing Water | Unit Weight | | $\gamma_k$ | 16kN/m$^3$ | | Compacted above groundwater table |
| | | Shear Strength | Total | $c_{uk}$ , $\phi_{uk}$ | 40kN/m$^2$ | 0˚ | |
| | | | Effective | $c_k$, $\phi_k$ | 5kN/m$^2$ | 23˚ | |
| | Below Standing Water | Unit Weight | | $\gamma_k$ | 17kN/m$^3$ | | Loosely placed. Potentially open voids between clay “clods” in the short term followed by long term softening and consolidation. |
| | | Shear Strength | Total | $c_{uk}$ , $\phi_{uk}$ | 40kN/m$^2$ | 0˚ | |
| | | | Effective | $c'_k$ , $\phi'_k$ | 0kN/m$^2$ | 21˚ | |

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

2.25 None selected as no further analysis of the capping is required.

## Selection of Appropriate Factors of Safety

2.26 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 SRA 6 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 ($c_u$) | | $\gamma_{cu}$ | 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 ($c_u$) | | $\gamma_{cu}$ | 1.40 |
| | | | Resistance R1 | | | |
| | | | Resistance | | $\gamma_{R;e}$ | 1.00 |

## Analyses

<u>Side Slope Subgrade</u>

2.27 Both the short and long term stability of the side slope subgrade have been assessed using the Slope/W software for a range of circular failures using total and effective stress parameters.

2.28 The analysis has included an accidental overdig of 1.00m into the basal subgrade and the effect of subsequent softening of this material.

2.29 Results of the Side Slope Subgrade analyses are presented in Appendix 1 and summarised below.

**Table SRA 7 Side Slope Subgrade Stability – Summary of Results**

| Run | File Name | Stress Condition | Factor of Safety | | Notes |
|---|---|---|---|---|---|
| | | | C1 | C2 | |
| 01 | Side Slope 1 | Total | 1.13 | | Side slope subgrade maximum face angle 34˚<br>Slope failure under combination 2 factors |
| 02 | Side Slope 2 | Total | | 0.86 | |
| 03 | Side Slope 3 | Total | 1.52 | | Slacken of Face angle to 27˚ (1v:2h) |
| 04 | Side Slope 4 | Total | | 1.15 | |
| 05 | Side Slope 5 | Effective | 1.52 | | Effective Stress Conditions will only effect the shear strength of the fine-grained materials |
| 06 | Side Slope 6 | Effective | | 1.15 | |
| 07 | Side Slope 7 | Effective | 1.33 | | Softening of the Upper level of the London Clay |
| 08 | Side Slope 8 | Effective | | 1.02 | |
| 09 | Side Slope 9 | Effective | 1.17 | | Accidental overdig 1.00m in softened LCF |
| 10 | Side Slope 10 | Effective | | 1.03 | |
| 11 | Side Slope 11 | Effective | 1.64 | | Side Slope Height up to 10m |
| 12 | Side Slope 12 | Effective | | 1.13 | |

<u>Side Slope Liner</u>

2.30 Initially the side slope liner material will be end tipped and allowed to consolidate under its own weight at its natural angle of repose.

2.31 The stability of the side slope liner was analysed using the computer programme Slope/W to calculate the factor of safety against failure entirely within the liner for a range circular failure surfaces using Morgenstern and Price's method.

2.32 The side slope liner stability analysis will initially investigate the placement of the material below standing water level and then investigate the effect of placing additional material above the standing water level. Effective stress conditions only will be analysed for the below water analysis whilst both total and effective stress conditions will be considered in the above water model.

2.33 Results of the side liner analyses are presented in Appendix 2 and summarised below.

**Table SRA 8 Side Slope Liner Stability – Summary of Results**

| Run | File Name | Stress Condition | Factor of Safety | | Notes |
|---|---|---|---|---|---|
| | | | C1 | C2 | |
| 13 | Side Liner 1 | Effective | 1.24 | | Underwater Placement of material consolidation under self-weight. Liner face angle = 17˚ |
| 14 | Side Liner 2 | Effective | | 1.00 | |
| 15 | Side Liner 3 | Total / Effective | 1.24 | | Placement of upper liner material, minimum 15.00m crest width, short term undrained conditions. |
| 16 | Side Liner 4 | Total / Effective | | 1.00 | |
| 17 | Side Liner 5 | Effective | 1.24 | | Placement of upper liner material, minimum 15.00m crest width, long term drained conditions. |
| 18 | Side Liner 6 | Effective | | 1.00 | |
| 19 | Side Liner 7 | Effective | 1.28 | | Placement of upper liner material, minimum 15.00m crest width and 5.00m bench, long term drained conditions. |
| 20 | Side Liner 8 | Effective | | 1.03 | |

Waste Mass

2.34 Waste stability must be assessed as part of the design process for the temporary waste slope configuration. 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.

2.35 The waste will be placed both above and below the standing water level such that the face angle formed below the standing water level will be dependent on the material properties of the waste and will achieve a stable slope with a factor of safety of 1.00. Therefore the following analysis of the waste mass and the proposed face angles is appropriate for the waste placed above the standing water level.

Temporary Waste Slopes

2.36 The placement of the waste will utilise a phased approach. The waste in each phase will be deposited in two stages the first stage will fill the void to approximately original ground level with the second filling above original ground level to achieve the final landform. The stage two tipping face will be kept a minimum of 20m from the slope formed during the first stage.

2.37 The maximum gradient of the temporary waste slopes during placement operations will be restricted to 1 (v):2 (h).

2.38 Leachate pore fluid pressures may develop in the waste mass during filling due to infiltration.

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

2.40 SlopeW has been used to undertake a serviceability limit state (SLS) investigation into failures wholly within the temporary waste slopes under short term total stress conditions.

2.41 The results of the SlopeW stability analyses are presented in Appendix 3 and in Table SRA 9.

**Table SRA 9 Temporary Waste Mass Slope Stability – Summary of Results**

| Run | File Name | Stress Condition | Serviceability Limit State | Notes |
|---|---|---|---|---|
| 21 | Waste Mass 1 | Total / Effective | 1.57 | Temporary Waste Mass Face at 1(v):2(h) Stage 1 Placement. Waste Mass undrained |
| 22 | Waste Mass 2 | Total / Effective | 1.57 | Rising leachate level in Waste Mass + 1.00 above standing water |
| 23 | Waste Mass 3 | Total / Effective | 1.57 | Rising leachate level in Waste Mass + 2.00 above standing water |

2.42 From the analysis of the temporary waste mass slopes it can be seen that if the waste mass is left for long periods of time such that leachate levels rise within the waste body a 1(v):2(h) slope will remain stable. However, during this period softening will also occur, leading to a reduction in shear strength.

Permanent Waste Slopes

2.43 Temporary waste slopes left for long periods should be considered as permanent and to represent these conditions an effective stress stability analysis has been carried out. Initially the waste mass has been modelled using the long term drained conditions and then the effect of softening has been considered.

2.44 The results of the Permanent Waste Mass Slope analyses are presented in Appendix 3 and a précis of the results is shown in Table SRA 10.

**Table SRA 10 Permanent Waste Mass Slope Stability – Summary of Results**

| Run | File Name | Stress Condition | Factor of Safety | | Notes |
|---|---|---|---|---|---|
| | | | C1 | C2 | |
| 24 | Waste Mass 4 | Effective | 1.29 | | Permanent Waste Mass Face at 1(v):2(h) Stage 1 Placement. Waste Slope marginally unstable under C2 |

| | | | | | |
|---|---|---|---|---|---|
| 25 | Waste Mass 5 | Effective | | 0.99 | Partial Factors |
| 26 | Waste Mass 6 | Effective | 1.50 | | Slacken Batter of Waste Face to 1(v):2.5(h) |
| 27 | Waste Mass 7 | Effective | | 1.16 | |
| 28 | Waste Mass 8 | Effective | | 1.05 | Long term softening of Waste Mass |

Settlement Waste Mass and Liner

2.45 Both the Side Slope Liner and the Waste Mass are to be placed beneath the standing water level by tipping and allowing the material to consolidate under its own weight. The fine-grained material of the liner and the waste mass will behave like a granular stratum and have many voids within it until it softens and consolidation occurs. Bulking factors for high plasticity clays are generally between 1.35 to 1.40 which means that for every metre of material placed 400mm of settlement may occur whilst the inter "clod" void spaces close. Therefore considering the placement of between 2.5 and 3.5m of material below standing water level consolidation settlements of between 1.00 and 1.40m should be expected.

2.46 Above standing water level settlements will be restricted to consolidation of the compacted clay liner / waste material and is likely to be less than 100mm.

## Assessment

### Basal Subgrade

2.47 The basal subgrade will comprise the in-situ London Clay Formation which is described as an over-consolidated firm to stiff grey silty Clay. The void will be created by the removal of the sands and gravels above the London Clay which will lead to a net unloading of the Basal Subgrade whilst placement of the inert waste will reload it. Given the differences in the unit weights of the London Clay and the inert waste there will be no increase in loading intensity on the Basal Subgrade. Therefore settlements of the basal subgrade will be limited to the elastic recompression of the London Clay which will not affect the integrity of this in-situ material.

### Side-Slope Subgrade

2.48 The side-slope subgrade will be formed by the extraction of the Shepperton Gravel Member.

2.49 All the side slope subgrade SlopeW analyses indicate that the Combination 2 partial factor set offers the more onerous of the two approaches recommended within the National Annex to EC7.

2.50 SlopeW runs 01 – 04 (Table SRA 7) indicate that the post mineral extraction slopes should not exceed 1(v): 2(h) to ensure long term stability.

2.51 SlopeW Runs 07 – 10 illustrate the effect of accidental overdig and softening of the London Clay basal subgrade. The results of the analyses indicate that the side slope subgrade will remain stable even in the unlikely event of systematic overdig into the London Clay and or softening of the basal London Clay Formation.

2.52 Although the majority of the extractable mineral is within 6.00m of the ground surface Slope W runs 11 -12 show that the side slope subgrade will remain stable with slope heights up to 10m.

2.53 It is concluded that the side slope subgrade will be stable at heights of up to 10.00m provided the side slope gradient does not exceed 1(v) : 2(h) (27°).

Side-Slope Liner

2.54 The side slope liner is to be constructed by end tipping selected fine-grained material below the standing water level and compacting the liner material above it. A minimum thickness of 15.00m will be achieved at the crest of the liner, whilst the thickness at the toe of the liner will be largely dependent on its natural angle of repose.

2.55 Initially the stability of the side slope liner beneath the standing water level was investigated using the software program SlopeW. The results indicate that partial factor combination C2 offers the most onerous conditions and to achieve a factor of safety of 1.00 the face angle of the side slope liner material is 17°. Although a factor of safety of 1.00 is indicative of a material on the point of failure if a slope is allowed to attain its own natural angle of repose by definition this will be at a factor of safety of 1.00.

2.56 SlopeW Runs 15 -18 (Table SRA 8) indicate that there is no effect to the liner stability from by the placement of the upper liner material with the factor of safety remaining at 1.00.

2.57 SlopeW Run 19 -20 investigate the effect of including a 5.00m bench and set back between the upper and lower side slope liner material. The analyses indicate that using combination 2 factors, a slight increase in factor of safety from 1.00 to 1.05 can be achieved by adopting the benched geometry.

2.58 In conclusion the side slope liner is stable using the method of construction proposed although large settlements should be expected during the end tipping phase of the construction as the material softens. The results of these settlements may lead to a requirement for some post-construction liner placement in order to maintain the required liner crest level.

Waste Mass

2.59 Inert waste will be placed above and below the standing water level. Below the standing water level the waste material will from a face angle equivalent to its natural angle of repose that will be stable with a factor of safety of 1.00.

2.60 Temporary waste slopes formed above the standing water level should be restricted to a face angle of less than 1(v) : 2 (h). Under these conditions a serviceability limit state SlopeW analysis indicated a minimum factor of safety 1.57.

2.61 Although the term leachate is used in the case of inert waste it refers to the inclusion of natural water either by percolation or inclusion during placement. Two SlopeW analyses have been carried out to represent an increase in leachate level (SlopeW Runs 22 and 23) and demonstrate that increases in leachate level have no discernible effect on the overall stability of the waste slopes.

2.62 If temporary waste faces are left unsupported in the long term they should be considered as permanent. SlopeW analyses have been carried out on permanent waste face using the appropriate Design Approach 1 combination 1 and 2 partial factors.

2.63 The results of the permanent waste face analysis indicate that using combination 2 partial factors a permanent waste face at 1(v) : 2(h) is unstable returning a factor of safety of 0.99.

2.64 Therefore in the event of temporary waste slopes being left for long periods of time the batter angle of the waste slope should be slackened to 1(v) : 2.5(h) which will ensure their stability and increase the factor of safety of the waste faces to 1.50.

2.65 The long term softening of the waste mass as a result of exposure to water infiltration or inclusion during placement has been modelled by reducing the effective cohesion to 4kN/m$^2$. SlopeW Run 28 indicates that the waste mass remains stable with a factor of safety of 1.05 even after considerable softening of the waste mass has taken place.

2.66 The results of the waste mass analyses indicate that both temporary and permanent waste slopes will remain stable under all foreseeable conditions provided the waste face gradients are limited to 1(v) : 2(h) and 1(v) : 2.5(v) for temporary and permanent waste slopes respectively.

## 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 in excess of that expected from the settlement predictions, and to identify instability of the waste mass itself at the earliest possible juncture.

Basal Subgrade Monitoring

3.2 The basal subgrade will remain below the standing water level and therefore no visual monitoring of this element will be possible.

Side Slope Subgrade

3.3 The side slopes should be visually monitored for instability both during the mineral extraction works and waste placement operations. In the event of any instances of instability appropriate action should be taken which may include buttressing the toe of the slope using selected fine grained liner material or reducing the side slope angle.

3.4 Care should be taken when plant is operating close to the crest of any side slope. Close inspection of the ground surface should be undertaken with particular attention being paid to the formation of tension cracks. If any features are identified all plant and vehicle movements in the area should be halted and a detailed inspection by a suitably qualified person carried out.

Side Slope Liner

3.5 Much of the side slope liner will be placed beneath the standing water level within the void by tipping selected material and allowing it consolidate under its own weight. This will lead to larger settlement than would normally be expected with material placed in a conventional manner.

3.6 Visual inspection of the side slope liner material placed above the standing water level should be undertaken until the liner is buttressed by the placement of the inert waste material. Particular attention should be paid to the area immediately adjacent to standing water especially during waste placement operations any tension cracking should be reported immediately and tipping operations in the area of the feature ceased immediately.

Waste Mass Monitoring

3.7 Visual monitoring of both temporary and permanent waste faces should be carried out on a regular basis during placement. In the event of any instability being identified appropriate action should be undertaken which is likely to comprise reducing the angle of the waste slope.

3.8 As much of the inert waste will be placed below the standing water level without compaction large settlement of the waste mass should be expected as the waste consolidates under gravity.

Although these settlements are predicted regular monitoring of all waste surfaces should be undertaken and additional placement carried out to maintain the required finished landform / level.

Capping System Monitoring

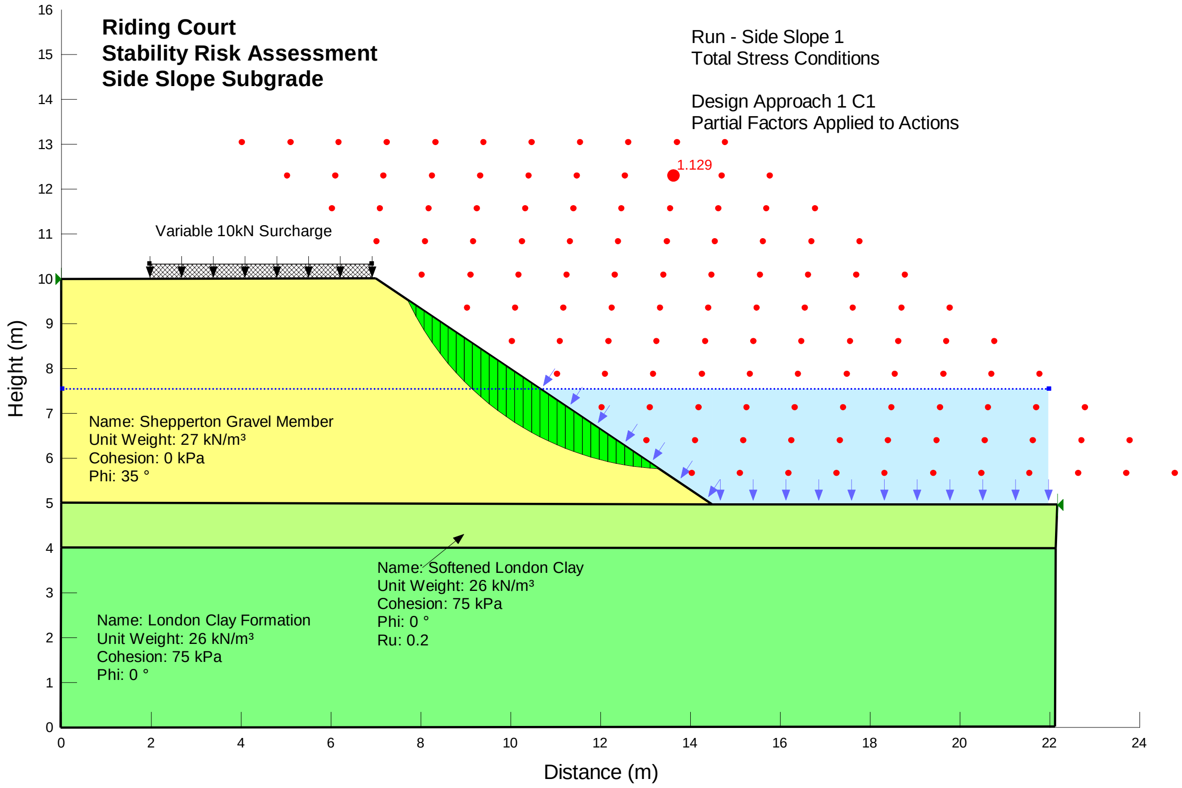
3.9 The condition of the surface of all restored areas will be monitored on a regular basis as part of the site inspection regimen.

3.10 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.

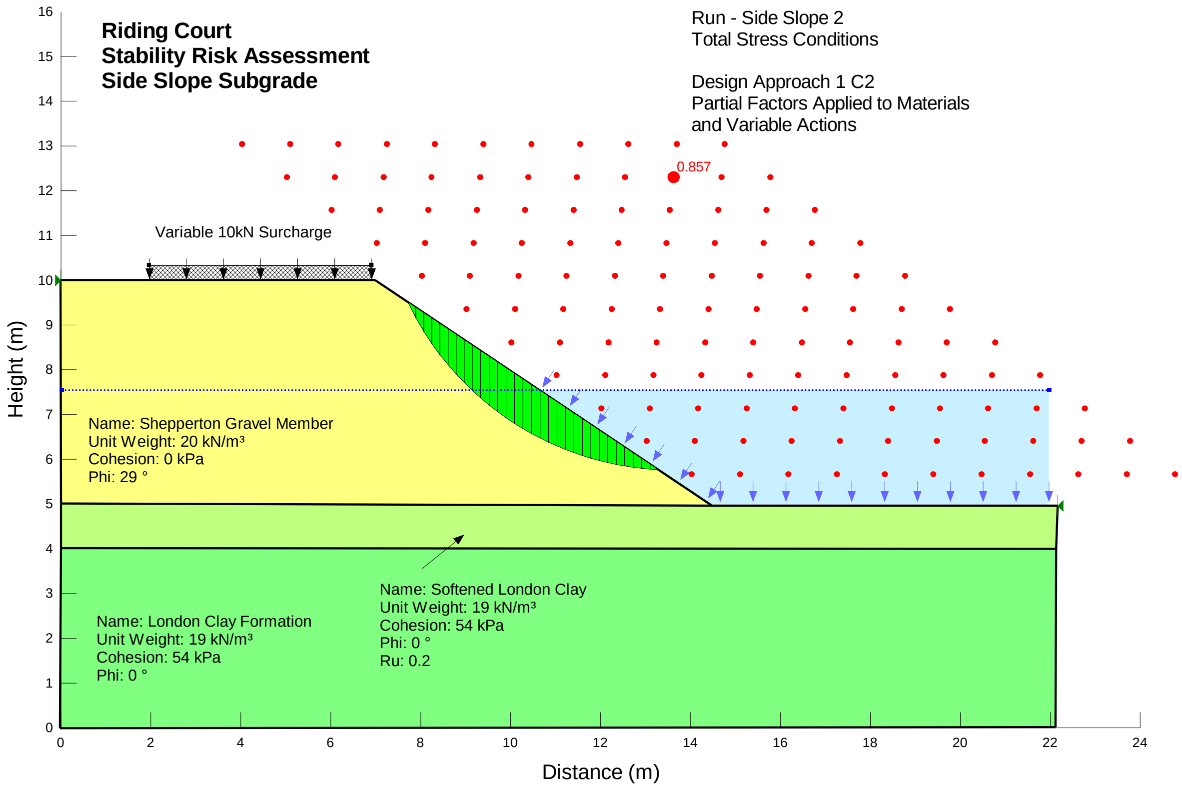
3.11 The Surface of the restored areas will be monitored by land survey techniques on a regular basis. These checks will be on a biannual basis for the first two years and then on an annual basis to the fifth year after restoration, when the periodicity reviewed with the Environment Agency.

# Appendix 1

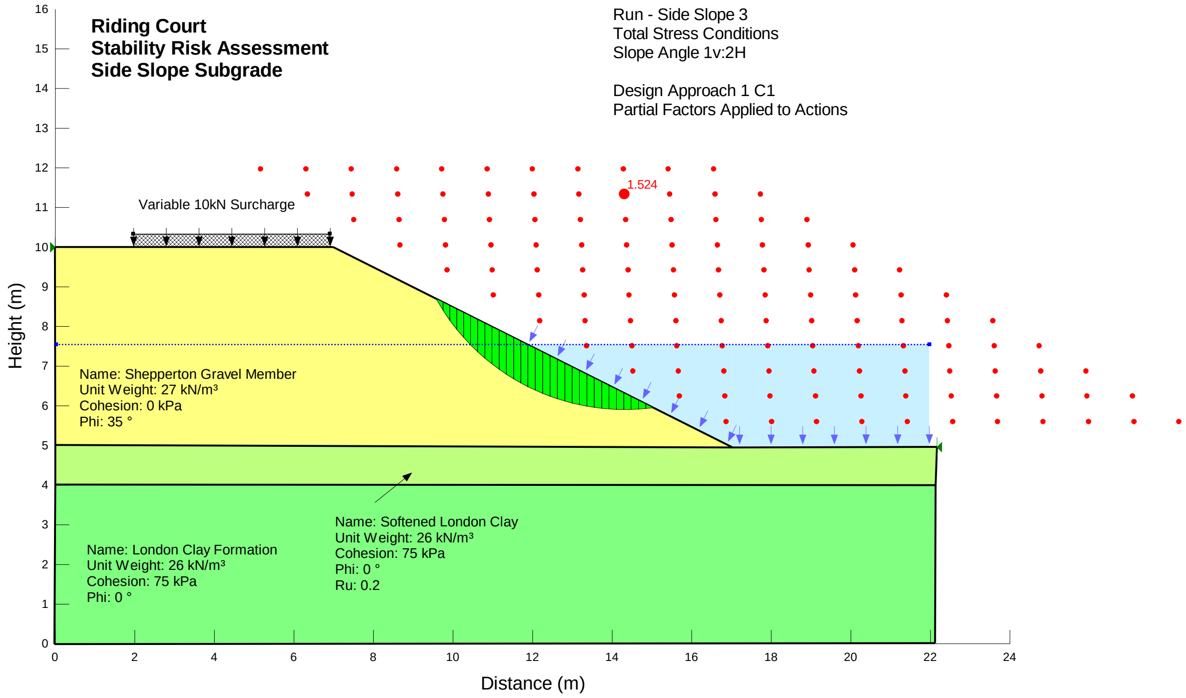
# Slope/W Worksheets – Side Slope Subgrade

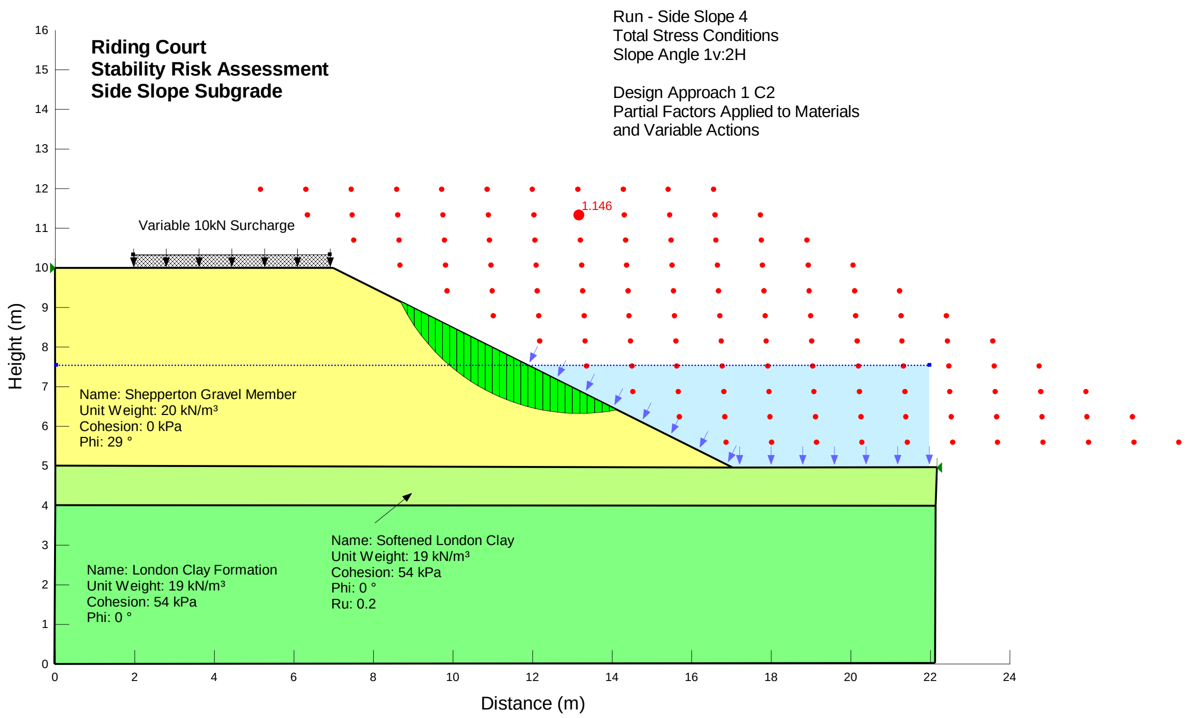


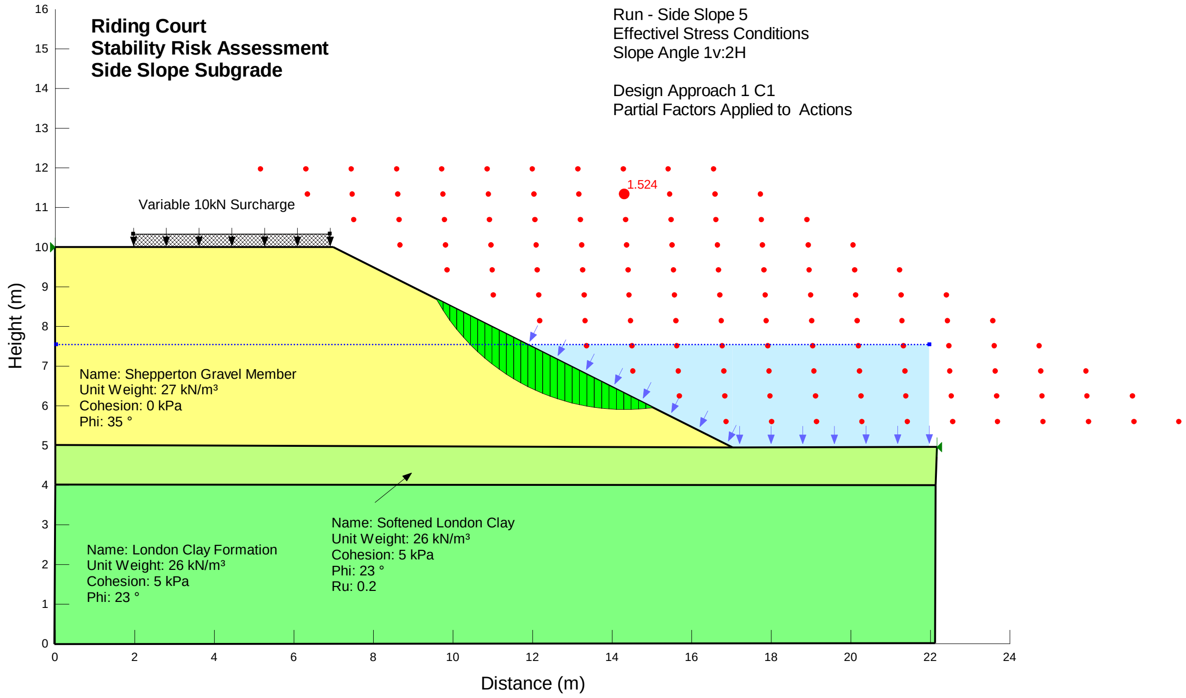
Riding Court
Stability Risk Assessment
Side Slope Subgrade
Run - Side Slope 1
Total Stress Conditions
Design Approach 1 C1
Partial Factors Applied to Actions
1.129
Variable 10kN Surcharge
Name: Shepperton Gravel Member
Unit Weight: 27 kN/m³
Cohesion: 0 kPa
Phi: 35 °
Name: Softened London Clay
Unit Weight: 26 kN/m³
Cohesion: 75 kPa
Phi: 0 °
Ru: 0.2
Name: London Clay Formation
Unit Weight: 26 kN/m³
Cohesion: 75 kPa
Phi: 0 °
Height (m)
Distance (m)

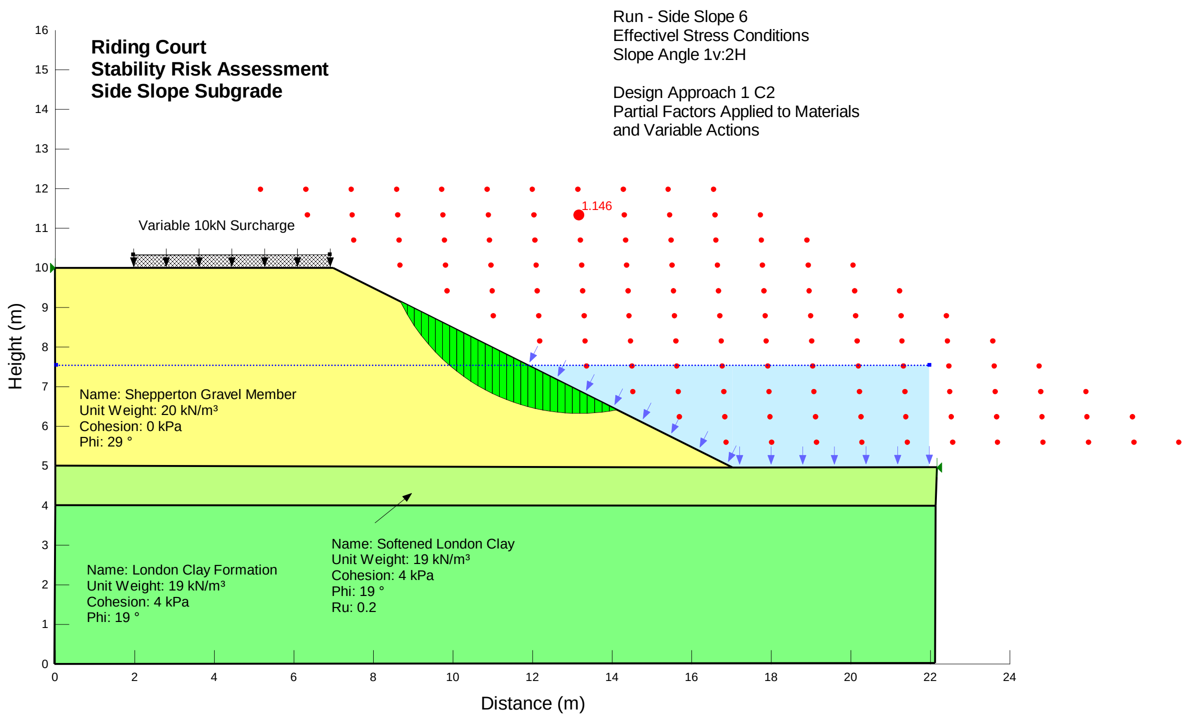



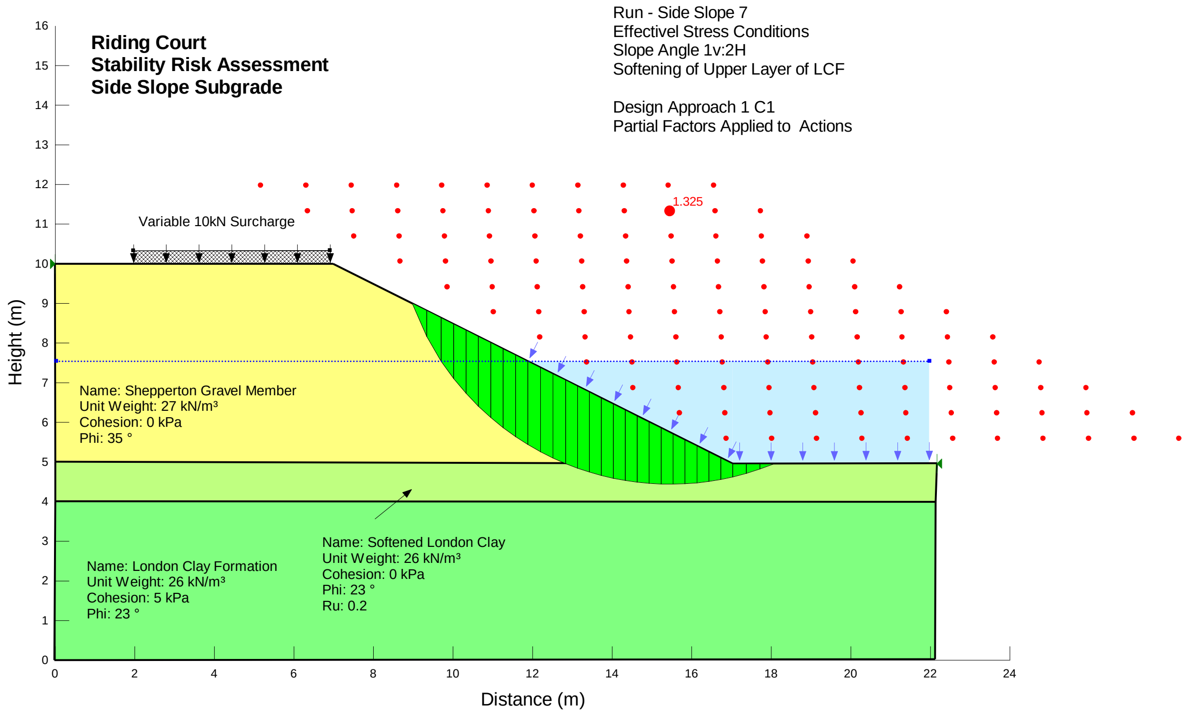
Riding Court
Stability Risk Assessment
Side Slope Subgrade
Run - Side Slope 2
Total Stress Conditions
Design Approach 1 C2
Partial Factors Applied to Materials
and Variable Actions
0.857
Variable 10kN Surcharge
Name: Shepperton Gravel Member
Unit Weight: 20 kN/m³
Cohesion: 0 kPa
Phi: 29 °
Name: Softened London Clay
Unit Weight: 19 kN/m³
Cohesion: 54 kPa
Phi: 0 °
Ru: 0.2
Name: London Clay Formation
Unit Weight: 19 kN/m³
Cohesion: 54 kPa
Phi: 0 °
Height (m)
Distance (m)

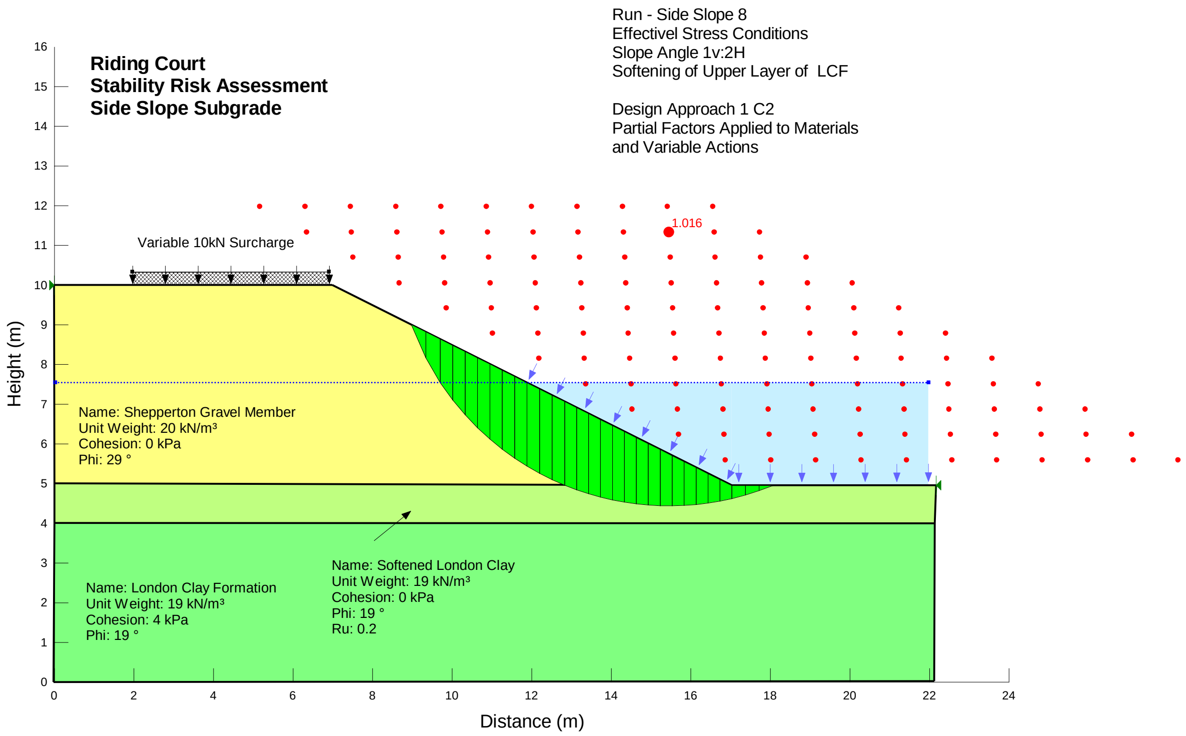

Riding Court
Stability Risk Assessment
Side Slope Subgrade
Run - Side Slope 3
Total Stress Conditions
Slope Angle 1v:2H
Design Approach 1 C1
Partial Factors Applied to Actions
1.524
Variable 10kN Surcharge
Name: Shepperton Gravel Member
Unit Weight: 27 kN/m³
Cohesion: 0 kPa
Phi: 35 °
Name: Softened London Clay
Unit Weight: 26 kN/m³
Cohesion: 75 kPa
Phi: 0 °
Ru: 0.2
Name: London Clay Formation
Unit Weight: 26 kN/m³
Cohesion: 75 kPa
Phi: 0 °
Height (m)
Distance (m)

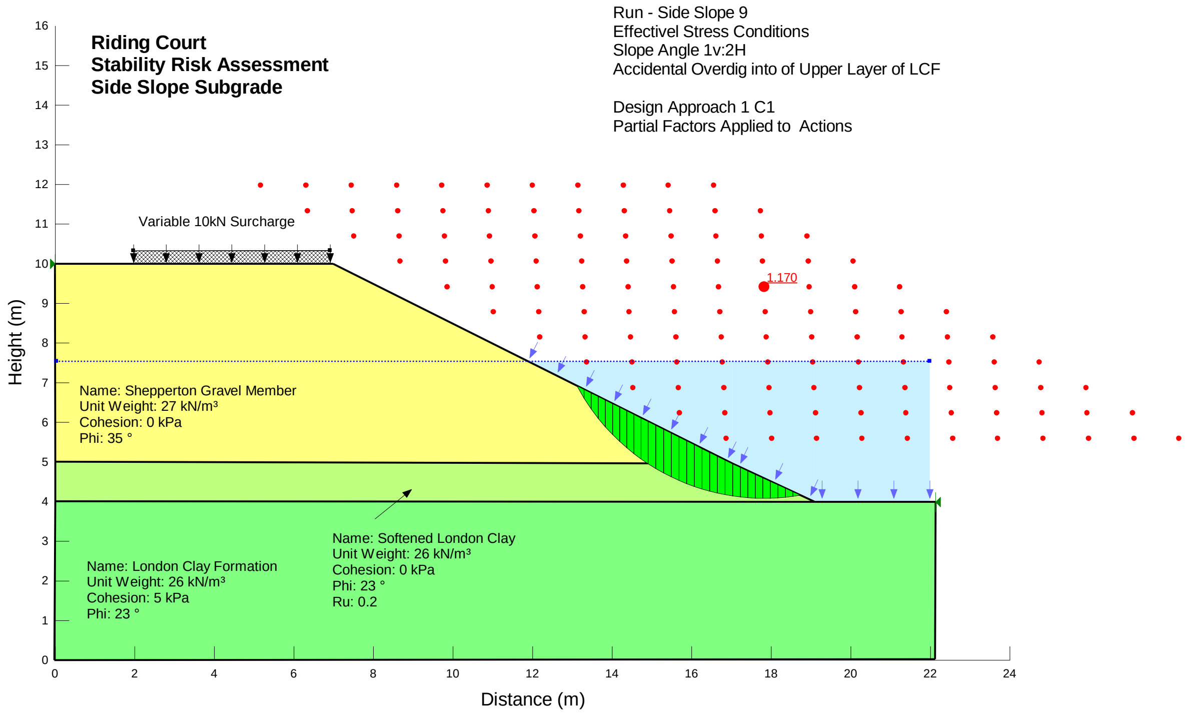

Riding Court
Stability Risk Assessment
Side Slope Subgrade
Run - Side Slope 4
Total Stress Conditions
Slope Angle 1v:2H
Design Approach 1 C2
Partial Factors Applied to Materials
and Variable Actions
1.146
Variable 10kN Surcharge
Name: Shepperton Gravel Member
Unit Weight: 20 kN/m³
Cohesion: 0 kPa
Phi: 29 °
Name: Softened London Clay
Unit Weight: 19 kN/m³
Cohesion: 54 kPa
Phi: 0 °
Ru: 0.2
Name: London Clay Formation
Unit Weight: 19 kN/m³
Cohesion: 54 kPa
Phi: 0 °
Height (m)
Distance (m)

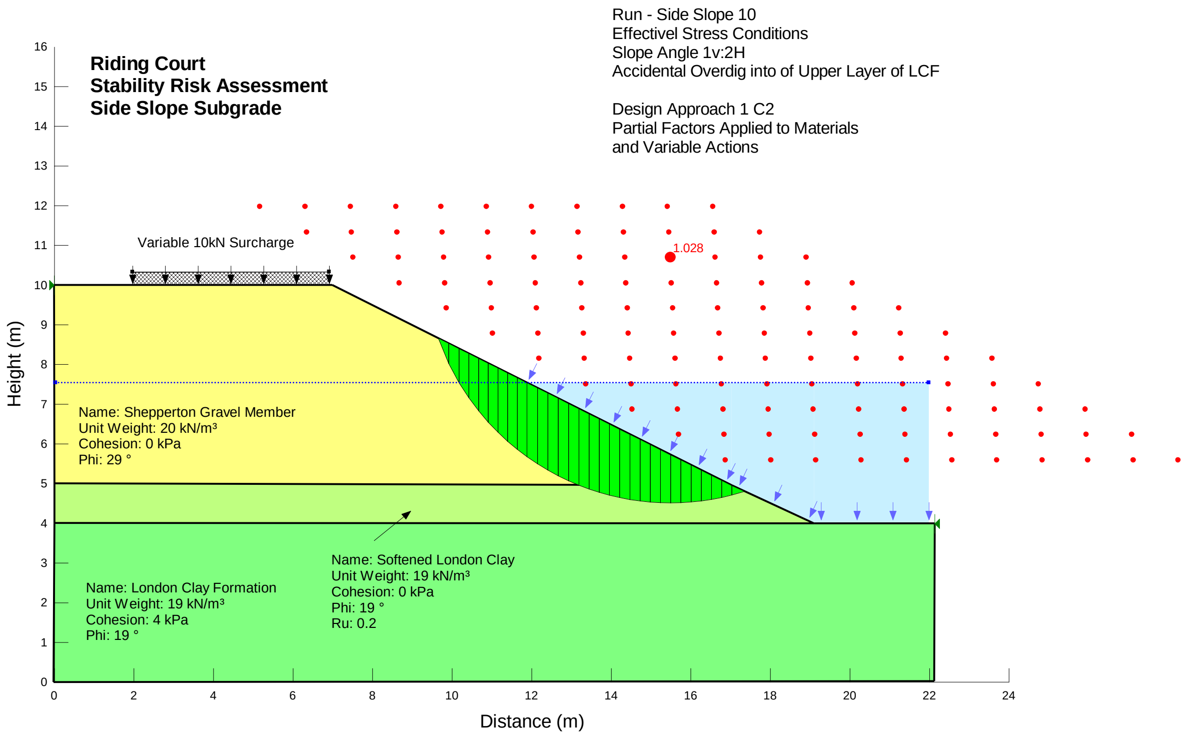

Riding Court
Stability Risk Assessment
Side Slope Subgrade
Run - Side Slope 5
Effective Stress Conditions
Slope Angle 1v:2H
Design Approach 1 C1
Partial Factors Applied to Actions
1.524
Variable 10kN Surcharge
Name: Shepperton Gravel Member
Unit Weight: 27 kN/m³
Cohesion: 0 kPa
Phi: 35 °
Name: London Clay Formation
Unit Weight: 26 kN/m³
Cohesion: 5 kPa
Phi: 23 °
Name: Softened London Clay
Unit Weight: 26 kN/m³
Cohesion: 5 kPa
Phi: 23 °
Ru: 0.2
Height (m)
Distance (m)

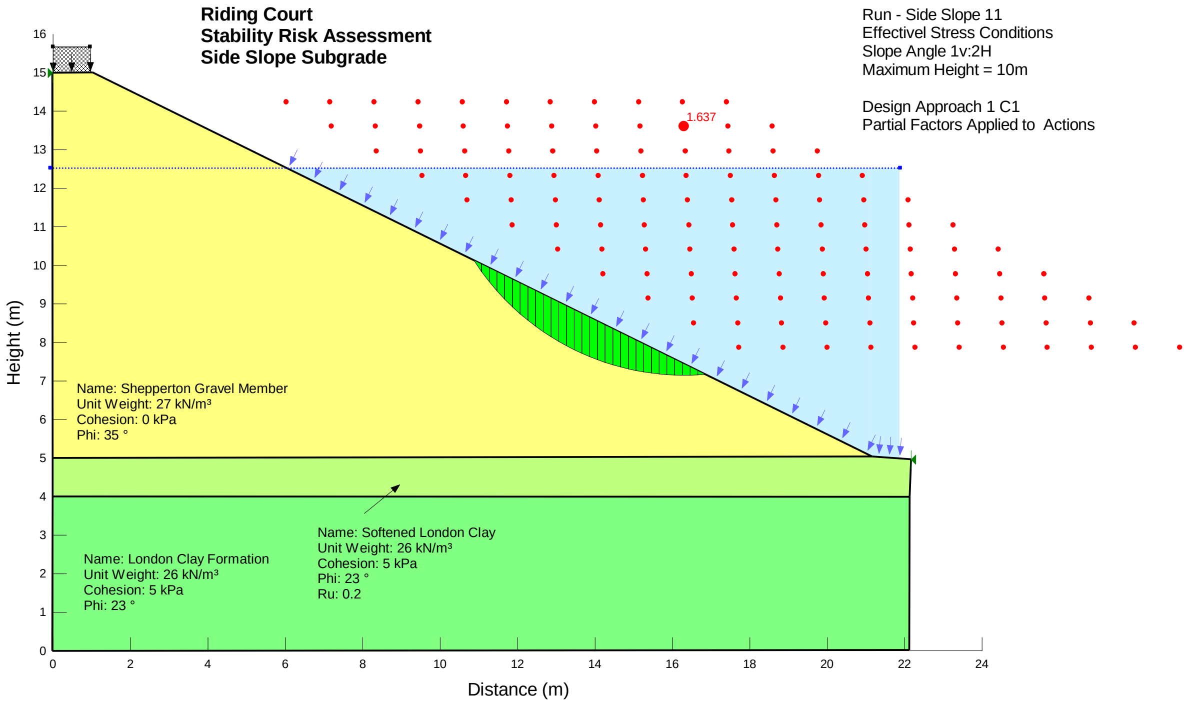

Riding Court
Stability Risk Assessment
Side Slope Subgrade
Run - Side Slope 6
Effective Stress Conditions
Slope Angle 1v:2H
Design Approach 1 C2
Partial Factors Applied to Materials
and Variable Actions
1.146
Variable 10kN Surcharge
Name: Shepperton Gravel Member
Unit Weight: 20 kN/m³
Cohesion: 0 kPa
Phi: 29 °
Name: London Clay Formation
Unit Weight: 19 kN/m³
Cohesion: 4 kPa
Phi: 19 °
Name: Softened London Clay
Unit Weight: 19 kN/m³
Cohesion: 4 kPa
Phi: 19 °
Ru: 0.2
Height (m)
Distance (m)

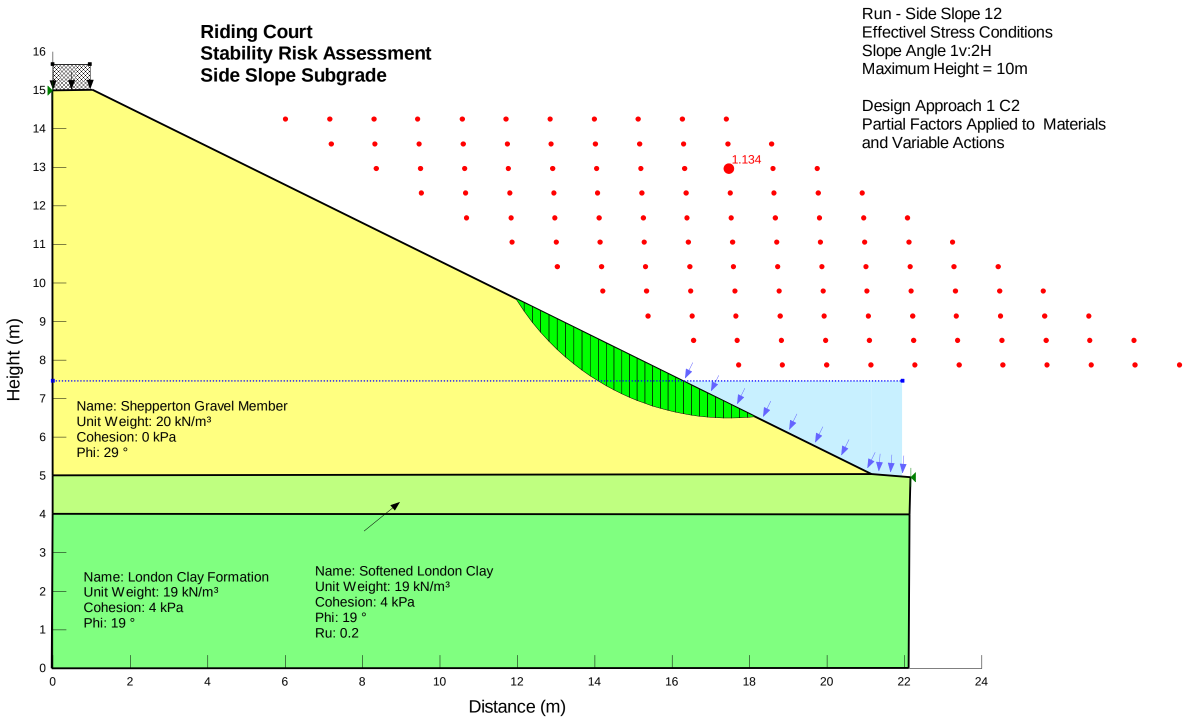

Riding Court
Stability Risk Assessment
Side Slope Subgrade
Run - Side Slope 7
Effective Stress Conditions
Slope Angle 1v:2H
Softening of Upper Layer of LCF
Design Approach 1 C1
Partial Factors Applied to Actions
1.325
Variable 10kN Surcharge
Name: Shepperton Gravel Member
Unit Weight: 27 kN/m³
Cohesion: 0 kPa
Phi: 35 °
Name: London Clay Formation
Unit Weight: 26 kN/m³
Cohesion: 5 kPa
Phi: 23 °
Name: Softened London Clay
Unit Weight: 26 kN/m³
Cohesion: 0 kPa
Phi: 23 °
Ru: 0.2
Height (m)
Distance (m)


Riding Court
Stability Risk Assessment
Side Slope Subgrade
Run - Side Slope 8
Effective Stress Conditions
Slope Angle 1v:2H
Softening of Upper Layer of LCF
Design Approach 1 C2
Partial Factors Applied to Materials
and Variable Actions
1.016
Variable 10kN Surcharge
Name: Shepperton Gravel Member
Unit Weight: 20 kN/m³
Cohesion: 0 kPa
Phi: 29 °
Name: London Clay Formation
Unit Weight: 19 kN/m³
Cohesion: 4 kPa
Phi: 19 °
Name: Softened London Clay
Unit Weight: 19 kN/m³
Cohesion: 0 kPa
Phi: 19 °
Ru: 0.2
Height (m)
Distance (m)


Run - Side Slope 9
Effective Stress Conditions
Slope Angle 1v:2H
Accidental Overdig into of Upper Layer of LCF
Design Approach 1 C1
Partial Factors Applied to Actions
Riding Court
Stability Risk Assessment
Side Slope Subgrade
Variable 10kN Surcharge
1.170
Name: Shepperton Gravel Member
Unit Weight: 27 kN/m³
Cohesion: 0 kPa
Phi: 35 °
Name: Softened London Clay
Unit Weight: 26 kN/m³
Cohesion: 0 kPa
Phi: 23 °
Ru: 0.2
Name: London Clay Formation
Unit Weight: 26 kN/m³
Cohesion: 5 kPa
Phi: 23 °
Height (m)
Distance (m)

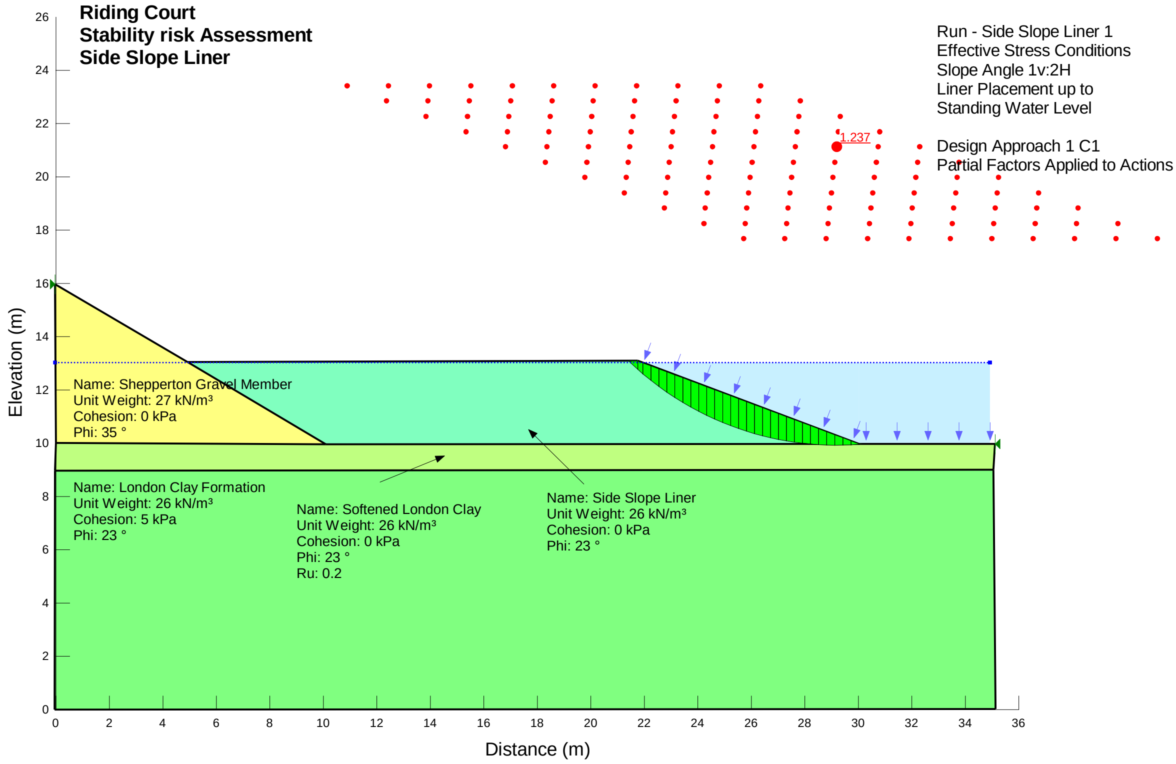

Run - Side Slope 10
Effective Stress Conditions
Slope Angle 1v:2H
Accidental Overdig into of Upper Layer of LCF
Design Approach 1 C2
Partial Factors Applied to Materials
and Variable Actions
Riding Court
Stability Risk Assessment
Side Slope Subgrade
Variable 10kN Surcharge
1.028
Name: Shepperton Gravel Member
Unit Weight: 20 kN/m³
Cohesion: 0 kPa
Phi: 29 °
Name: Softened London Clay
Unit Weight: 19 kN/m³
Cohesion: 0 kPa
Phi: 19 °
Ru: 0.2
Name: London Clay Formation
Unit Weight: 19 kN/m³
Cohesion: 4 kPa
Phi: 19 °
Height (m)
Distance (m)

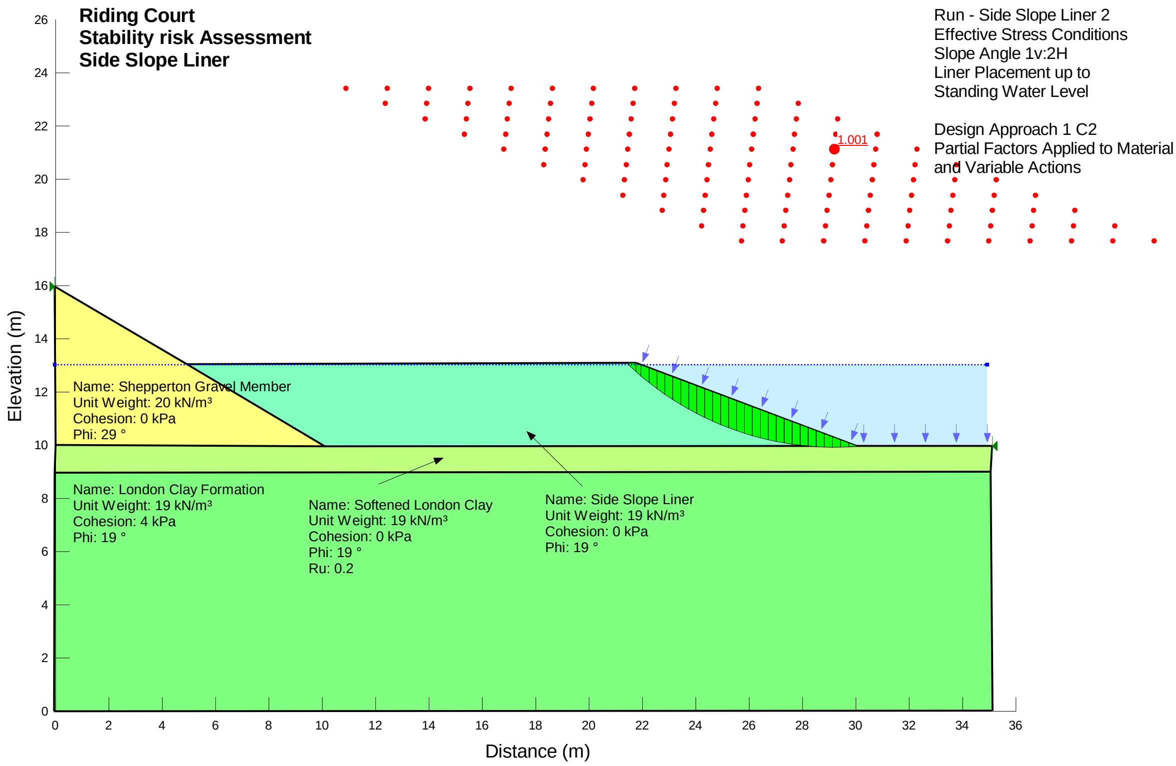

Riding Court
Stability Risk Assessment
Side Slope Subgrade
Run - Side Slope 11
Effective Stress Conditions
Slope Angle 1v:2H
Maximum Height = 10m
Design Approach 1 C1
Partial Factors Applied to Actions
1.637
Name: Shepperton Gravel Member
Unit Weight: 27 kN/m³
Cohesion: 0 kPa
Phi: 35 °
Name: Softened London Clay
Unit Weight: 26 kN/m³
Cohesion: 5 kPa
Phi: 23 °
Ru: 0.2
Name: London Clay Formation
Unit Weight: 26 kN/m³
Cohesion: 5 kPa
Phi: 23 °
Height (m)
Distance (m)

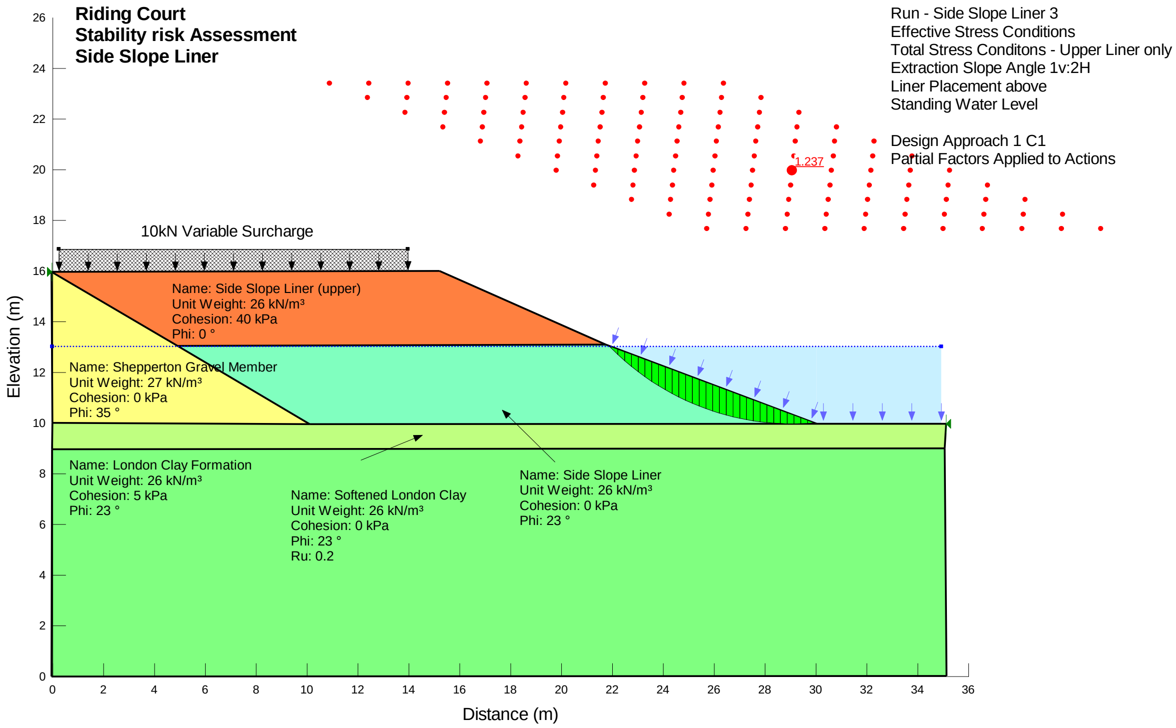

Riding Court
Stability Risk Assessment
Side Slope Subgrade
Run - Side Slope 12
Effective Stress Conditions
Slope Angle 1v:2H
Maximum Height = 10m
Design Approach 1 C2
Partial Factors Applied to Materials and Variable Actions
1.134
Name: Shepperton Gravel Member
Unit Weight: 20 kN/m³
Cohesion: 0 kPa
Phi: 29 °
Name: London Clay Formation
Unit Weight: 19 kN/m³
Cohesion: 4 kPa
Phi: 19 °
Name: Softened London Clay
Unit Weight: 19 kN/m³
Cohesion: 4 kPa
Phi: 19 °
Ru: 0.2
Height (m)
Distance (m)

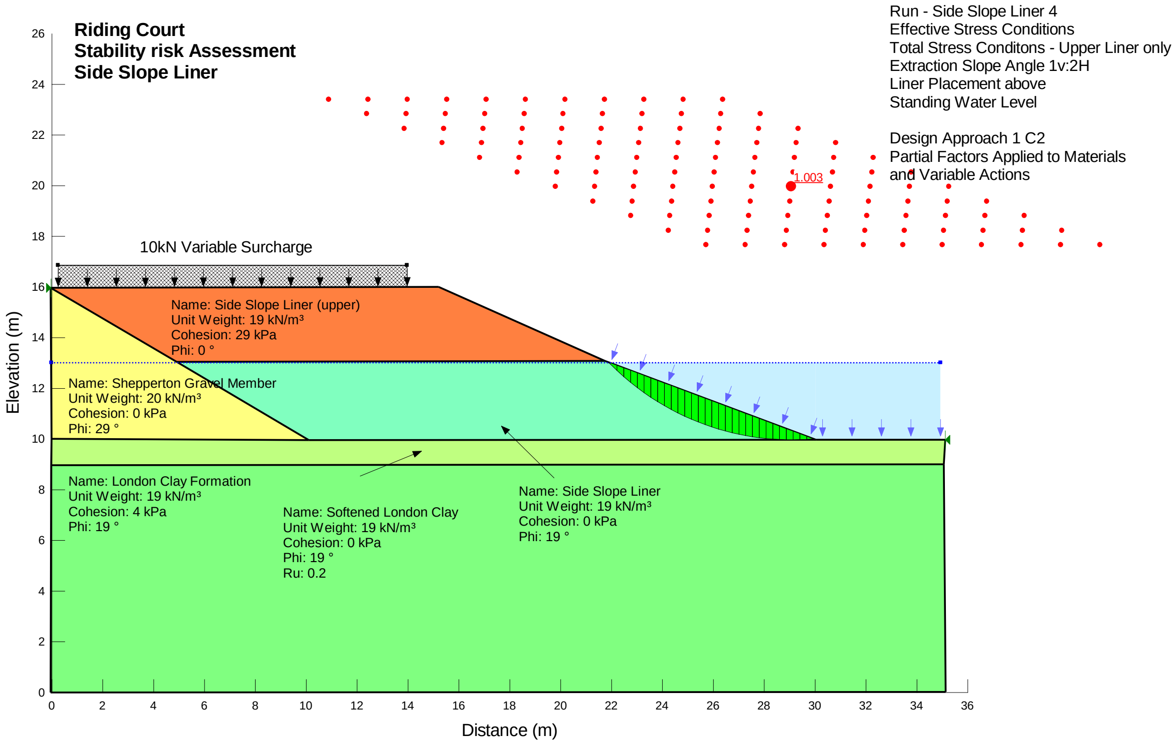
# Appendix 2

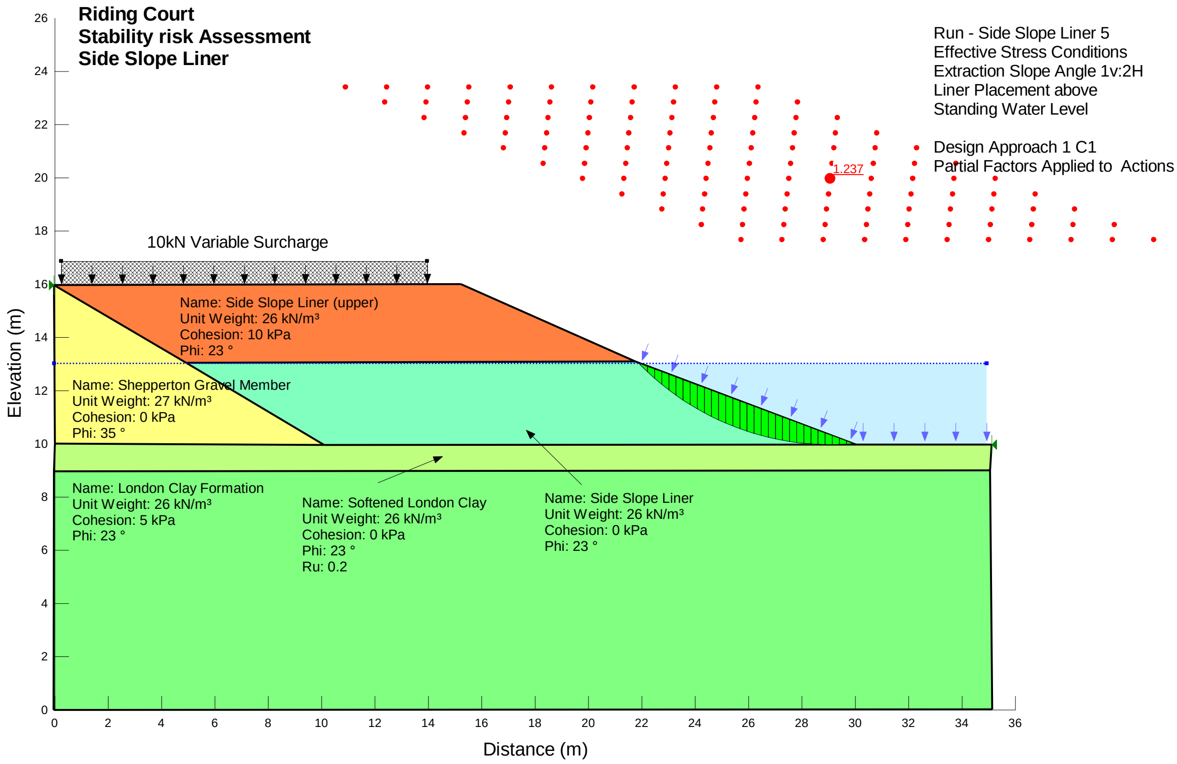
# Slope/W Worksheets – Side Slope Liner

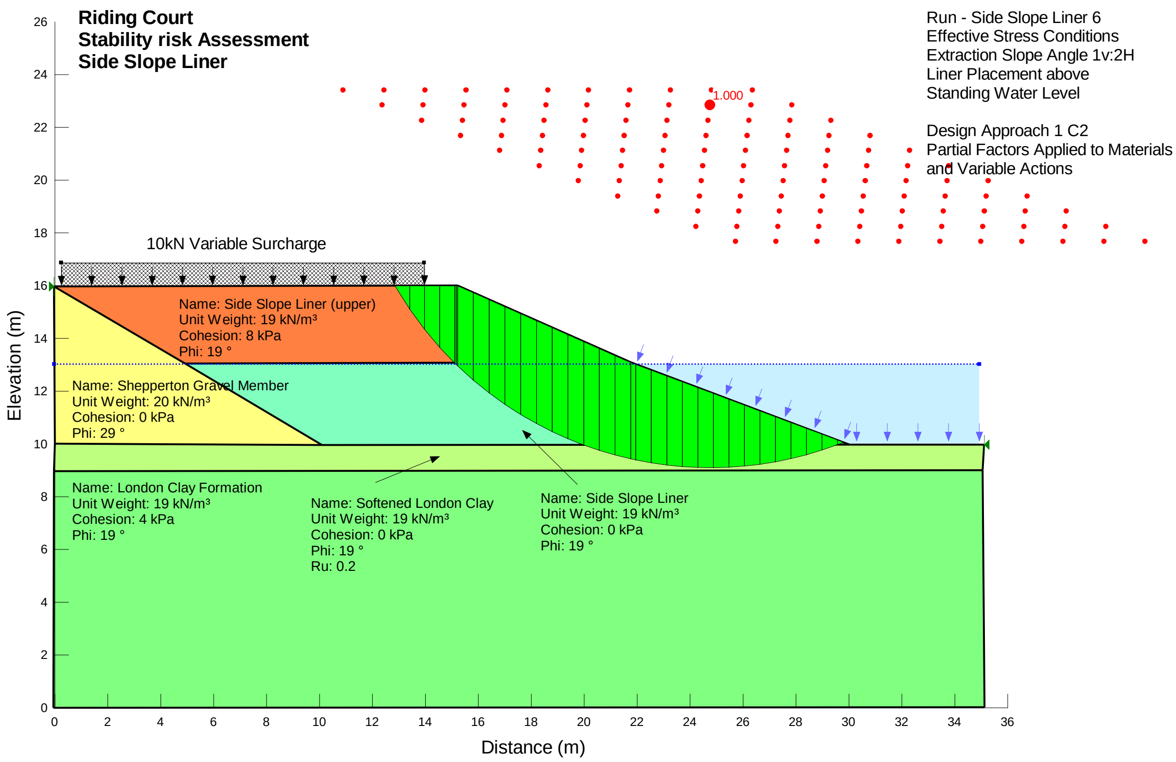

Riding Court
Stability risk Assessment
Side Slope Liner
Run - Side Slope Liner 1
Effective Stress Conditions
Slope Angle 1v:2H
Liner Placement up to
Standing Water Level
Design Approach 1 C1
Partial Factors Applied to Actions
1.237
Name: Shepperton Gravel Member
Unit Weight: 27 kN/m³
Cohesion: 0 kPa
Phi: 35 °
Name: London Clay Formation
Unit Weight: 26 kN/m³
Cohesion: 5 kPa
Phi: 23 °
Name: Softened London Clay
Unit Weight: 26 kN/m³
Cohesion: 0 kPa
Phi: 23 °
Ru: 0.2
Name: Side Slope Liner
Unit Weight: 26 kN/m³
Cohesion: 0 kPa
Phi: 23 °
Elevation (m)
Distance (m)

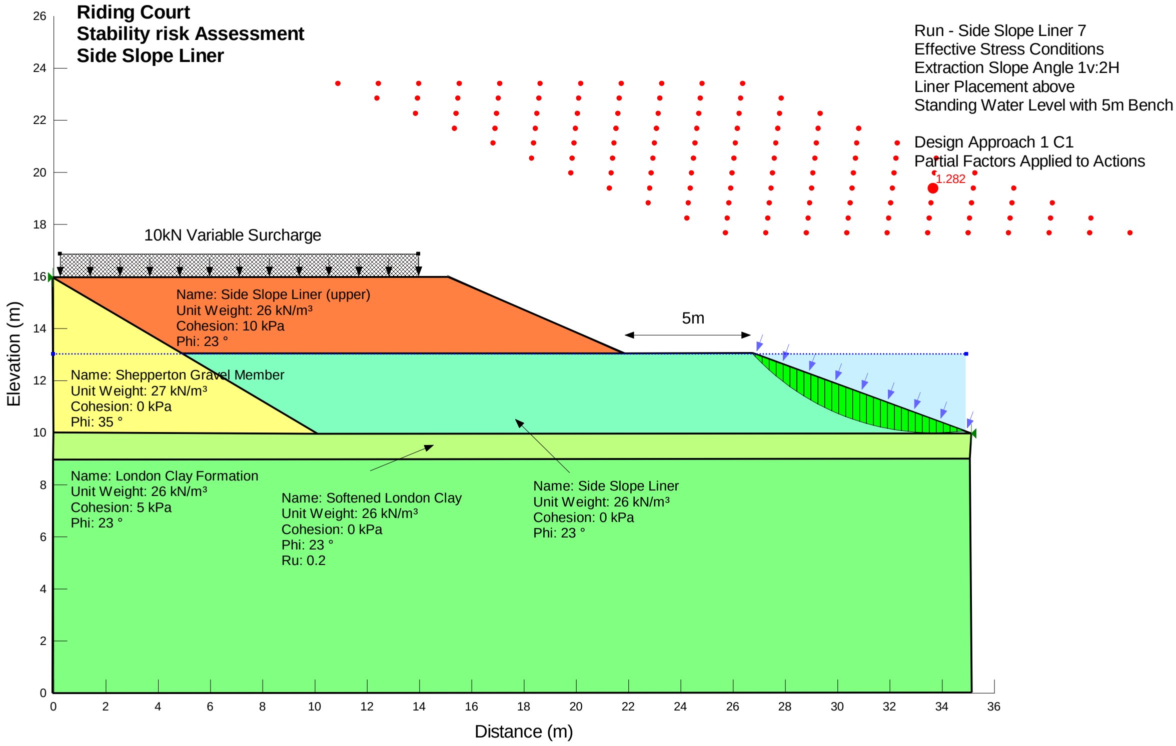

Riding Court
Stability risk Assessment
Side Slope Liner
Run - Side Slope Liner 2
Effective Stress Conditions
Slope Angle 1v:2H
Liner Placement up to
Standing Water Level
Design Approach 1 C2
Partial Factors Applied to Material
and Variable Actions
1.001
Name: Shepperton Gravel Member
Unit Weight: 20 kN/m³
Cohesion: 0 kPa
Phi: 29 °
Name: London Clay Formation
Unit Weight: 19 kN/m³
Cohesion: 4 kPa
Phi: 19 °
Name: Softened London Clay
Unit Weight: 19 kN/m³
Cohesion: 0 kPa
Phi: 19 °
Ru: 0.2
Name: Side Slope Liner
Unit Weight: 19 kN/m³
Cohesion: 0 kPa
Phi: 19 °
Elevation (m)
Distance (m)

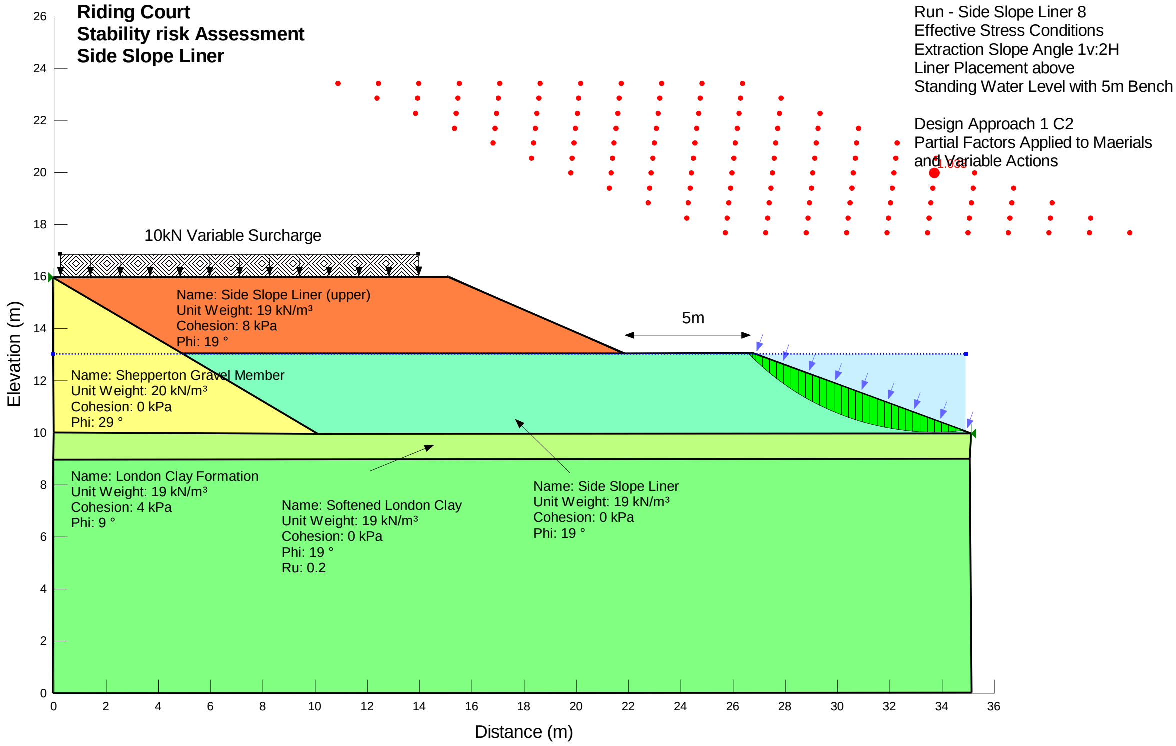

Riding Court
Stability risk Assessment
Side Slope Liner
Run - Side Slope Liner 3
Effective Stress Conditions
Total Stress Conditons - Upper Liner only
Extraction Slope Angle 1v:2H
Liner Placement above
Standing Water Level
Design Approach 1 C1
Partial Factors Applied to Actions
1.237
10kN Variable Surcharge
Name: Side Slope Liner (upper)
Unit Weight: 26 kN/m³
Cohesion: 40 kPa
Phi: 0 °
Name: Shepperton Gravel Member
Unit Weight: 27 kN/m³
Cohesion: 0 kPa
Phi: 35 °
Name: London Clay Formation
Unit Weight: 26 kN/m³
Cohesion: 5 kPa
Phi: 23 °
Name: Softened London Clay
Unit Weight: 26 kN/m³
Cohesion: 0 kPa
Phi: 23 °
Ru: 0.2
Name: Side Slope Liner
Unit Weight: 26 kN/m³
Cohesion: 0 kPa
Phi: 23 °
Elevation (m)
Distance (m)


Riding Court
Stability risk Assessment
Side Slope Liner
Run - Side Slope Liner 4
Effective Stress Conditions
Total Stress Conditons - Upper Liner only
Extraction Slope Angle 1v:2H
Liner Placement above
Standing Water Level
Design Approach 1 C2
Partial Factors Applied to Materials
and Variable Actions
1.003
10kN Variable Surcharge
Name: Side Slope Liner (upper)
Unit Weight: 19 kN/m³
Cohesion: 29 kPa
Phi: 0 °
Name: Shepperton Gravel Member
Unit Weight: 20 kN/m³
Cohesion: 0 kPa
Phi: 29 °
Name: London Clay Formation
Unit Weight: 19 kN/m³
Cohesion: 4 kPa
Phi: 19 °
Name: Softened London Clay
Unit Weight: 19 kN/m³
Cohesion: 0 kPa
Phi: 19 °
Ru: 0.2
Name: Side Slope Liner
Unit Weight: 19 kN/m³
Cohesion: 0 kPa
Phi: 19 °
Elevation (m)
Distance (m)


Riding Court
Stability risk Assessment
Side Slope Liner
Run - Side Slope Liner 5
Effective Stress Conditions
Extraction Slope Angle 1v:2H
Liner Placement above
Standing Water Level
Design Approach 1 C1
Partial Factors Applied to Actions
1.237
10kN Variable Surcharge
Name: Side Slope Liner (upper)
Unit Weight: 26 kN/m³
Cohesion: 10 kPa
Phi: 23 °
Name: Shepperton Gravel Member
Unit Weight: 27 kN/m³
Cohesion: 0 kPa
Phi: 35 °
Name: London Clay Formation
Unit Weight: 26 kN/m³
Cohesion: 5 kPa
Phi: 23 °
Name: Softened London Clay
Unit Weight: 26 kN/m³
Cohesion: 0 kPa
Phi: 23 °
Ru: 0.2
Name: Side Slope Liner
Unit Weight: 26 kN/m³
Cohesion: 0 kPa
Phi: 23 °
Elevation (m)
Distance (m)

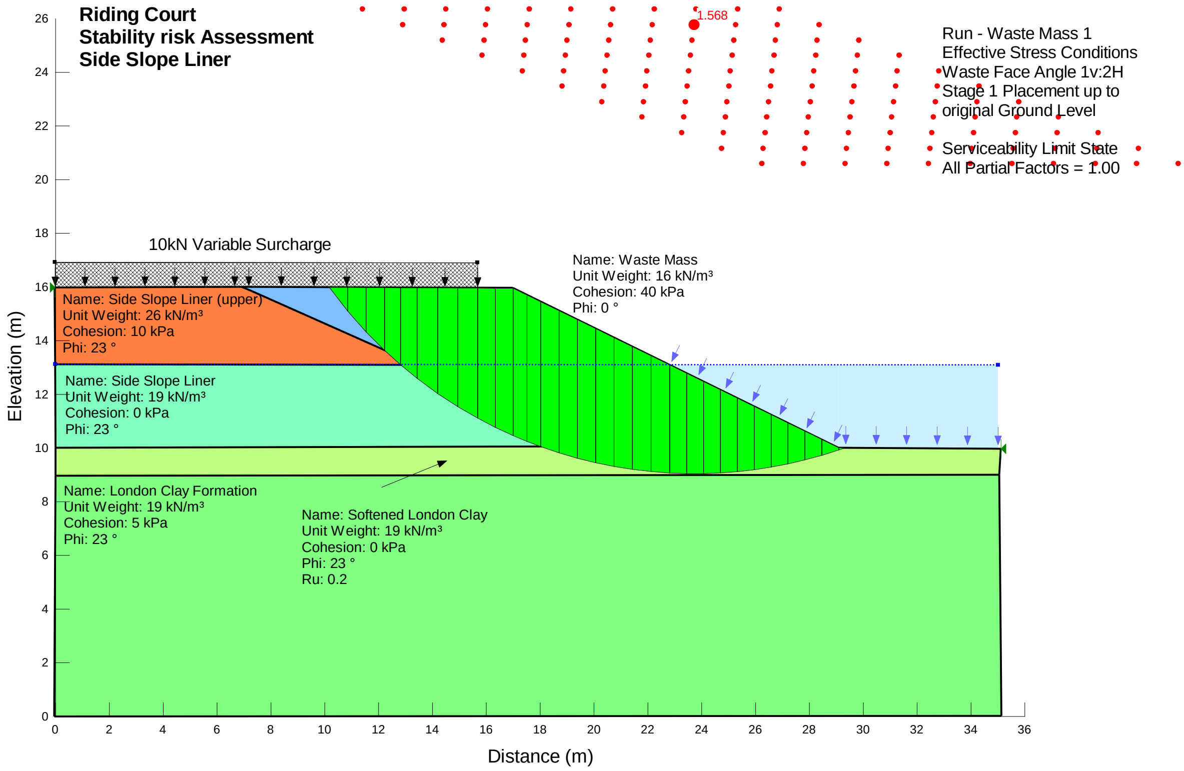

Riding Court
Stability risk Assessment
Side Slope Liner
Run - Side Slope Liner 6
Effective Stress Conditions
Extraction Slope Angle 1v:2H
Liner Placement above
Standing Water Level
Design Approach 1 C2
Partial Factors Applied to Materials
and Variable Actions
1.000
10kN Variable Surcharge
Name: Side Slope Liner (upper)
Unit Weight: 19 kN/m³
Cohesion: 8 kPa
Phi: 19 °
Name: Shepperton Gravel Member
Unit Weight: 20 kN/m³
Cohesion: 0 kPa
Phi: 29 °
Name: London Clay Formation
Unit Weight: 19 kN/m³
Cohesion: 4 kPa
Phi: 19 °
Name: Softened London Clay
Unit Weight: 19 kN/m³
Cohesion: 0 kPa
Phi: 19 °
Ru: 0.2
Name: Side Slope Liner
Unit Weight: 19 kN/m³
Cohesion: 0 kPa
Phi: 19 °
Elevation (m)
Distance (m)


Riding Court
Stability risk Assessment
Side Slope Liner
Run - Side Slope Liner 7
Effective Stress Conditions
Extraction Slope Angle 1v:2H
Liner Placement above
Standing Water Level with 5m Bench
Design Approach 1 C1
Partial Factors Applied to Actions
1.282
10kN Variable Surcharge
5m
Name: Side Slope Liner (upper)
Unit Weight: 26 kN/m³
Cohesion: 10 kPa
Phi: 23 °
Name: Shepperton Gravel Member
Unit Weight: 27 kN/m³
Cohesion: 0 kPa
Phi: 35 °
Name: London Clay Formation
Unit Weight: 26 kN/m³
Cohesion: 5 kPa
Phi: 23 °
Name: Softened London Clay
Unit Weight: 26 kN/m³
Cohesion: 0 kPa
Phi: 23 °
Ru: 0.2
Name: Side Slope Liner
Unit Weight: 26 kN/m³
Cohesion: 0 kPa
Phi: 23 °
Elevation (m)
Distance (m)

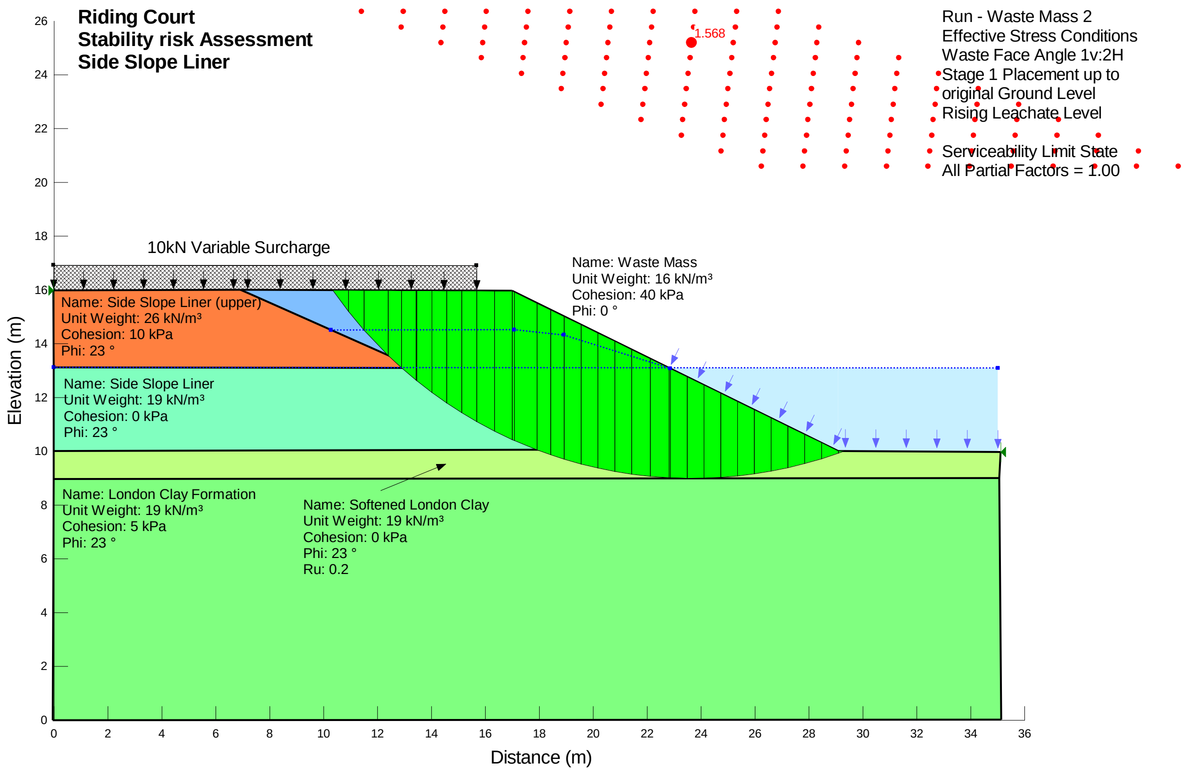

Riding Court
Stability risk Assessment
Side Slope Liner
Run - Side Slope Liner 8
Effective Stress Conditions
Extraction Slope Angle 1v:2H
Liner Placement above
Standing Water Level with 5m Bench
Design Approach 1 C2
Partial Factors Applied to Maerials
and Variable Actions
10kN Variable Surcharge
5m
Name: Side Slope Liner (upper)
Unit Weight: 19 kN/m³
Cohesion: 8 kPa
Phi: 19 °
Name: Shepperton Gravel Member
Unit Weight: 20 kN/m³
Cohesion: 0 kPa
Phi: 29 °
Name: London Clay Formation
Unit Weight: 19 kN/m³
Cohesion: 4 kPa
Phi: 9 °
Name: Softened London Clay
Unit Weight: 19 kN/m³
Cohesion: 0 kPa
Phi: 19 °
Ru: 0.2
Name: Side Slope Liner
Unit Weight: 19 kN/m³
Cohesion: 0 kPa
Phi: 19 °
Elevation (m)
Distance (m)

# Appendix 3

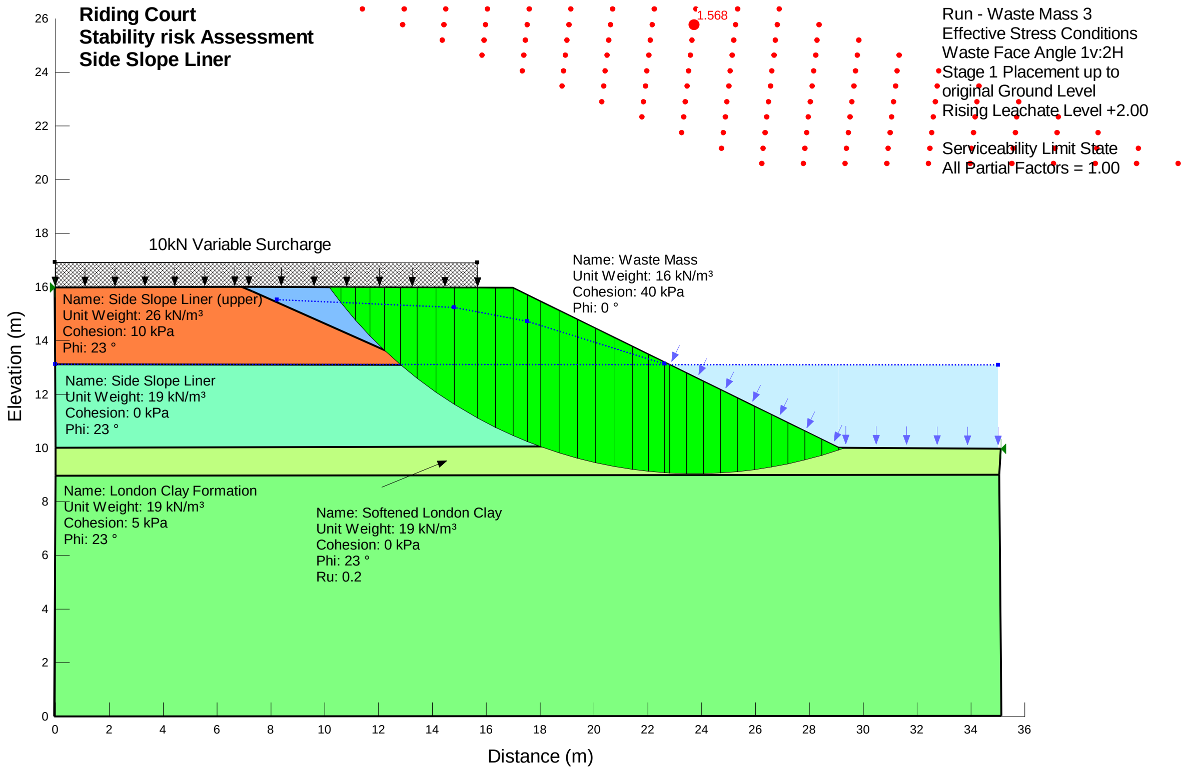
# Slope/W Worksheets – Waste Mass

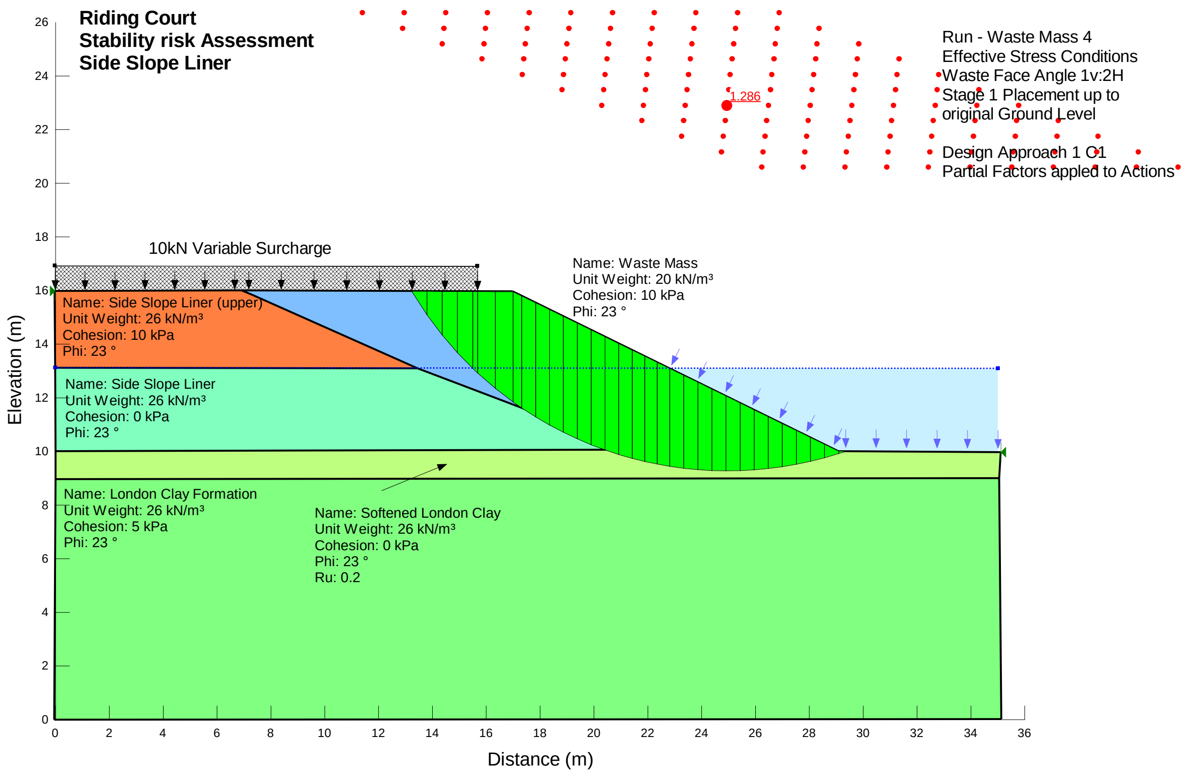


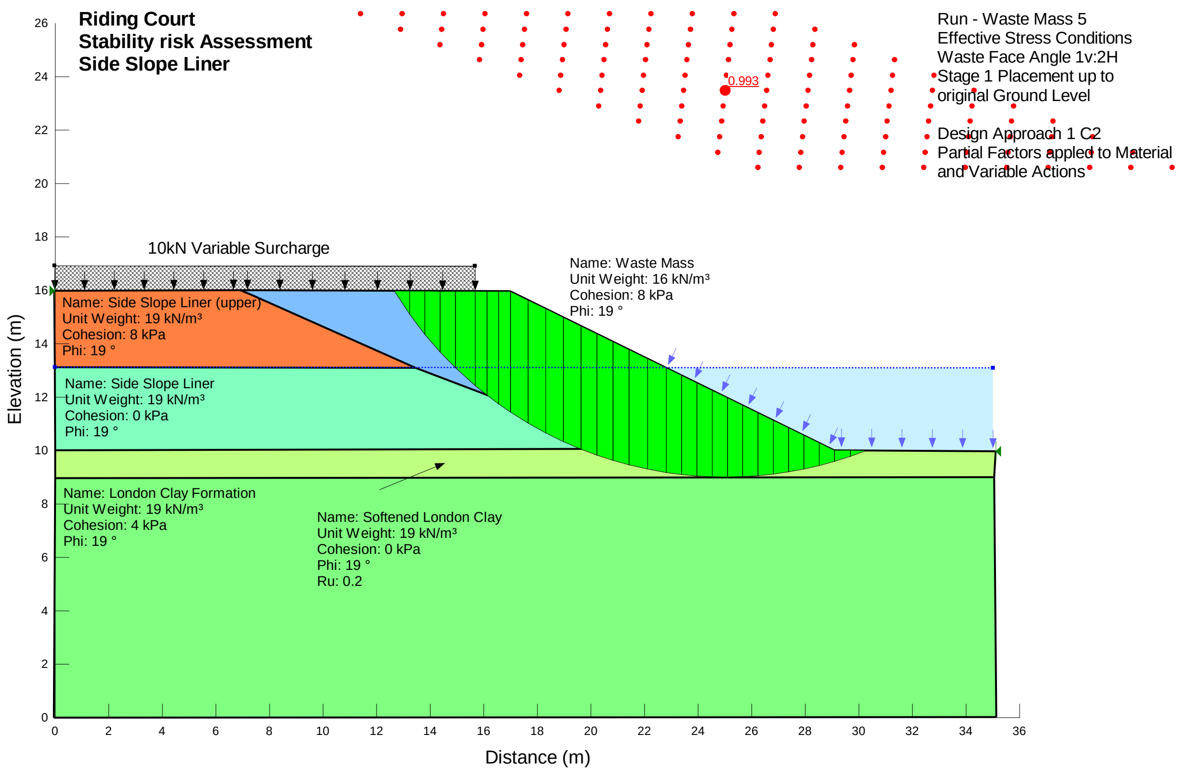
Riding Court
Stability risk Assessment
Side Slope Liner
1.568
Run - Waste Mass 1
Effective Stress Conditions
Waste Face Angle 1v:2H
Stage 1 Placement up to
original Ground Level
Serviceability Limit State
All Partial Factors = 1.00
10kN Variable Surcharge
Name: Waste Mass
Unit Weight: 16 kN/m³
Cohesion: 40 kPa
Phi: 0 °
Name: Side Slope Liner (upper)
Unit Weight: 26 kN/m³
Cohesion: 10 kPa
Phi: 23 °
Name: Side Slope Liner
Unit Weight: 19 kN/m³
Cohesion: 0 kPa
Phi: 23 °
Name: London Clay Formation
Unit Weight: 19 kN/m³
Cohesion: 5 kPa
Phi: 23 °
Name: Softened London Clay
Unit Weight: 19 kN/m³
Cohesion: 0 kPa
Phi: 23 °
Ru: 0.2
Elevation (m)
Distance (m)

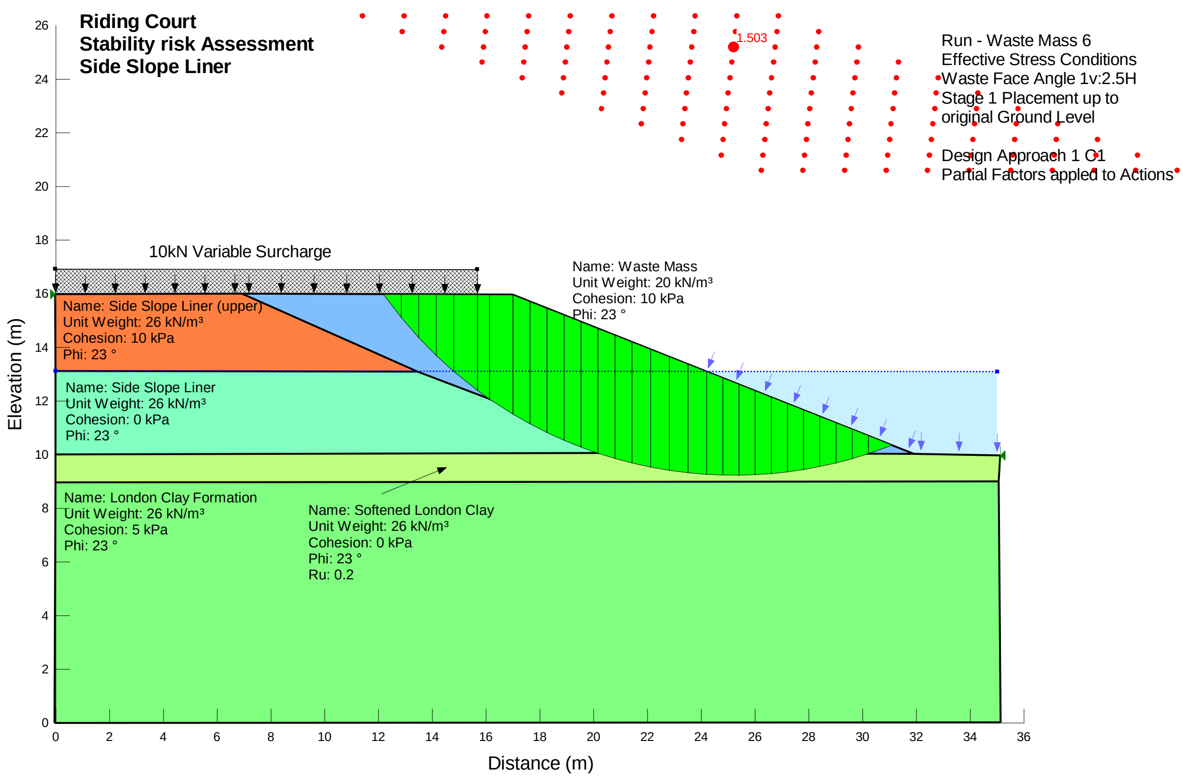



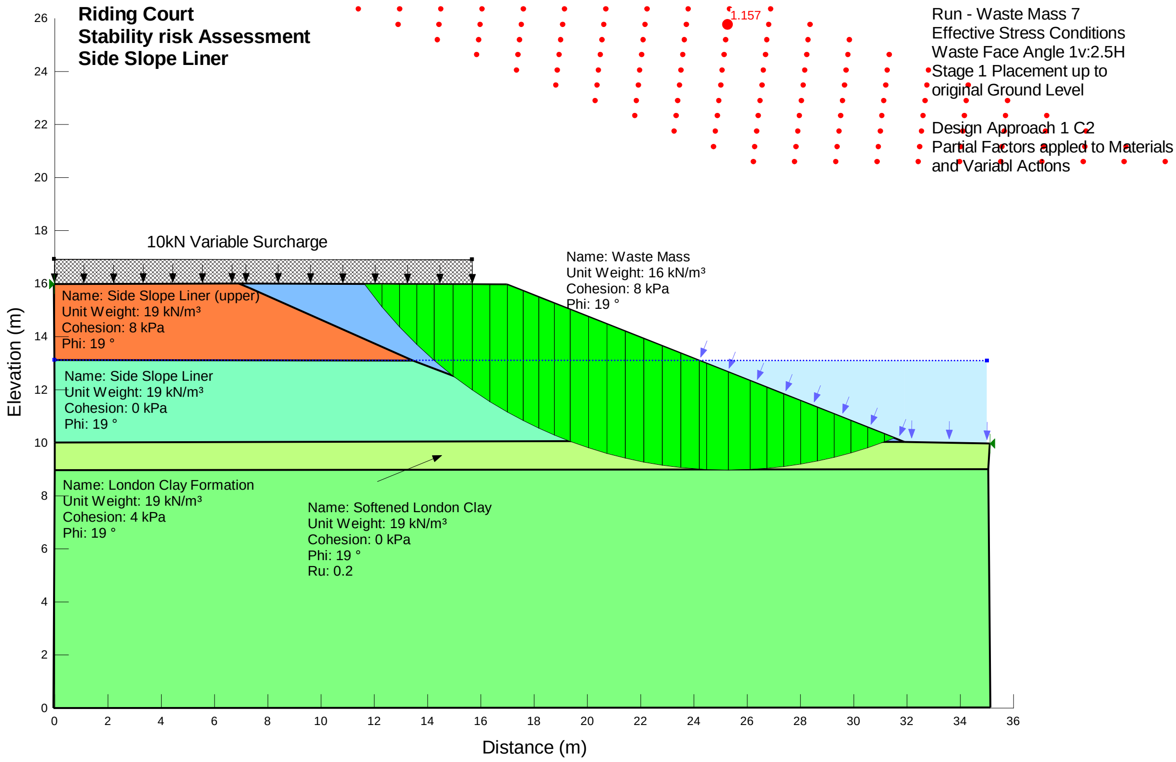
Riding Court
Stability risk Assessment
Side Slope Liner
1.568
Run - Waste Mass 2
Effective Stress Conditions
Waste Face Angle 1v:2H
Stage 1 Placement up to
original Ground Level
Rising Leachate Level
Serviceability Limit State
All Partial Factors = 1.00
10kN Variable Surcharge
Name: Waste Mass
Unit Weight: 16 kN/m³
Cohesion: 40 kPa
Phi: 0 °
Name: Side Slope Liner (upper)
Unit Weight: 26 kN/m³
Cohesion: 10 kPa
Phi: 23 °
Name: Side Slope Liner
Unit Weight: 19 kN/m³
Cohesion: 0 kPa
Phi: 23 °
Name: London Clay Formation
Unit Weight: 19 kN/m³
Cohesion: 5 kPa
Phi: 23 °
Name: Softened London Clay
Unit Weight: 19 kN/m³
Cohesion: 0 kPa
Phi: 23 °
Ru: 0.2
Elevation (m)
Distance (m)

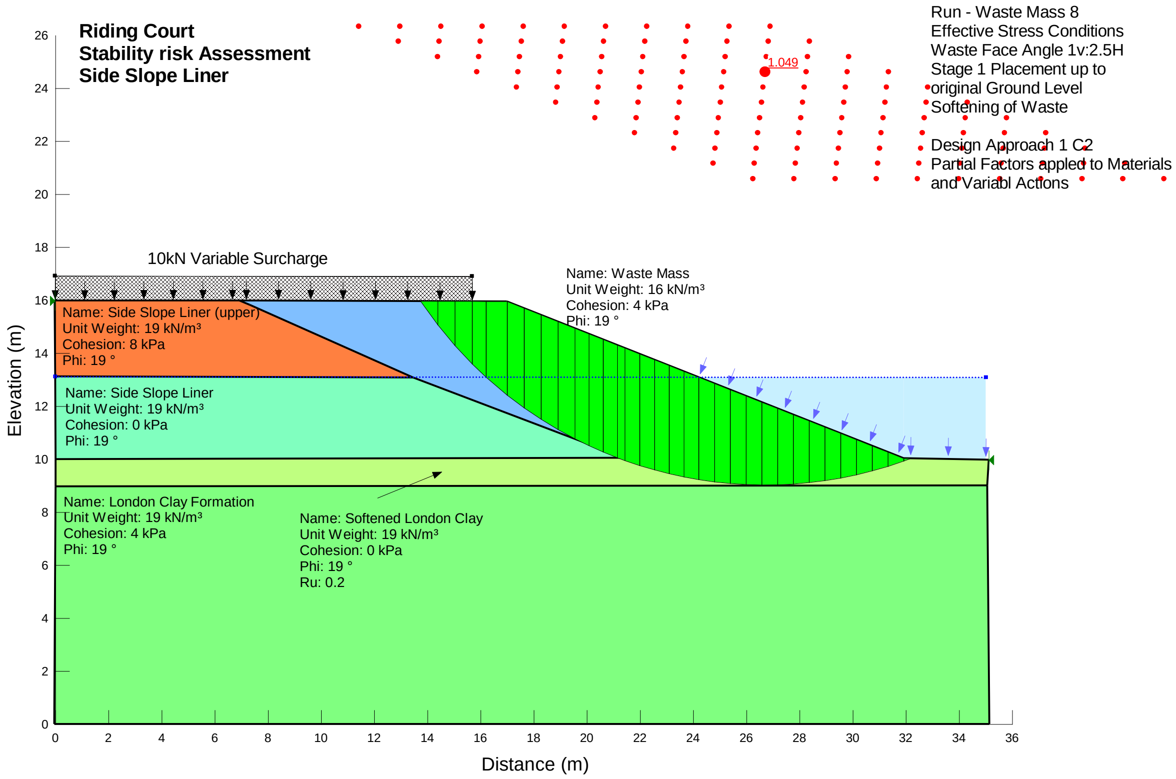

Riding Court
Stability risk Assessment
Side Slope Liner
1.568
Run - Waste Mass 3
Effective Stress Conditions
Waste Face Angle 1v:2H
Stage 1 Placement up to
original Ground Level
Rising Leachate Level +2.00
Serviceability Limit State
All Partial Factors = 1.00
10kN Variable Surcharge
Name: Waste Mass
Unit Weight: 16 kN/m³
Cohesion: 40 kPa
Phi: 0 °
Name: Side Slope Liner (upper)
Unit Weight: 26 kN/m³
Cohesion: 10 kPa
Phi: 23 °
Name: Side Slope Liner
Unit Weight: 19 kN/m³
Cohesion: 0 kPa
Phi: 23 °
Name: London Clay Formation
Unit Weight: 19 kN/m³
Cohesion: 5 kPa
Phi: 23 °
Name: Softened London Clay
Unit Weight: 19 kN/m³
Cohesion: 0 kPa
Phi: 23 °
Ru: 0.2
Elevation (m)
Distance (m)


Riding Court
Stability risk Assessment
Side Slope Liner
1.286
Run - Waste Mass 4
Effective Stress Conditions
Waste Face Angle 1v:2H
Stage 1 Placement up to
original Ground Level
Design Approach 1 C1
Partial Factors appled to Actions
10kN Variable Surcharge
Name: Waste Mass
Unit Weight: 20 kN/m³
Cohesion: 10 kPa
Phi: 23 °
Name: Side Slope Liner (upper)
Unit Weight: 26 kN/m³
Cohesion: 10 kPa
Phi: 23 °
Name: Side Slope Liner
Unit Weight: 26 kN/m³
Cohesion: 0 kPa
Phi: 23 °
Name: London Clay Formation
Unit Weight: 26 kN/m³
Cohesion: 5 kPa
Phi: 23 °
Name: Softened London Clay
Unit Weight: 26 kN/m³
Cohesion: 0 kPa
Phi: 23 °
Ru: 0.2
Elevation (m)
Distance (m)


Riding Court
Stability risk Assessment
Side Slope Liner
Run - Waste Mass 5
Effective Stress Conditions
Waste Face Angle 1v:2H
Stage 1 Placement up to original Ground Level
Design Approach 1 C2
Partial Factors appled to Material and Variable Actions
0.993
10kN Variable Surcharge
Name: Side Slope Liner (upper)
Unit Weight: 19 kN/m³
Cohesion: 8 kPa
Phi: 19 °
Name: Side Slope Liner
Unit Weight: 19 kN/m³
Cohesion: 0 kPa
Phi: 19 °
Name: Waste Mass
Unit Weight: 16 kN/m³
Cohesion: 8 kPa
Phi: 19 °
Name: London Clay Formation
Unit Weight: 19 kN/m³
Cohesion: 4 kPa
Phi: 19 °
Name: Softened London Clay
Unit Weight: 19 kN/m³
Cohesion: 0 kPa
Phi: 19 °
Ru: 0.2
Elevation (m)
Distance (m)


Riding Court
Stability risk Assessment
Side Slope Liner
Run - Waste Mass 6
Effective Stress Conditions
Waste Face Angle 1v:2.5H
Stage 1 Placement up to original Ground Level
Design Approach 1 C1
Partial Factors appled to Actions
1.503
10kN Variable Surcharge
Name: Side Slope Liner (upper)
Unit Weight: 26 kN/m³
Cohesion: 10 kPa
Phi: 23 °
Name: Side Slope Liner
Unit Weight: 26 kN/m³
Cohesion: 0 kPa
Phi: 23 °
Name: Waste Mass
Unit Weight: 20 kN/m³
Cohesion: 10 kPa
Phi: 23 °
Name: London Clay Formation
Unit Weight: 26 kN/m³
Cohesion: 5 kPa
Phi: 23 °
Name: Softened London Clay
Unit Weight: 26 kN/m³
Cohesion: 0 kPa
Phi: 23 °
Ru: 0.2
Elevation (m)
Distance (m)


Riding Court
Stability risk Assessment
Side Slope Liner
1.157
Run - Waste Mass 7
Effective Stress Conditions
Waste Face Angle 1v:2.5H
Stage 1 Placement up to
original Ground Level
Design Approach 1 C2
Partial Factors appled to Materials
and Variabl Actions
10kN Variable Surcharge
Name: Waste Mass
Unit Weight: 16 kN/m³
Cohesion: 8 kPa
Phi: 19 °
Name: Side Slope Liner (upper)
Unit Weight: 19 kN/m³
Cohesion: 8 kPa
Phi: 19 °
Name: Side Slope Liner
Unit Weight: 19 kN/m³
Cohesion: 0 kPa
Phi: 19 °
Name: London Clay Formation
Unit Weight: 19 kN/m³
Cohesion: 4 kPa
Phi: 19 °
Name: Softened London Clay
Unit Weight: 19 kN/m³
Cohesion: 0 kPa
Phi: 19 °
Ru: 0.2
Elevation (m)
Distance (m)


Riding Court
Stability risk Assessment
Side Slope Liner
1.049
Run - Waste Mass 8
Effective Stress Conditions
Waste Face Angle 1v:2.5H
Stage 1 Placement up to
original Ground Level
Softening of Waste
Design Approach 1 C2
Partial Factors appled to Materials
and Variabl Actions
10kN Variable Surcharge
Name: Waste Mass
Unit Weight: 16 kN/m³
Cohesion: 4 kPa
Phi: 19 °
Name: Side Slope Liner (upper)
Unit Weight: 19 kN/m³
Cohesion: 8 kPa
Phi: 19 °
Name: Side Slope Liner
Unit Weight: 19 kN/m³
Cohesion: 0 kPa
Phi: 19 °
Name: London Clay Formation
Unit Weight: 19 kN/m³
Cohesion: 4 kPa
Phi: 19 °
Name: Softened London Clay
Unit Weight: 19 kN/m³
Cohesion: 0 kPa
Phi: 19 °
Ru: 0.2
Elevation (m)
Distance (m)