Stability Risk Assessment for
STAINBY QUARRY
nr Colsterworth, Lincolnshire

ref. CES/STQ/101 v4
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Greenfield enviro

Quality Assurance Review

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1. REPORT CONTEXT

1.1.1 Greenfield Environmental Ltd has been commissioned by GP Planning Ltd, acting on behalf of Construction & Environmental Services Ltd (CES Ltd), to produce a Stability Risk Assessment for the proposed inert waste landfilling at Stainby Quarry, near Colsterworth, Lincolnshire. The site is located approximately 1.5km north of Stainby village, approximately 1.8km west of Colsterworth in Lincolnshire (see Figure 1). A Geotechnical Assessment of Stainby Quarry was undertaken by Greenfield Environmental during January 2020.

1.1.2 This 2024 revision of the SRA report supersedes and replaces the 2021 rev2 and 2024 rev3 SRA documents.

1.1.3 The proposed inert landfill area comprises a currently operational limestone quarry excavation (see Figure 2). The current void has reached its permitted plan extents and is now being deepened in the current phase of extraction. To the immediate east of the proposed landfill area is an existing landfill site in a former quarry (Colsterworth Landfill Site) that is operated by FCC Environment Ltd. The area to be landfilled comprises a roughly triangular void surrounded on all sides by limestone faces, although there is an open gap in the northern/central part of the east side that links through to the adjacent FCC landfill site.

2. CONCEPTUAL STABILITY SITE MODEL

2.1 Site Geology

2.1.1 The conceptual stability site model has been developed on the basis of geological information and cross-sections presented in the HRA report prepared by Hafren Water, issued in June 2024, plus information gathered during a site visit and topographic survey carried out by Greenfield Environmental (in November 2019) and the Geotechnical Assessment (GA) for the site (A Geotechnical Assessment Review of Stainby Quarry, Nr Colsterworth, Lincolnshire, dated January 2020), by Greenfield Environmental.

2.1.2 The site is an active limestone quarry, triangular in shape, that extracts limestone (of the Lower Lincolnshire Limestone Member) to be crushed for aggregate. The site comprises an excavation area in the western part of the site that at the time of the 2019 topographic survey had a base level of approximately 128mAOD (see Figure 2) in which the basal mudstone had been exposed, although further excavation has taken place since then, with a slightly lower central and southern zone with ground levels between 123-125mOD where the floor of the quarry has been left just above the base of the limestone.

2.1.3 The geological maps published by the British Geological Survey (BGS), indicate that the bedrock geology comprises the Lower Lincolnshire Limestone of Middle Jurassic age (see Figure 3), with no cover of superficial deposits indicated on or adjacent to the site. The Lower Lincolnshire Limestone is described by the BGS as comprising limestones dominated by low-energy calcilutite, and peloidal wackestone and packstone, commonly including sandy limestone or calcareous sandstone in the basal part. Underlying the Lower Lincolnshire Limestone are the mixed strata of the Grantham Formation (formerly the Lower Estuarine Series), described by the BGS as comprising mudstones, sandy mudstones and argillaceous siltstone-sandstones, and the Northampton Sand Formation, which underlies the Grantham Formation, where it is present, and is described as comprising greenish grey sandy ironstone, weathering to brown limonitic sandstone, with the uppermost beds generally comprising ferruginous sandstone. The Northampton Sand is underlain by the Whitby Mudstone.

2.1.4 The geological mapping indicates that the Grantham Formation is discontinuous in the area and may pinch out in some areas, however, observations of the completed cut faces on the adjacent landfill site suggest that the Grantham Formation mudstones are likely to be consistent across the site. The geological mapping indicates that the geology of the site is further complicated by two SE-NW trending normal faults, which are indicated to affect the western part of the site. The downthrow is on the eastern side of these faults, and some visual evidence of this faulting was noted during the site inspection for the 2020 GA report.

2.1.5 The 2024 HRA report by Hafren Water has involved a very comprehensive review of BGS archive borehole logs and other borehole logs in the area of the site, which has been used to develop geological cross-sections for the site, which are presented in the HRA report. The cross-sections indicate that the Lower Lincolnshire Limestone dips towards the east at around 2° and that the downthrows of the two faults are between 1-3m. The combination of the dip and the faulting suggests that the base level of the Lower Lincolnshire Limestone is at around 130-132mAOD in the extreme western corner of the site (as confirmed at the location of the Grantham Mudstone clay sampling trial pit dug in 2022 - details in Appendix A), dropping to around 127-130mAOD in the central part of the site between the faults, and then dropping further to between 123-126mAOD in the eastern part.

2.1.6 Discussions with CESL in 2024 have confirmed that at the time of the 2019 topographic survey the quarry base in the eastern part had been excavated to finished level (around 123-124mAOD), with a thin layer of limestone left in the base as a running surface. The central part of the quarry was subsequently worked the same way with a thin limestone layer left in the base. The western area, where the Grantham Formation clay was exposed at higher level due to the faulting, was worked to the same level as the central area to win clay for the AGB liner – Northampton Sand material was not encountered in the base of the clay excavation area. On completion of clay excavation, surplus quarry spoil was placed as subgrade fill over the clay/mudstone to form the subgrade for the AGB liner.

2.1.7 The final extraction level is therefore anticipated to have varied across the site from around 125-128mAOD in the west to around 123mAOD in the east (see Figure 4).

2.1.8 As noted in Section 2.1.6, in the western part of the quarry site, the quarry was extended down below the base of the limestone to win clay from the Grantham Formation mudstone for use in the basal and sidewall liner layers and the dividing bund between the site and the adjacent FCC landfill. The Grantham Formation is underlain by ironstone of the Northampton Sand Formation, however, the excavation was terminated before ironstone was encountered in the base.

2.1.9 The crest levels of the perimeter quarry faces range from 137-138mAOD, indicating depths of around 6-15m to the base of the limestone, increasing in height from west to east, although the proposed clay extraction in the western part of the site, below the base of the limestone, will result in overall completed quarry face heights of 10-12m in that area. It should be noted that in the northern/central part of the eastern face the workings have broken through the face into the adjacent FCC Colsterworth landfill site, with the quarry floor linking through. The angles of exposed faces on the site range between 45° to subvertical and generally appeared to be stable with only very small-scale rockfalls of small blocks and small-scale toppling failures observed, however, a zone of weak sandy limestone was observed in the central part of the Southern face which had resulted in some limited face failure and undermining of a soil bund at the crest of the face due to degradation and weathering of the weaker material.

2.1.10 The exposed quarry faces on the three sides of the quarry comprised medium bedded buff coloured limestones, with thin sandy limestone interbeds around 100mm thick, considered to be of the Lower Lincolnshire Limestone. The dip of the strata is gentle towards the east and there are subvertical joint sets that are generally medium spaced that are cut off by occasional more massive medium to thick beds that have a medium to wide joint spacing. The more thickly bedded strata become more frequent further down the sequence/quarry face. The limestone at the top of the faces is typically capped by a weathered surface layer of heavily weathered limestone cobbles in a sandy clay matrix around 1m thick.

2.1.11 Once the limestone had been fully extracted, in the western part of the site the base of the excavation was extended into the underlying mudstone. Arisings of mudstone clay from the floor of the quarry, supplemented by selected suitable material won from the incoming inert waste, will be used to form the artificial geological barrier clay lining system around the quarry base and side slopes, with placement of inert landfill waste into the void following on. The side slopes of the proposed landfill will therefore on most sides comprise in-situ Lower Lincolnshire Limestone, with Grantham Formation mudstone only exposed in the base of the face in the western areas taken down to win clay. In the northern/central part of the Eastern face, towards the latter stages of the landfilling, it is proposed that clay won from the base of the quarry or selected suitable material won from the incoming inert waste will also be used to form a dividing bund of compacted clay material to provide the side slope of the proposed CES Ltd landfill and separation between it and the FCC Colsterworth landfill to the east in this section.

2.1.12 The waste material to be imported into the site that is to be applied for on the landfill licence will be a variety of the forms of Inert Waste listed in the European Waste Catalogue. The site will only accept materials classified as non-hazardous, and will exclude wastes that are solely or mainly of dusts, powders or loose fibres, and not in a form that is either sludge or liquid. The waste materials could comprise a variety of materials: glass; concrete; bricks; tiles and ceramics; waste mineral in the form of sand and stones; and soil and stones.

2.1.13 On completion of the placing of the inert waste, it is proposed to install two gas monitoring standpipes within the waste mass to facilitate long-term monitoring of gases.

2.1.14 The limestone bedrock is classified as a Principal Aquifer, overlying Secondary Aquifer (Grantham Formation and Northampton Sand Formation), as indicated by the Environment Agency/DEFRA aquifer designation and groundwater source protection maps. The site does not lie within a groundwater Source Protection Zone. The

Groundwater Vulnerability is defined as high for the limestone, and intermediate to high for the underlying strata. At the GA site inspection in 2019, no surface water or groundwater seepages were observed in the quarry or the adjacent landfill site, and the review of groundwater levels in the monitoring boreholes on the site presented in the 2024 HRA indicates that groundwater is present towards the base of the Northampton Sands, perched on the underlying Whitby Mudstone, and that the overlying Grantham and Lower Lincolnshire Limestone strata are essentially dry.

2.2 Basal Sub-Grade Model

2.2.1 The base level of the void has been formed at a level of around 125-128mAOD in the western part of the site, and 123-125mOD in the central and eastern parts. The basal subgrade mainly comprises a thin layer of limestone overlying clay/mudstone deposits of the Grantham Formation, whilst in the western part of the site clay/mudstone deposits of the Grantham Formation were exposed, but have subsequently been overlain by subgrade fill of surplus quarry spoil of limestone debris. The groundwater levels are expected to be at some depth below the permitted base of excavation, within the underlying Northampton Sands stratum.

2.3 Side Slope Sub-Grade Model

2.3.1 The quarry rock face side slopes will largely comprise deposits of the Lower Lincolnshire Limestone, with Grantham Formation mudstone in the lower part of the side slope in the western part of the site where the quarry base level has been taken deeper to win Grantham Formation clay. In the northern/central part of the eastern edge of the site the limestone rock face between the CES Ltd quarry site and the adjacent FCC Colsterworth landfill site has been removed, and along this edge section a bund of subgrade fill material comprising clay won from the western part of the quarry base, supplemented by selected suitable material won from the incoming inert waste, will be placed and compacted to an appropriate level to form the side slope and to provide separation from the adjacent landfill.

2.3.2 The quarry rock face heights in the limestone range between 8-15m, but in the western part of the site the faces will extend below the base of the limestone, to the base of the Grantham Formation mudstone (see Figure 4), resulting in overall potential face heights of up to 10-12m maximum in the western part of the site and up to 14-15m elsewhere in the quarry. The proposed restoration levels along the eastern edge of the site range between 136-140mAOD, with the highest levels in the central part, and therefore the dividing subgrade fill bund between the CES Ltd quarry site and the adjacent landfill to the east will be up to around 13-17m high.

2.3.3 The overall quarry rock face angles in the limestone and underlying mudstone will range up to 55° in most cases, although on the North face and parts of the East face there are old existing faces that have been cut at 73° and 78° respectively. During the site inspection for the geotechnical assessment, the exposed limestone faces in the quarry were generally noted to become more structured towards the base of the faces, with the uppermost parts being more weathered and jointed, with thinner beds. The exposed limestone faces generally appeared to be stable with only very small scale rockfalls of small blocks and small scale toppling failures observed, and in the western part of the floor, where it will be taken down to the base of the underlying mudstone, a 2-3m wide bench could be left at the base of the limestone face to catch any minor debris falls.

2.3.4 Where the side slopes comprise quarry rock faces, which are generally relatively steep, imported cohesive subgrade fill will be placed against the faces to create a 1 in 1 facing batter slope to provide a sloping surface on which the AGB liner layer can be constructed.

2.3.5 The dividing bund is proposed to be formed using natural mudstone clay won from the base of the quarry placed and compacted in thin layers to form lifts of around 3m high. Where necessary, this will be supplemented by selected suitable material won from the incoming inert waste. The western face of the dividing bund is proposed to have a 1v in 1h face. The compaction of the clay in the bund will be such that it will comply with the permeability requirements for the AGB liner layer, and therefore the AGB layer will be integral with the outer face of the bund and will not require to be constructed separately. Shortly after each lift of the dividing bund is completed, landfill waste will be compacted up against it, and benched into it, to provide lateral buttressing of the inside side slope face of the dividing bund. The outer face of the dividing bund will be formed to a suitable face angle, the angle of which will depend on how long after bund placement the landfilling on the FCC site will follow on.

2.3.6 North and south of the section of the eastern boundary of the site where the dividing bund is required, 'walls' of undisturbed limestone have been left in place, providing physical separation from the adjacent FCC landfill site.

2.4 Basal Lining System Model

2.4.1 The basal lining system will comprise an artificial geological barrier (AGB) comprising suitable cohesive materials won from the base of the excavation, where necessary supplemented by chemically and physically suitable imported cohesive inert wastes, compacted to achieve an appropriate maximum permeability or lower: the AGB layer shall have a permeability equivalent to $1x10^{-7}$m/s at a thickness of 1.0m. If the permeability of the compacted liner materials is higher than this, the liner thickness will be adjusted to achieve the same effective permeability/thickness ratio (i.e. 5.0m thick at $5x10^{-7}$m/s). The proposed landfill design proposes a minimum AGB thickness of 1.0m.

2.4.2 It is proposed that the clay lining material will be won from the Grantham Formation mudstone underlying the limestone in the base of the western part of the quarry, and will be supplemented by chemically and physically suitable imported cohesive inert waste . For clay material to be considered suitable for use as a liner it must have the following properties, and the site won material and any imported waste used to form the AGB liner layer will be tested to confirm compliance:

- no evidence of stones over 125mm,
- no water be seen to leach from the material,
- be possible to roll into a 3mm thick rod without crumbling and
- have a minimum shear strength of 45kN/m^2

2.4.3 Sampling and testing of the mudstone materials underlying the limestone from the western part of the floor of the quarry site was undertaken in 2022, details of which are presented in Appendix A. The testing indicates that the clay won from the mudstone has the following properties:

- Natural moisture content 22%;
- Plastic Limit 20%;
- Liquid Limit 45%;
- Plasticity Index 25%;
- 95% passing 425µm sieve, 86% passing 63µm sieve, no stone content retained on 6.3mm sieve;
- bulk density (when compacted at natural moisture content using 2.5kg rammer) of 2.02Mg/m^3, dry density 1.70Mg/m^3;
- undrained shear strength of sample compacted at natural moisture content 62kN/m^2.

The results comply with the guidance given in Table 4 of the Environment Agency guidance - *Earthworks in landfill engineering: LFE4*, June 2014, which indicates that the material will be suitable to act as a Landfill Directive compliant geological barrier when compacted. Based on the test data and our experience of similar materials, the permeability of the compacted mudstone clay material is anticipated to be significantly lower than 1 x 10^{-7}m/sec.

2.4.4 Compliance testing of the AGB liner layer will be undertaken as part of the CQA regime for the site. Where imported inert waste is used to form the AGB layer, the chemical suitability, pollution potential and waste acceptance of the waste materials brought to the site will be controlled via the implementation of the Waste Acceptance Plan proposed for the site, as included within the Environmental Management (Summary) Plan – which will ensure that the waste materials are inert as defined by the Landfill directive, article 2(e) and contain no hazardous substances, and are therefore suitable for use in the AGB, provided that they are physically suitable. The suitability of the physical properties of any waste materials proposed for use to form the geological barrier will be checked via an assessment of their compliance with the basic properties outlined in paragraphs 2.4.2 and 2.4.3 above, coupled with laboratory testing of the materials as appropriate. The details of the proposals for physical suitability testing and compaction compliance testing of the liner materials will be detailed in the CQA Plan for the site.

2.4.5 The groundwater level is expected to lie below the proposed base of excavation, which will be the top of the Northampton Sand Formation in the western area where the base of the quarry is taken deeper to win clay, so uplift pressures will not develop on the underside of the basal liner.

2.4.6 The facility is to be utilised for the disposal of inert wastes only. Under the Environmental Permitting (England and Wales) Regulations (2016), inert sites are not required to collect leachate. No artificial sealing liner or leachate drainage layers are proposed.

2.4.7 Schematic diagrams showing the basal lining system model are presented in Figure 5.

2.5 Side Slope Lining System Model

2.5.1 The side slope AGB lining system will comprise suitable site-won mudstone clay materials as discussed in Section 2.4 above, where necessary supplemented by chemically and physically suitable imported cohesive inert wastes, spread and compacted in layers to achieve a permeability less than or equivalent to 1 x 10^{-7}m/s at a minimum thickness of 1m, although greater thicknesses may be used to achieve the same equivalent permeability/thickness ratio if more permeable/variable materials are used (i.e. 5m thick at $5x10^{-7}$m/s). The barrier will be constructed in 3m high lifts against the quarry face side slopes ahead of the deposit of waste in the landfill body.

2.5.2 A minimum AGB layer thickness of 1m is proposed at a maximum permeability of $1x10^{-7}$m/s. Where the side slopes comprise quarry rock faces, which are generally relatively steep, as noted in Section 2.3.4 above, imported cohesive subgrade fill will be placed against the faces to create a 1 in 1 subgrade side slope, and the AGB liner layer will be constructed on its sloping surface. In the section where the dividing bund will be placed on the eastern boundary of the site, the inside face of the bund will also be constructed to a side slope of 1 in 1, enabling the AGB layer to be constructed in the same way.

2.5.3 As per Section 2.4 above, the AGB layer will comprise engineered compacted clay material of low permeability, formed using site-won materials, supplemented if necessary using selected physically/chemically suitable imported cohesive inert waste. As the construction of the liner progresses in advance of the level of the landfill mass, it will be unconfined for a short period of time above the level of the adjacent waste and will be subject to undrained strength parameters in this condition. The rate of progress of placing of the landfill waste will be such that, within a short period, while the clay liner remains in a undrained state, waste will be compacted against the liner to ensure that is confined and supported by the fill, ensuring long-term support against the liner.

2.5.4 Any lining system placed on the side slope of the dividing bund within the FCC landfill site will be the responsibility of FCC and is not discussed further in this SRA document.

2.5.5 A schematic diagram showing the side slope lining system model is presented in Figure 5.

2.6 Waste Mass Model

2.6.1 The proposed waste stream will comprise inert waste, comprising a mix of inert materials: glass; concrete; bricks; tiles and ceramics; waste mineral in the form of sand and stones; and soil and stones arising from construction, demolition and excavation works. The maximum waste thickness will be approximately 17-20m, including liner and any cover material.

2.6.2 Although no detailed information is available as to the precise composition and properties of the waste, these types of materials are expected to have favourable properties in terms of strength: either undrained and drained shear strength properties for inert wastes exhibiting cohesive behaviour, or soil friction angle for inert wastes exhibiting granular behaviour. To maximise the efficient use of the available void, the waste materials will be heavily compacted by repeated passes of earthmoving equipment. Where the waste mass is considered in stability analysis work for this SRA, the possibilities that it might comprise either all cohesive material or all granular material will be considered in the analyses.

2.6.3 Throughout the operational period, the water level within the quarry void will be maintained below the base by pumping if necessary. The temporary waste slopes will therefore be essentially dry.

2.6.4 Temporary slopes within the waste body will be benched at an overall gradient of approximately 1v in 3h (adjusted on site to suit the materials) constructed in 3m lifts to ensure it remains stable and that any minor slips do not affect the landfilling operations. The proposed final landform will tie in with the levels of the adjacent land around the site boundaries.

2.6.5 Schematic diagrams showing the waste model are presented in Figure 5.

2.7 Capping System Model

2.7.1 Environment Agency guidance for inert landfills states that a capping system is not required for inert landfill sites.

3. STABILITY RISK ASSESSMENT – Risk Screening

3.1 Basal Sub-Grade Screening

3.1.1 The basal sub-grade will mainly comprise a thin layer of limestone overlying clay/mudstone deposits of the Grantham Formation, whilst in the western part of the site clay/mudstone deposits of the Grantham Formation were exposed, but have subsequently been overlain by subgrade fill of surplus quarry spoil of limestone debris, and has a slightly eastward sloping base. The rock strata and compacted quarry spoil subgrade fill in the basal sub-grade are therefore expected to be in a dense to very dense condition and excessive deformation of the basal sub-grade due to highly compressible materials in the sub-grade is not a plausible risk.

3.1.2 No detailed stability risk assessment of the basal subgrade is considered necessary as it is to be cut to a gently sloping surface and no highly compressible materials are anticipated to be present, however the sub-grade will be inspected prior to placement of the basal AGB liner to confirm that it provides a suitable stable base.

3.2 Side Slope Sub-Grade Screening

3.2.1 The side slope sub-grade on the north and south sides of the side, and for much of the eastern side, will comprise side slopes of cohesive subgrade fill built up at 1 in 1 against the former quarry faces of in-situ limestone of the Lower Lincolnshire Limestone Formation, overlying Grantham Formation mudstones in the western part. Similarly, the western face of the dividing bund on the eastern side of the site will also be built with a 1 in 1 side slope using Grantham Formation mudstone clay cohesive material won from the site. Stability analysis of the side slope subgrade is required in the short-term case before the AGB liner layer and/or waste is placed against it.

3.2.2 Progressive construction of the AGB layer on the side slope subgrade, with progressive landfilling of waste against the AGB layer following rapidly afterwards, will enhance the stability of the side slope subgrade. The proposed inert waste is non-biodegradable and will not be susceptible to shrinkage, therefore it will continue to provide additional support to the side slope subgrade in the long-term. In the light of the above, no analysis of the long-term stability of the side slope sub-grade is proposed.

3.2.3 In the case of the outer (eastern) face of the dividing bund, within the adjacent active FCC Colsterworth landfill site, analysis of its stability under both short- and long-term conditions is required as the timescale of landfilling against it is not certain at this time and is not within the control of CES Ltd.

3.3 Basal Lining System Screening

3.3.1 An AGB liner layer is required at the base of the quarry. The basal liner is to comprise engineered low permeability clays that will be deposited and compacted in a controlled manner to ensure the AGB meets the required specification. The AGB clay layer material will be subject to significant compaction as part of its formation, and is therefore not expected to undergo any significant compression under the loads applied by the landfill wastes.

3.3.2 The base of the proposed landfill will generally have a fall of less than 5°, and is considered to be a stable gradient without the requirement for stability analysis. The underlying bedrock and compacted subgrade fill sub-grade is also considered to be suitably stable, therefore no numerical stability analysis of the basal liner is proposed.

3.4 Side Slope Lining System Screening

3.4.1 An AGB liner layer is required against the 1 in 1 side slopes formed using subgrade fill against the former quarry faces and the western side slope of the dividing bund.

The AGB layer will be constructed to an engineering specification in a series of lifts, with waste placed against it shortly after placement, to limit any deterioration due to weathering/desiccation etc. In the case of the western side slope of the dividing bund, the AGB layer will be constructed concurrently as an integral part of the dividing bund, and will be raised in a series of lifts to form a 1 in 1 face, with waste placed against it following closely on from placement.

3.4.2 The AGB layer will be inspected immediately before waste is placed against it to identify any evidence of erosion or slippage, and in the unlikely event that such defects are identified, appropriate remedial measures will be implemented ahead of the deposit of waste. Properly constructed haul roads will be constructed to prevent damage to the AGB layer and operational procedures will be put in place to ensure the barrier is not damaged by the landfill plant engaged in spreading the waste.

3.4.3 The AGB liner layer will comprise engineered clay material. As the AGB layer is constructed, its side slope will be in an unconfined state for a short period of time, during which it will be operating under undrained strength parameters. Shortly after placing each lift of the side slope liner, landfill waste will be compacted against it to ensure that is confined, providing long-term support to the liner. The short-term stability of the liner during the construction phase before waste is placed against it therefore needs to be assessed as part of the stability risk assessment, involving a maximum individual temporary face height of 3m.

3.4.4 The inert waste materials that are likely to be imported to the site will be a mix of inert clays, granular materials and other waste materials that behave as granular materials. The waste will be compacted to a high degree in layers by large earthmoving equipment to ensure the void is commercially optimised. The density and compressibility of the waste fill and the AGB liner are therefore unlikely to be significantly different due to similar relative degrees of compaction. Significant differential settlement between the liner system and waste mass is therefore not considered likely to occur because the waste mass will be well compacted, reducing the voids present within the landfill mass. A slightly greater degree of settlement might take place towards the centre (on plan) of the waste mass, however, settlement in this area will not affect the stability of the side slope AGB liner system.

3.4.5 The high degree of compaction of the landfill waste, comparable to that of the AGB liner, and the working method of incremental alternating lifts of AGB liner and waste, will ensure that there is no significant down-drag that would affect the side slope AGB liner, and the lateral earth pressure from the inert material will ensure that the liner is confined with no plausible likelihood of its deformation into the compacted fill.

3.5 Waste Mass Screening – temporary waste slopes

3.5.1 The site will be progressively filled in phases. The landfill material will be compacted in layers using best practice to ensure the waste surface is trafficable and that the available void capacity is maximised. As the inert waste is imported and placed in the site there will be an exposed waste slope or slopes that will progress across the site.

3.5.2 The temporary waste slopes will reach a maximum height of 3m with a maximum face angle of 1v in 3h proposed, which will be adjusted on site as needed to ensure stability, and will only have the potential to fail internally within the site until the void area is full. As the waste will be inert, any instability affecting the temporary waste slopes would not introduce any risk of releasing potentially polluting substances to air or to controlled waters, and any instability would not cause a release of waste outside the site boundary. Any minor failures that may occur will be small scale and would be contained within the active landfill, and will result in adjustment of the face angles in the waste to slacker angles, and therefore will not adversely affect the side slope or basal AGB layer that will form the subgrade to the base and side slopes of the landfill.

3.5.3 Taking these factors into account, it is not considered that detailed analysis of the temporary waste slopes is required.

3.6 Waste Mass Screening – completed restoration slopes

3.6.1 The maximum gradient of the final waste slopes will be no greater than 1v in 6h, which, taking into account the nature of the waste, is considered to be a stable gradient without the requirement for stability analysis.

3.6.2 As the waste to be deposited within the landfill is inert, and the rate of filling relatively slow, any settlement is expected to occur largely concurrent with filling. Any long-term settlement is expected to be insignificant, consequently excessive total or differential settlement of the waste body is considered to be very unlikely. No settlement analysis is therefore considered to be necessary.

3.6.3 As the waste will be inert, there is no risk of instability causing a release of potentially polluting substances to air or to controlled waters.

3.7 Capping System Screening

3.7.1 No capping system is proposed, consequently no assessment is required.

3.8 Lifecycle Phases

3.8.1 The critical phase of stability in the side slope subgrade faces, the western slope of the dividing bund and the AGB layer on the side slopes will occur prior to the placement of waste fill material against them (short-term temporary state – undrained conditions in cohesive materials). In this phase the AGB layer on the side slopes will be self-supporting over the short period until the waste is placed against it. The placement of waste will provide additional support to the barrier.

3.8.2 The wastes to be deposited in the landfill will be inert, containing no biodegradable materials. The landfill waste is to comprise a mix of fine grained soils, clays and granular materials. The waste will not undergo significant settlement or shrinkage which could result in loss of support and instability affecting the AGB. Thus, further analysis of the AGB following the placement of waste material is not required.

3.8.3 Stability analysis is however required to consider the short-term, temporary exposure (prior to the placement of waste) of the AGB on the side slopes, and of the side slope subgrade 1 in slopes.

3.8.4 Short- and long-term stability analysis is required of the outer (eastern) side slope of the dividing bund.

3.8.5 There is no requirement for leachate management, gas management, daily cover or temporary capping as the waste will be inert.

3.8.6 Once the landfilling work has been completed, it is proposed to install two gas monitoring standpipes into the waste mass to facilitate long-term monitoring of gas generation rates and concentrations. The long-term stability of the gas monitoring standpipes and the integrity of the basal liner beneath them is considered in Section 5 of the SRA.

3.9 Data Summary

3.9.1 Basal sub-grade - some geotechnical testing of the basal sub-grade materials where they comprise Grantham Formation mudstone is available (see Appendix A), but not for the underlying Northampton Sands, therefore some assumptions have been made based on experience and engineering judgement for the bulk of the site.

3.9.2 Side slope sub-grade - no geotechnical testing of the side slope subgrade fill materials is available, therefore assumptions based on site observations, experience and engineering judgement have been derived, however, geotechnical testing of the Grantham Formation mudstone clays, which will be used to form the dividing bund and its side slopes, is available.

3.9.3 Artificial Geological Barrier – geotechnical test data for the Grantham Formation mudstone clays proposed for use to form the AGB is available, therefore parameters based on the test data, experience and engineering judgement have been derived.

3.9.4 Groundwater – an assumed groundwater level near the base of the Northampton Sands ironstone has been adopted in the stability analyses.

4. STABILITY RISK ASSESSMENT

4.1 Justification for Modelling Approach and Software

4.1.1 In order to analyse all components of the landfill and their interactions with the site geology, the site geology and proposed landfill components have been analysed using 2D limit equilibrium geotechnical slope stability analysis software Slide 5.0 published by Rocscience. This software is appropriate and suitable to represent all the considered phases of the lifecycle. The goal of analysis is to understand the likely slip surfaces and determine the lowest factor of safety for each considered slope profile for all lifecycle phases.

4.1.2 Slide is an industry standard programme which performs two-dimensional slope stability analysis to study circular and non-circular slip surfaces. The analysis has been carried out using the Bishop simplified method of slices assuming circular failure modes. Three-dimensional effects have not been modelled.

4.1.3 Each slope profile considered has been analysed by defining the relevant material properties and using Bishop's method of slices to derive a factor of safety on shear strength. The Factors of Safety (FoS) tabulated are results for the worst case critical slip surface following an automated iterative search by the SLIDE software which finds the surface with the lowest factor safety.

4.1.4 In any long-term analyses, although the general groundwater table will be below the base level of the proposed landfill, an r_u value of 0.25 has been assumed for all materials in the analysis.

4.2 Justification of Geotechnical Parameters Selected for Analysis

4.2.1 ***Parameters Selected for Basal Subgrade*** **–** Stability analysis of the basal subgrade is not necessary as it was removed from the assessment at the risk screening stage.

4.2.2 ***Parameters Selected for Side Slope Sub-Grade*** **–** Stability analysis of the side slope subgrade fill 1 in 1 slopes against the quarry faces is required for the short-term (cohesive undrained) construction case. Similarly, the short-term stability of the western face of the dividing bund, which integrally includes the AGB liner layer, is also required. The short- (cohesive undrained) and long-term (effective drained) strength parameters of the dividing bund material are also required for the short- and long-term stability assessment of its eastern face.

4.2.3 The quarry side slope materials underlying the side slope subgrade fill, and the basal sub-grade materials, comprise limestone and mudstone rock materials with high inherent shear strength, significantly higher than the side slope subgrade fill materials and the dividing bund fill and therefore, in the stability analyses of these features, these materials have been considered as being infinitely strong – i.e. failure surfaces cannot pass through these materials, they can only form in the subgrade fill or dividing bund materials themselves.

4.2.4 The adopted strength parameters of the side slope subgrade fill and dividing bund material are presented in the table below.

Material	**Undrained Shear strength**	**Bulk Unit Weight**	**Effective friction angle**	**Effective cohesion**	**Justification**
	Cu kPa	γ_b kN/m³	Φ′ degrees	c' kPa	
Cohesive subgrade fill	45	18.0	27	0	Based on information published in BS8002 – assuming cohesive with stones
Dividing bund – Grantham Formation clay	45	19.0	26	0	Based on lab test data & information published in BS8002 for phi’$_{crit}$ for clay PI 25% (+1° for peak friction)

4.2.5 ***Parameters Selected for Artificial Geological Barrier (AGB)***

4.2.6 The parameters used for the short-term stability analysis of the side slope liner system are based on the presumed undrained shear strengths of the liner materials. For the short-term stability analysis of the side slope liner, the adjacent basal liner at the foot of the side slope has been assigned the same soil parameters.

4.2.7 The long-term stability of the side slope liner on the inside edge of the proposed landfill was removed from the assessment at the risk screening stage.

4.2.8 The basal sub-grade materials, and the quarry side slope materials underlying the side slope subgrade fill, comprise limestone and mudstone rock materials with high inherent shear strength, significantly higher than the AGB materials, and therefore, in the stability analyses of the short-term stability of the side slope liner, these materials have been considered as being infinitely strong – i.e. failure surfaces cannot pass through these materials, they can only form in the AGB liner materials themselves, and/or in the side slope subgrade fill or dividing bund fill where these underlie the AGB liner layer.

4.2.9 The adopted shear strength parameters of the artificial geological barrier are presented in the table below. The CQA testing will ensure that should imported inert waste materials be incorporated into the AGB liner layer, the strength properties of these materials will be equivalent to, or stronger than, the properties of the Grantham Formation mudstone clays used in the AGB.

Material	**Undrained Shear strength**	**Bulk Unit Weight**	**Effective friction angle**	**Effective cohesion**	**Justification**
	Cu kPa	γ_b kN/m^3	Φ′ degrees	c' kPa	
AGB layer – Grantham Formation clay or inert cohesive waste	45	19.0	26	0	Based on lab test data & information published in BS8002 for phi'_{crit} for clay PI 25% (+1° for peak friction)

4.2.10 ***Parameters Selected for Waste Analysis*** - Analysis of the stability of the waste is not necessary as it was removed from the assessment at the risk screening stage, however, the short and long-term stability of the outer (eastern) face of the dividing bund between the two landfill sites needs to be considered. The adopted strength parameters of the cohesive and granular waste materials are presented in the table overleaf. The compacted cohesive waste is the worst-case material due to lower effective friction in the long-term case, and the critical scenario requiring stability analysis is the long-term (effective drained) case.

Material	Undrained Shear strength	Bulk Unit Weight	Effective friction angle	Effective cohesion	Justification
	Cu kPa	γ_b kN/m^3	Φ′ degrees	c' kPa	
Compacted cohesive waste	40	16.0	27	0	Based on information published in BS8002 – assuming cohesive with stones
Compacted granular waste	n/a	17.0	35	0	Based on information published in BS8002 – assuming subrounded with I_D 50%

4.2.11 *Selection of appropriate Factors of Safety* - The slope stability analyses have been carried out in general accordance with BS6031:2009 using lower third average soil parameter assumptions, with a target minimum factor of safety of 1.3 adopted for both short-term stability and long-term stability.

4.3 Slope stability analyses

4.3.1 *Side Slope 1 in 1 subgrade fill slopes*

4.3.2 Slope stability analysis has been conducted to consider a cross-section representing the existing quarry face profile of around 60°, of 14m height, with subgrade fill banked up against the face to form at side slope of 1 in 1. A 2m width is assumed at the crest of the subgrade fill.

4.3.3 The model is based on the assumption that the site within the application area will remain dry. Analysis has been carried out for the situation shortly after the construction of the full height side slope subgrade fill, before the deposition of waste, and therefore considers short-term undrained conditions. Undrained conditions are considered to apply over the relatively short period before waste is built up against the face, buttressing it.

4.3.4 The analysis results in a calculated minimum Factor of Safety under BS6031 of 1.70 in the short-term undrained case, which is significantly greater than 1.30 and is therefore considered acceptable. Output from the slope stability analysis is presented in Appendix B.

4.3.5 ***Side Slope AGB Liner Layer Analysis***

4.3.6 Slope stability analysis has been conducted to consider a cross-section representing the existing quarry face profile of around 60°, faced with subgrade fill to form a 1 in 1 side slope, with a 1m thick layer of AGB placed on top with an outer slope of 1 in 1.

4.3.7 The model is based on the assumption that the site within the application area will remain dry. Analysis has been carried out for the situation shortly after placement of the AGB to full height, before the deposition of waste, and therefore considers short-term undrained conditions. Undrained conditions are considered to apply over the relatively short period before waste is built up against the face, buttressing it.

4.3.8 The analysis results in a calculated minimum Factor of Safety under BS6031 of 1.49 in the short-term undrained case, which is significantly greater than 1.30 and is therefore considered acceptable. Output from the slope stability analysis is presented in Appendix B.

4.3.9 ***Side Slope Analyses – Dividing Bund Western Face***

4.3.10 Slope stability analysis has been conducted to consider a cross-section comprising the inside face of the dividing bund constructed or trimmed to an angle of 1 in 1. The dividing bund is assumed to be 14m high and 4m wide at the top.

4.3.11 The model is based on the assumption that the site within the application area will remain dry. Analysis has been carried out for the situation shortly after the construction of the dividing bund, before the deposition of waste against it. Undrained conditions are considered to apply over the relatively short period before waste is built up against the face, buttressing it.

4.3.12 The analyses resulted in calculated minimum Factors of Safety under BS6031 in the short-term undrained scenario of 1.03 for the inner bund face, which falls below the target FoS of 1.30 and is unacceptable. Additional analyses have been undertaken assuming a temporary during construction reduced bund height of 10m, and also of the 14m high bund with 4m of granular waste placed against it. The 10m high bund analysis short-term analysis gives a FoS of 1.44, whilst the analysis of the 14m high bund with waste placed to 4m height against its base gives FoS 1.34, both of which exceed the target FoS of 1.3 and are therefore considered acceptable. Outputs from the slope stability analyses are presented in Appendix C.

4.3.13 The management protocols for the construction of the dividing bund will ensure that it does not exceed 10m high without side support from waste.

4.3.14 ***Side Slope Analyses – Dividing Bund Eastern Face***

4.3.15 The stability analysis on the outer face of the dividing bund is influenced by how long a time gap there is before placement of waste starts against it, buttressing it. The analysis of the western face indicates that an outer face angle of 1 in 1 could be used provided that the overall unsupported height during construction does not exceed 10m, and therefore in that scenario, placing of waste in the FCC landfill against its eastern face would need to take place before the bund reaches full height.

4.3.16 If a very long time gap is anticipated on the FCC side, where the dividing bund is built up to 14m full height and the clay fill drains to long-term conditions, analysis using an outer face angle of 1v in 4h would provide a FoS of 1.33, which complies with the target of 1.30 but is a very shallow angle. Other options might be to construct the bund to an outer face of 1 in 1 and place temporary fill against it to ensure support until such time as placing of waste occurs. In practice, it is anticipated that the liaison between CES Ltd and FCC over the timing of the placing of waste against the dividing bund will be such that the dividing bund can be constructed with outer face angles of 1 in 1 with waste placed to ensure the unsupported height is less than 10m at all times during construction.

4.3.17 Output from the slope stability analysis of the long-term unsupported eastern face is presented in Appendix C for information.

4.4 Assessment

4.4.1 ***Basal Sub-Grade Assessment***

4.4.2 Potential failure of the basal subgrade was removed from the assessment at the risk screening stage.

4.4.3 ***Side Slope Sub-Grade Assessment – Quarry Faces***

4.4.4 Analysis of the side slope where subgrade fill is to be placed against the quarry faces has yielded a factor of safety in excess of the target of 1.3 for the short-term undrained scenario. The proposed side slopes in subgrade fill of 1 in 1 are therefore considered satisfactorily stable.

4.4.5 ***Basal Liner Assessment***

4.4.6 Potential failure of the basal liner was removed from the assessment at the risk screening stage.

4.4.7 ***Side Slope AGB Assessment – Quarry Faces***

4.4.8 Stability analysis for the side slope geological barrier has yielded factors of safety in excess of the target factor of safety of 1.5 for the short-term undrained scenario. The proposed 1 in 1 temporary slope of the AGB on the side slopes are therefore considered satisfactorily stable.

4.4.9 ***Side Slope Subgrade Assessment – Dividing Bund***

4.4.10 Stability analyses have yielded factors of safety for the proposed 1 in 1 side slopes of the dividing bund that are in excess of the target factor of safety of 1.3, although to achieve this, the site management protocols and phasing of the landfilling work implemented must ensure that the unsupported heights of the bund faces do not exceed 10m high under short-term (undrained) conditions.

4.4.11 This level of management and phasing can easily be implemented within the CES Ltd site, however, on the FCC side liaison will be required between the two parties to ensure that this is the case. In a worst case (extreme implausible) scenario where the dividing bund fully reaches drained long-term conditions, an outer face angle of 1v in 4h would be required to ensure a FoS of >1.3. In practice it is anticipated that the liaison and planning between the two parties will enable a steeper outer face to be constructed, or material will be temporarily banked up against the eastern face of the dividing bund to ensure its stability until such time that waste can be placed against it.

5. Monitoring

5.1 The Risk Based Monitoring Scheme

5.1.1 ***Side Slope Lining System Monitoring during construction***

5.1.2 Visual inspection of the subgrade fill side slopes and the artificial geological barrier will be undertaken on a weekly basis by the Site Manager, and immediately before deposition of any new section of the barrier or of waste against it. Records of these inspections will be entered in the Site Diary. Should any slippage be identified, the affected area will be cordoned-off to prevent the deposition of AGB or waste against the defective area until such time as remedial works have been undertaken. Remedial works are likely to comprise removal of the slipped mass and benching of new clay into the underlying material.

5.1.3 Waste Mass Monitoring during construction

5.1.4 Visual inspection of the waste slopes shall be undertaken on a weekly basis by the Site Manager. Records of these inspections shall be recorded in the Site Diary.

5.2 Long-term Gas Monitoring of the Waste Mass

5.2.1 Once infilling of the void with compacted inert waste has been completed, the two proposed gas monitoring standpipes will be installed. As the inert waste placed within the landfill will be well compacted by repeated passes of the earthmoving equipment during its placement, with no biodegradable elements present, and the rate of filling will be relatively slow, any settlement of the inert waste is expected to occur largely concurrent with filling. Any long-term settlement is expected to be insignificant, consequently excessive total or differential settlement of the waste mass body is considered to be very unlikely. Therefore, the proposed gas monitoring standpipes are to be of standard specification/detailing/construction, with no provision to accommodate long-term settlement of the inert waste.

5.2.2 It will be important to ensure that the proposed target base depth of the standpipes and of the installation boreholes is carefully controlled so that the thickness or integrity of the basal AGB is not adversely impacted either during the installation operations, or during the life of the landfill. The base of the quarry will be formed at around 121mAOD, and the basal lining system will be placed directly over it. In order to protect the integrity of the basal lining system, the gas monitoring standpipes and their associated installation boreholes will be terminated a minimum of 2m above the top of the basal lining system at the installation borehole location. This will require careful management and quality control of the landfilling work and accurate topographic survey control of the subsequent installation works:

- The elevation of the top surface of the completed basal liner shall be recorded by topographic survey at a number of spot locations, with some targeted at, and close to, the proposed locations of the two gas monitoring standpipes;

- similarly, the surface elevation of the completed landfill shall be recorded by topographic survey shortly after completion, including at the proposed standpipe locations, to enable the detailed design, specification and termination depth of the gas monitoring installations to be finalised;

- at the time of the installation works, the standpipe installation borehole locations shall be set out using topographic survey to within 0.5m on plan, and the surface elevation at the two locations taken, cross-checked against the basal liner surface elevations at the locations, and the target termination depth of the installation boreholes adjusted if necessary;

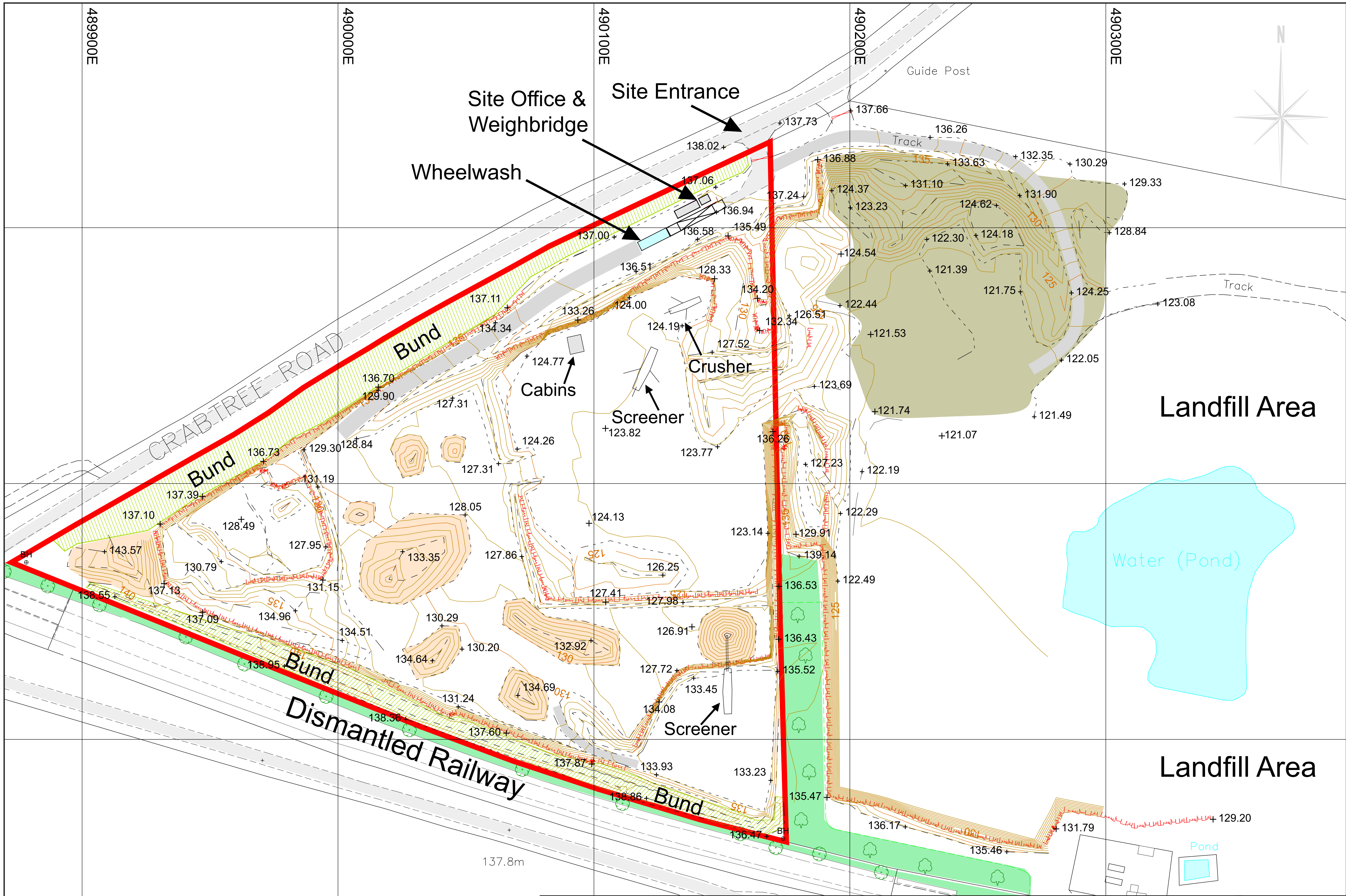
- during the drilling work the advancement of the borehole to the target termination depth shall be carefully controlled to ensure that over-drilling does not occur.

5.2.3 The latter two elements above will be dealt with via the CQA procedures that will be developed in advance of the monitoring infrastructure installation work.

Figures

Figure 1	Scale: NTS	Client: Construction & Environmental Services Ltd	Greenfield enviro
Title: Site location	Checked: TRS	Project: Stability risk assessment	
File ref: Figure 1.cdr	Revision: 00	Site: Stainby Quarry, Lincolnshire	
Date: 17/12/2018	Drawn: TRS		

Greenfield Environmental
Bellotts House, Bellotts Road, Bath, BA2 3RT
Tel/fax: 01225 333414
email: bath@greenfieldenviro.co.uk



Key
- Site Boundary
- Woodland
- Stockpiles
- Bund
- Water
- Backfill/Tip Area
- Quarry Ramps
- Rockface
- 124.13 Levels
- Portacabins /Container

Site surveyed by Greenfield Environmental November 2019. Based upon 2013 Ordnance Survey 1:2500 digital base with the permission of The Controller of Her Majesty's Stationary Office. © Crown Copyright. Licence No. 100020505

Scale
0m 50m

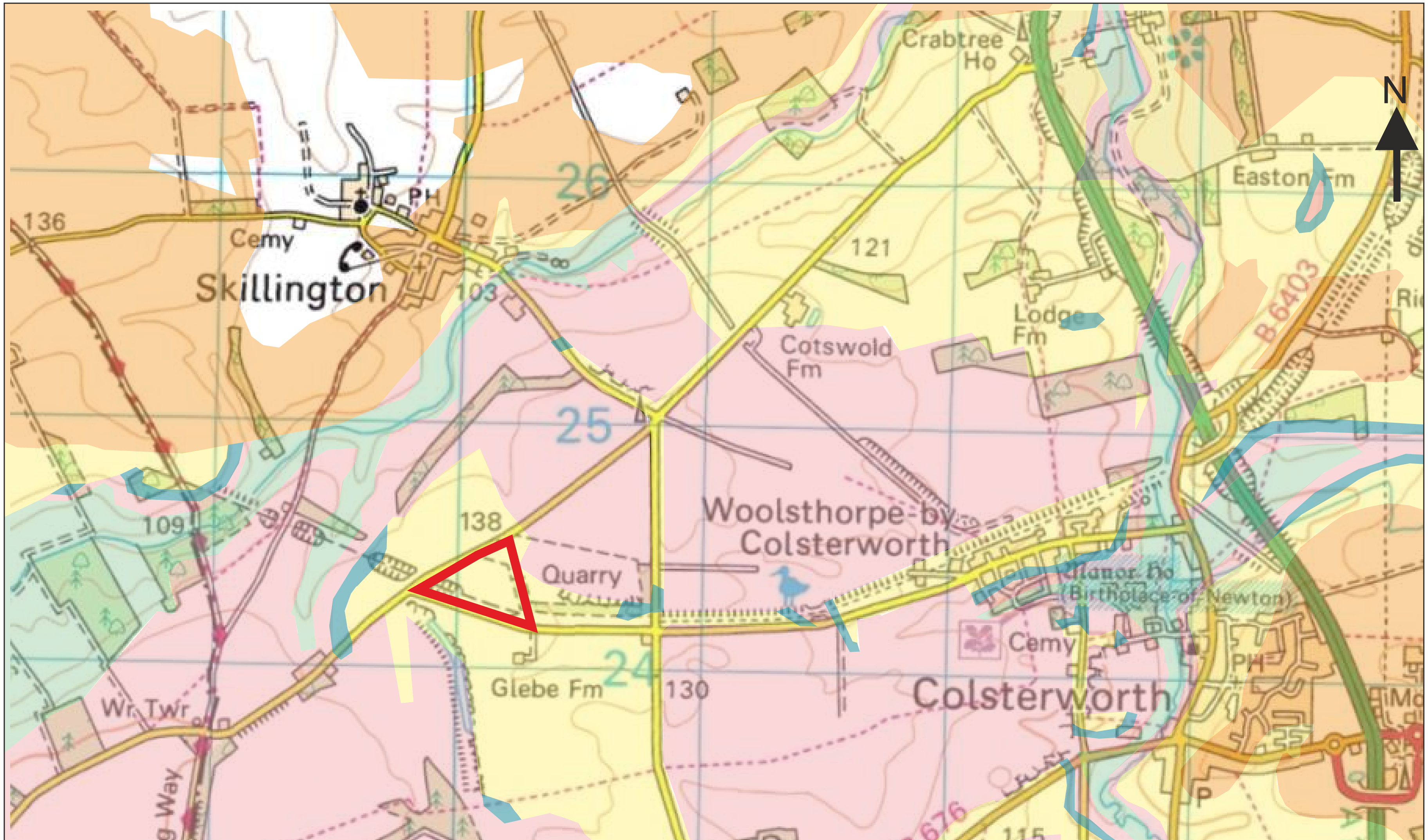
Figure 2		
Title: Site plan		
File ref: Figure 2.cdr	Revision: 01	Scale: 1:1500 @ A3
Date: 26/6/2024	Drawn: TRS	Checked: TRS

Client
Construction & Environmental Services Ltd

Project
Stability risk assessment

Site
Stainby Quarry,
Lincolnshire

Greenfield enviro
Greenfield Environmental
Bellotts House, Bellotts Road, Bath, BA2 3RT
Tel/fax: 01225 333414
email: bath@greenfieldenviro.co.uk



Key

Site Location

Geology

- Upper Lincolnshire Limestone Formation
- Lower Lincolnshire Limestone Formation
- Grantham Formation (Estuarine Series)
- Northampton Sand Formation
- Whitby Mudstone Formation (Lias)

Title	Geology Map
Project	Geotechnical Assessment
Site	Stainby Quarry
Scale	nts
Project No.	CES/STQ/101

Figure 3

Title:
Site geology

File ref:	Revision:	Scale:
Figure 3.cdr	01	NTS
Date:	**Drawn:**	**Checked:**
27/6/2024	TRS	TRS

Client
Construction & Environmental Services Ltd

Project
Stability risk assessment

Site
Stainby Quarry,
Lincolnshire

Greenfield enviro
Greenfield Environmental
Bellotts House, Bellotts Road, Bath, BA2 3RT
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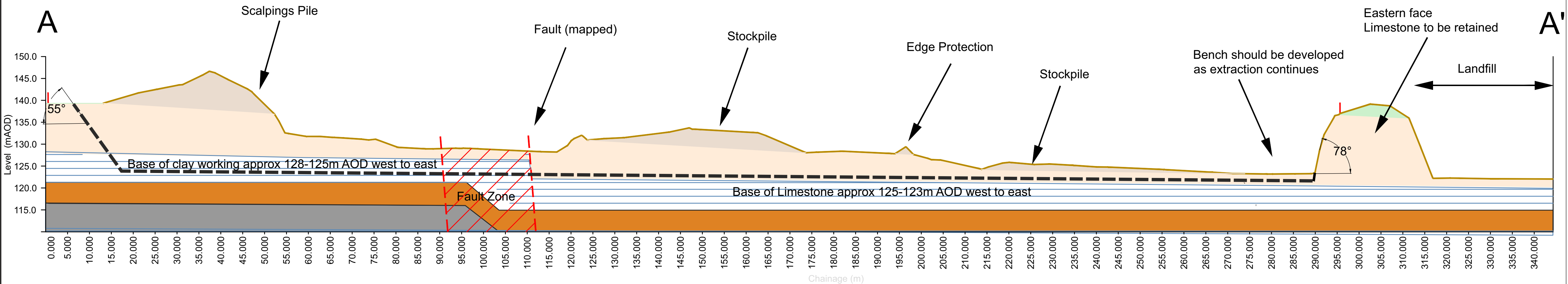
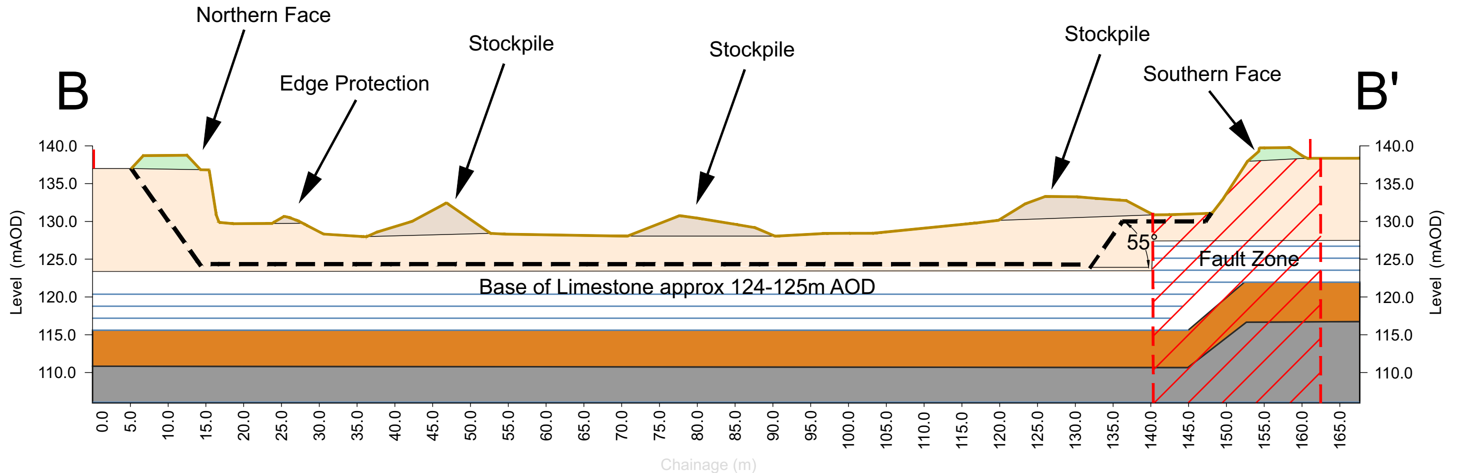
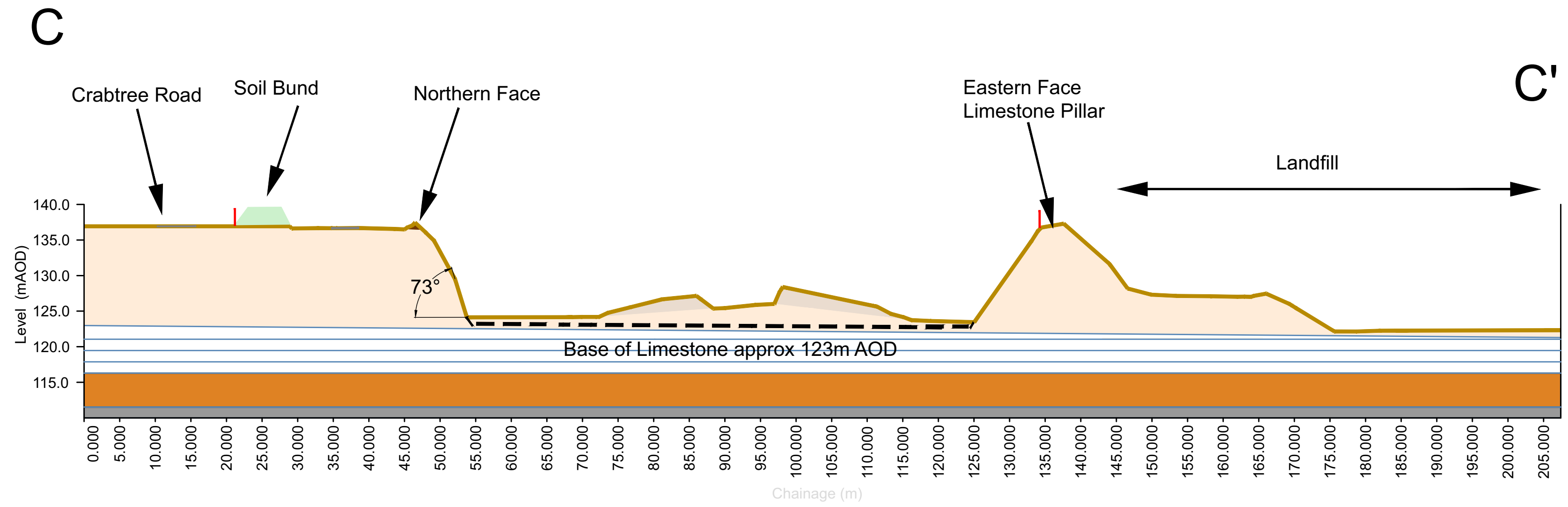
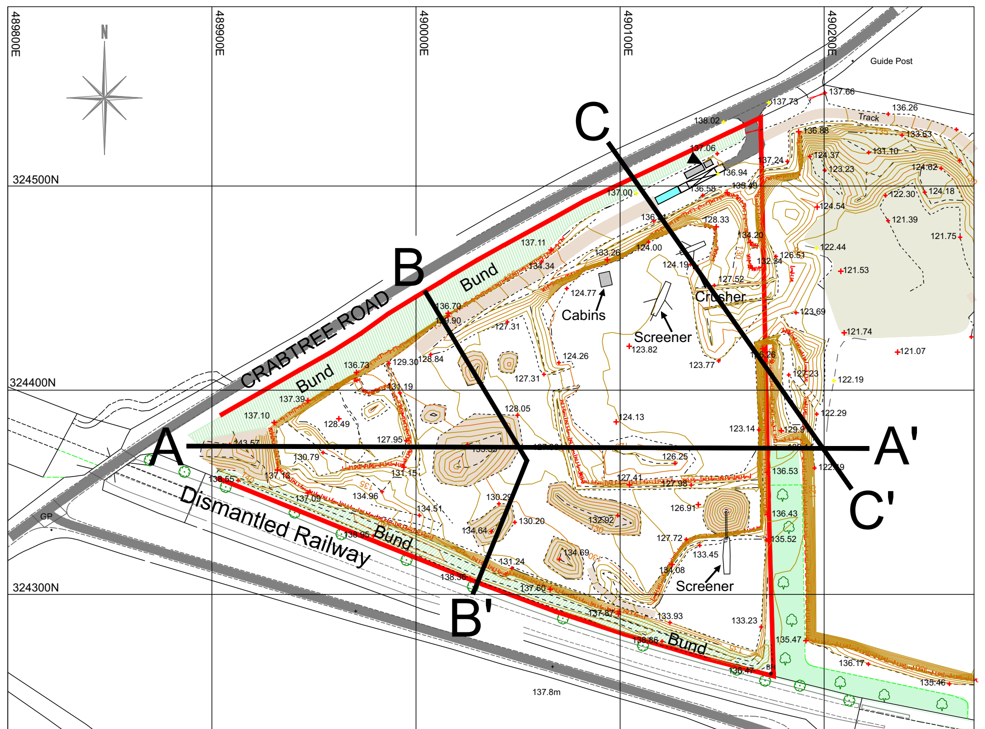
email: bath@greenfieldenviro.co.uk









Key

- Site Boundary
- Lower Lincolnshire Limestone
- Grantham Formation (Mudstone)
- Northampton Sands (Ironstone)
- Whitby Mudstone
- Stockpiles
- Bund
- Proposed Design

Site surveyed by Greenfield Environmental November 2019.
Based upon 2013 Ordnance Survey 1:2500 digital base with the permission of The Controller of Her Majesty's Stationary Office.

Scale
0m 50m

Figure 4

Title:
Site schematic cross-sections

File ref:	Revision:	Scale:
Figure 4.cdr	02	1:1000 @ A3
Date:	Drawn:	Checked:
29/11/2024	TRS	TRS

Client
Construction & Environmental Services Ltd

Project
Stability risk assessment

Site
Stainby Quarry, Lincolnshire

Greenfield enviro
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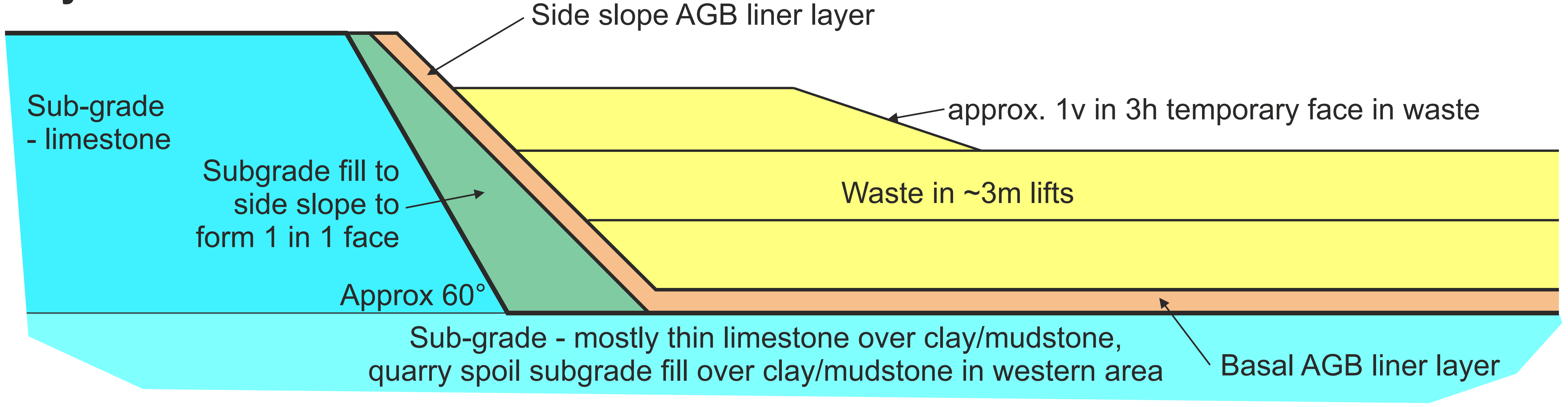
Quarry face model



Dividing bund model

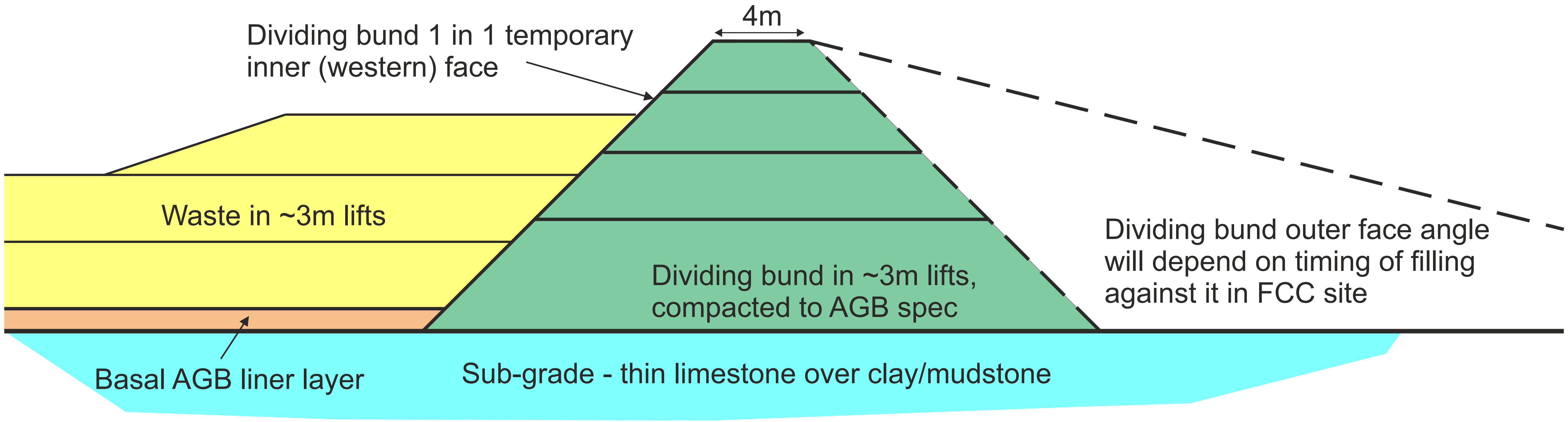


Figure 5			Client: Construction & Environmental Services Ltd	
Title: Schematic liner models			Project: Stability risk assessment	
File ref: Figure 5.cdr	Revision: 02	Scale: NTS	Site: Stainby Quarry, Lincolnshire	
Date: 29/11/2024	Drawn: TRS	Checked: TRS		

Greenfield enviro
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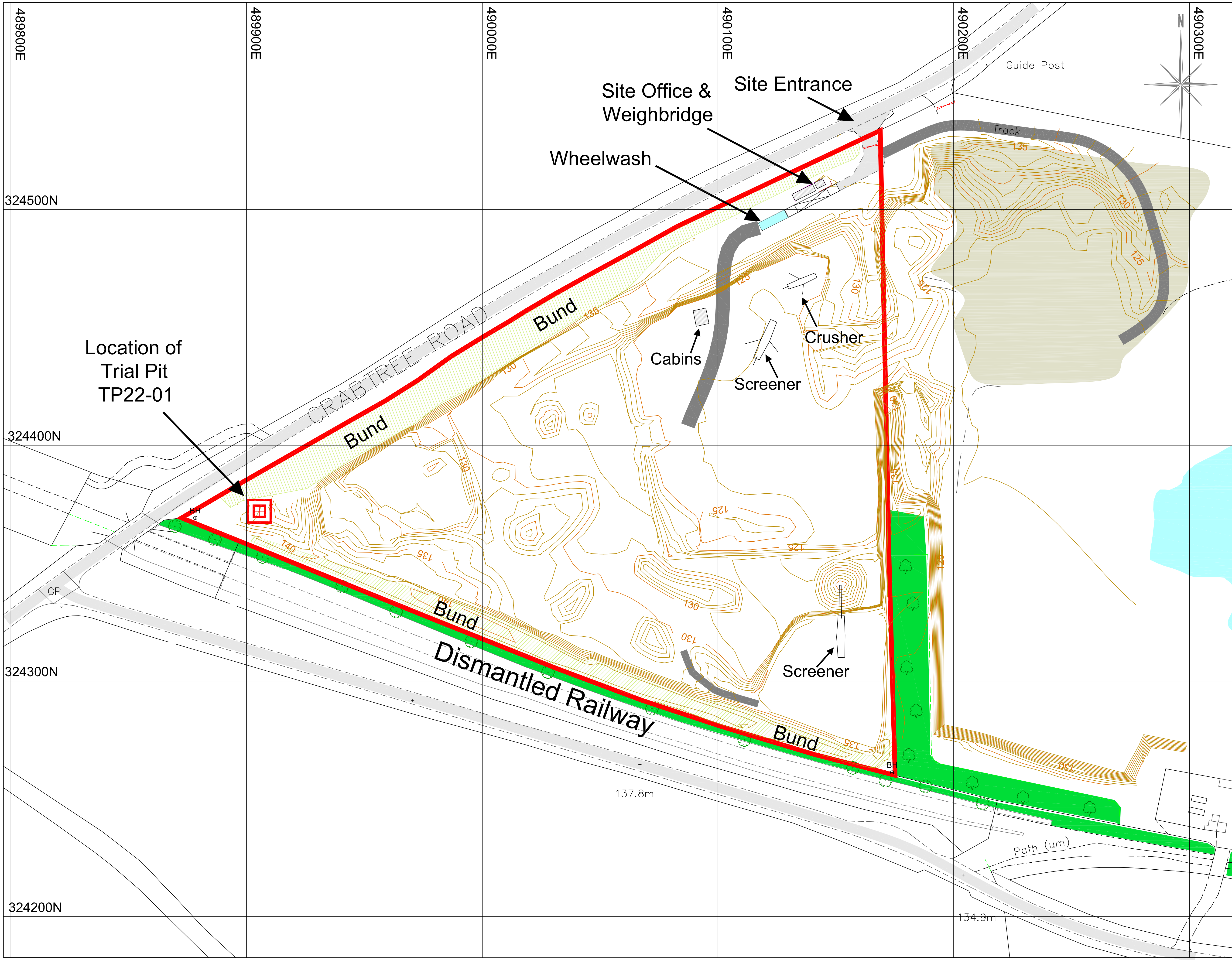
Appendix A – Details of sampling and testing of the clays in the quarry floor



Key

- Site Boundary
- Woodland
- Bund
- Water
- Backfill/Tip Area
- Quarry Ramps
- Portacabins /Container
- Trial Pit

Scale

0m 25m 50m

Site
Stainby Quarry, Lincolnshire

Project
Clay Liner 2022

Title
Trial Pit Location

Scale: 1:1500 @ A3
File: STB Site Plan with 2022 Trial Pit.dwg
Project No. CES/STQ/100
Drawn by: ISC Date: 20/06/2022

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Greenfield Environmental Ltd
Bath Office
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Email: bath@greenfieldenviro.co.uk

TRIAL PIT LOG

Project			TRIAL PIT No
Stainby Quarry - Basal Clay			**TP 22-01**
Job No: CESL/SQ/001	Dates: start 07-06-22, finish 07-06-22	Ground Level (m OD): 132.98	
Client: **CESL**		Co-Ordinates (OS Grid): E 489,905.0 N 324,372.0	Sheet: 1 of 1

Legend	Depth (elev)	DESCRIPTION	Depth	No	Remarks/Tests
	0.60 (132.38)	OVERBURDEN CLAY - Soft orangish brown mottled with light orange, silty slightly sandy CLAY. Gravel sized fragments of buff limestone. Colour of the clay lightens with depth. Overburden storage material has been tipped onto limestone after extraction.			
	0.70 (132.28)	LIMESTONE - Buff yellow LIMESTONE. Strongly bedded.			
	1.00 (131.98)	CLAY - Light bluish grey silty, slightly sandy CLAY. Silt occurs in laminated bands in the clay. Clay is soft to firm with rare gravel observed.	0.70-1.00	B1	
			0.70-1.00	D1	
			0.70-1.00	B2	

TRIAL PIT PHOTOS:

GENERAL REMARKS

Pit stable, no groundwater encountered.

All dimensions in metres Scale 1:18.75	Engineer	Method/ Plant Used	Logged By B Donaghey

Nicholls Colton Group
7 - 11 Harding Street
Leicester
LE1 4DH

Greenfield Associates
1 Commercial Road
Keyworth
Notts
NG12 5JS

Analytical Test Report: L22/02972/GRE - 22-27043

Your Project Reference:	**SQ/CL/2022 Stainby Quarry**		
Your Order Number:	SQ/CL/2022	Testing Received / Instructed:	08/06/2022 / 08/05/2022
Report Issue Number:	1	Sample Tested:	08/05 to 15/06/2022
Samples Analysed:	2 soil samples	Report issued:	16/06/2022

Signed

Lee Harbottle
GCM Operations Manager
Nicholls Colton Group

Notes:

Samples will be retained for 14 days after issue of this report unless otherwise requested.

The results included within the report are representative of the samples submitted for analysis.

A certificate of sampling was not supplied

Samples were supplied by customer, results apply to the samples as received.

Within the report any information provided by the client is identified with a '#'

Where specification limits are included these are for guidance only. Where a measured value has been highlighted this is not implying acceptance or failure and certainty of measurement values have not been taken into account.

Uncertainty of measurement values are available on request.

Accreditation Key

UKAS = UKAS Accreditation, u = Unaccredited

Date of Issue10/12/2020

Owned by Emily Blissett - Commercial Reporting Supervisor
Authorised by Lee Harbottle - GCM Operations Manager
L:\DATA\REPORTS\GRE209\[L22-02972-GRE - 22-27043.XLSM]Cover Sheet

Nicholls Colton Group
7 - 11 Harding Street
Leicester
LE1 4DH

L22/02972/GRE - 22-27043

Project Reference - SQ/CL/2022 Stainby Quarry

Analytical Test Results - Soil

NC Reference		**240113**	**240114**
Client Sample ID (#)		SQ22	SQ22
Client Sample Location (#)		-	-
Client Sample Type (#)		T	B
Client Sample Number (#)		1	2
Depth - Top (m) (#)		-	-
Depth - Bottom (m) (#)		-	-
Date of Sampling (#)		07/06/2022	07/06/2022
Sample type		Disturbed	Disturbed
Sample Description		Brown slightly gravelly silty clay	Grey brown clay
Determinant	**Units**		
Moisture Content	(%)	22	-
Moisture Content Prep	-	3.2.3.2 (medium)	-
Fines passing 425µm test sieve	(%)	95	-
Liquid Limit	(%)	45	-
Plastic Limit	(%)	20	-
Plasticity Index	(%)	25	-
PI preparation	-	from its natural state	-
PI Test Method		clause 4.3 (definitive)	-
BS1377 PSD			
125.0	(% Passing)	-	100
90.0	(% Passing)	-	100
75.0	(% Passing)	-	100
63.0	(% Passing)	-	100
50.0	(% Passing)	-	100
37.5	(% Passing)	-	100
28.0	(% Passing)	-	100
20.0	(% Passing)	-	100
14.0	(% Passing)	-	100
10.0	(% Passing)	-	100
6.3	(% Passing)	-	100
5.0	(% Passing)	-	99
3.35	(% Passing)	-	98
2.00	(% Passing)	-	97
1.18	(% Passing)	-	96
0.600	(% Passing)	-	93
0.425	(% Passing)	-	92
0.300	(% Passing)	-	91
0.212	(% Passing)	-	90
0.150	(% Passing)	-	90
0.063	(% Passing)	-	86
PSD test Method	-	-	9.2 Wet Sieve
BS1377 Bulk Density		-	2.07
Bulk Density	(Mg/m^3)	-	2.07
Dry Density	(Mg/m^3)	-	1.70
Moisture content	(%)	-	22
HSV	-	-	62

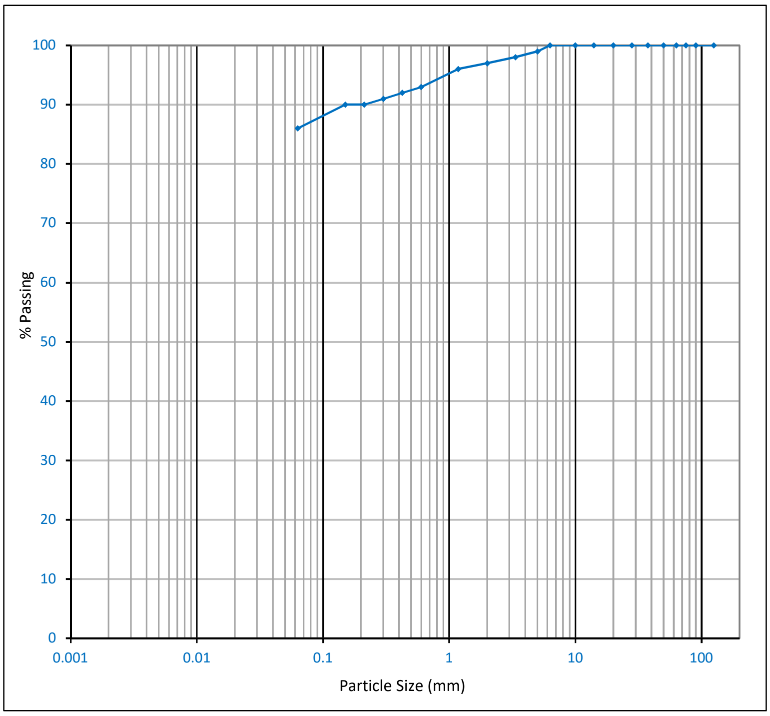
Nicholls Colton Group
7 - 11 Harding Street
Leicester
LE1 4DH

L22/02972/GRE - 22-27043

Project Reference - SQ/CL/2022 Stainby Quarry

Material Analysis Results

NC Reference	**240114**
Client Sample ID (#)	SQ22
Client Sample Location (#)	-
Client Sample Type (#)	B
Client Sample Number (#)	2
Depth - Top (m) (#)	-
Depth - Bottom (m) (#)	-
Date of Sampling (#)	07/06/2022
Sample type	Disturbed
Sample Description	Grey brown clay



Sieve Size (mm)	Passing (%)	
125	100	Cobbles
90	100	
75	100	
63	100	0
50	100	Gravel
37.5	100	
28	100	
20	100	
14	100	
10	100	
6.3	100	
5	99	
3.35	98	2
2	97	Sand
1.18	96	
0.6	93	
0.425	92	
0.3	91	
0.212	90	
0.15	90	
0.063	86	12
		Fines 86

NOTES :

Nicholls Colton Group
7 - 11 Harding Street
Leicester
LE1 4DH

L22/02972/GRE - 22-27043

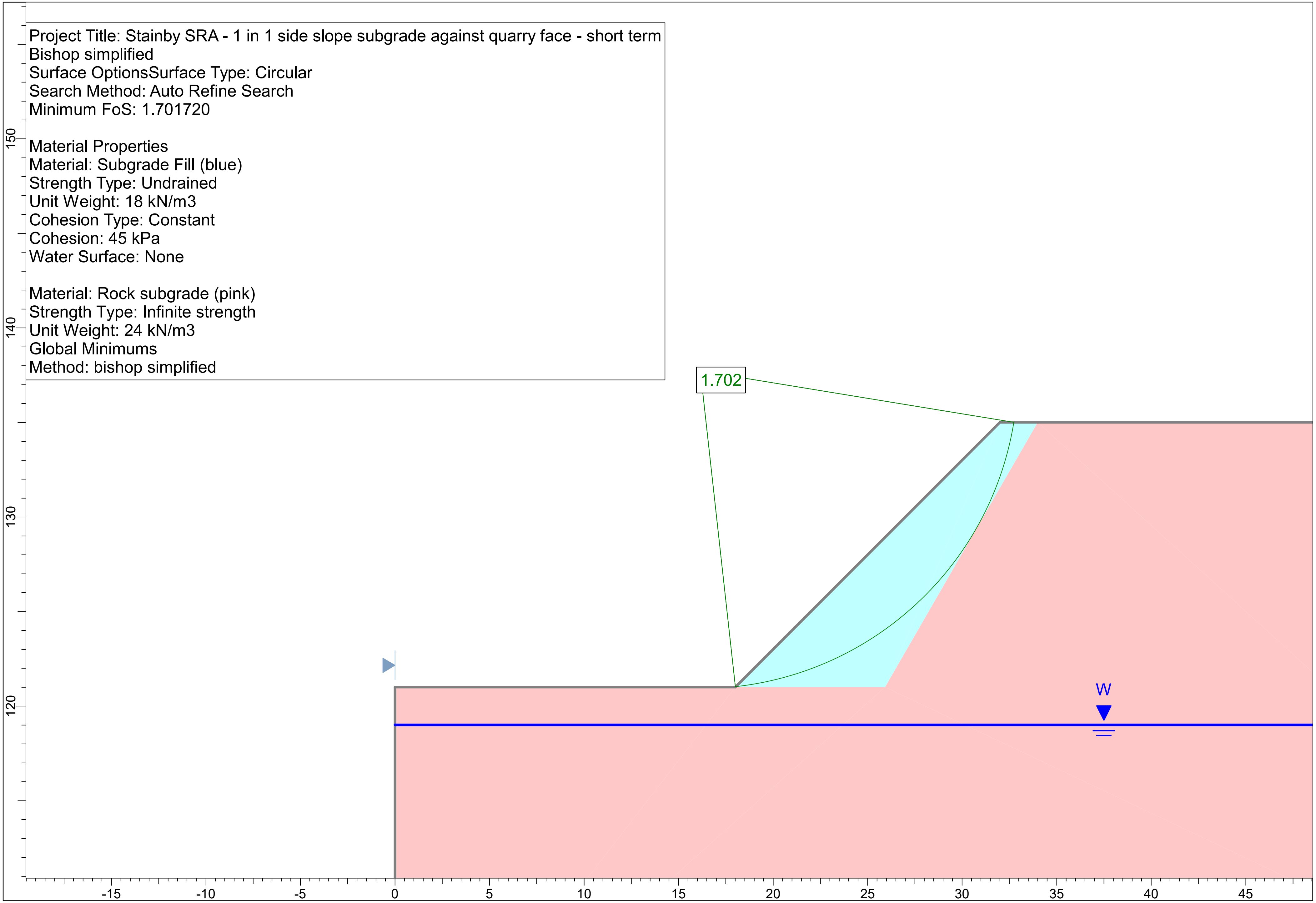
Project Reference - SQ/CL/2022 Stainby Quarry

Analysis Methodologies

Determinant	Title	Details and Test method used
1377BULKD	BS1377 Bulk Density	1377 Bulk Density 1. Sample preparation was in accordance with BS 1377 : Part 1 : 2016. 2. Testing was in accordance with BS 1377 : Part 4 : 1990 Clause 4.
1377MOIST	BS1377 Moisture Content	1377 Moisture Content 1. Sample preparation was in accordance with BS1377:Part 1:2016. 2. Moisture content testing was in accordance with BS1377 : Part 2 :1990
1377PI DEF	BS1377 Plasticity Index (definitive)	1377 Plasticity Index (Definitive) 1. Sample preparation was in accordance with BS1377:Part 1:2016. 2. Testing was in accordance with BS1377:Part 2:1990
1377PSD	BS1377 PSD	1377 Particle Size Distribution 1. Sample preparation was in accordance with BS1377:Part 1:2016. 2. Testing was in accordance with BS1377:Part 2:1990 clause 9.2 wet sieving method
HSV	Hand Shear Vane	Testing was in accordance with in-house method statement MS-5S Shear Strength

Appendix B – SLIDE slope stability analysis output sheets

Side slope subgrade fill and AGB side slope layer


Project Title: Stainby SRA - 1 in 1 side slope subgrade against quarry face - short term
Bishop simplified
Surface OptionsSurface Type: Circular
Search Method: Auto Refine Search
Minimum FoS: 1.701720
Material Properties
Material: Subgrade Fill (blue)
Strength Type: Undrained
Unit Weight: 18 kN/m3
Cohesion Type: Constant
Cohesion: 45 kPa
Water Surface: None
Material: Rock subgrade (pink)
Strength Type: Infinite strength
Unit Weight: 24 kN/m3
Global Minimums
Method: bishop simplified
1.702
W
150
140
130
120
-15
-10
-5
0
5
10
15
20
25
30
35
40
45

Slide Analysis Information

Document Name

File Name: Stainby 1in1 subgrade fill sideslope ST.sli

Project Settings

Project Title: Stainby SRA - 1 in 1 side slope subgrade against quarry face - short term
Failure Direction: Right to Left
Units of Measurement: SI Units
Pore Fluid Unit Weight: 9.81 kN/m3
Groundwater Method: Water Surfaces
Data Output: Standard
Calculate Excess Pore Pressure: Off
Allow Ru with Water Surfaces or Grids: Off
Random Numbers: Pseudo-random Seed
Random Number Seed: 10116
Random Number Generation Method: Park and Miller v.3

Analysis Methods

Analysis Methods used:
Bishop simplified

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50

Surface Options

Surface Type: Circular
Search Method: Auto Refine Search
Divisions along slope: 20
Circles per division: 20
Number of iterations: 20
Divisions to use in next iteration: 50%
Composite Surfaces: Disabled
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Material Properties

Material: Subgrade Fill
Strength Type: Undrained
Unit Weight: 18 kN/m3
Cohesion Type: Constant
Cohesion: 45 kPa
Water Surface: None

Material: Rock subgrade
Strength Type: Infinite strength
Unit Weight: 24 kN/m3

List of All Coordinates

Material Boundary

18.000	121.000
25.917	121.000
34.000	135.000

External Boundary

75.000	97.759
75.000	135.000
34.000	135.000
32.000	135.000
18.000	121.000
0.000	121.000
0.000	97.759

Water Table

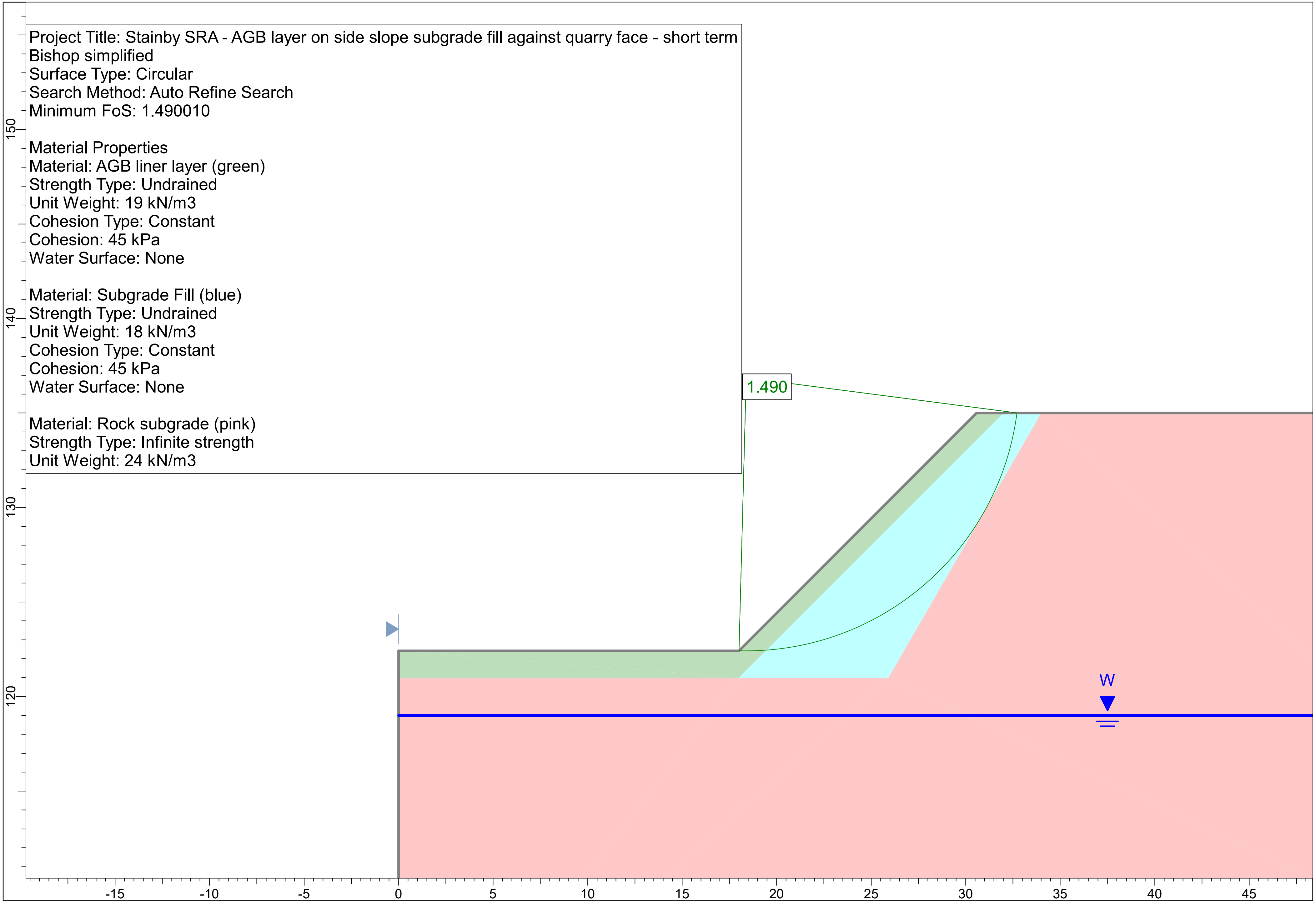
0.000	119.000
75.000	119.000

Project Title: Stainby SRA - AGB layer on side slope subgrade fill against quarry face - short term
Bishop simplified
Surface Type: Circular
Search Method: Auto Refine Search
Minimum FoS: 1.490010

Material Properties
Material: AGB liner layer (green)
Strength Type: Undrained
Unit Weight: 19 kN/m3
Cohesion Type: Constant
Cohesion: 45 kPa
Water Surface: None

Material: Subgrade Fill (blue)
Strength Type: Undrained
Unit Weight: 18 kN/m3
Cohesion Type: Constant
Cohesion: 45 kPa
Water Surface: None

Material: Rock subgrade (pink)
Strength Type: Infinite strength
Unit Weight: 24 kN/m3



Slide Analysis Information

Document Name

File Name: Stainby 1in1 AGB+subgrade fill sideslope ST.sli

Project Settings

Project Title: Stainby SRA - AGB layer on side slope liner against quarry face - short term
Failure Direction: Right to Left
Units of Measurement: SI Units
Pore Fluid Unit Weight: 9.81 kN/m3
Groundwater Method: Water Surfaces
Data Output: Standard
Calculate Excess Pore Pressure: Off
Allow Ru with Water Surfaces or Grids: Off
Random Numbers: Pseudo-random Seed
Random Number Seed: 10116
Random Number Generation Method: Park and Miller v.3

Analysis Methods

Analysis Methods used:
Bishop simplified

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50

Surface Options

Surface Type: Circular
Search Method: Auto Refine Search
Divisions along slope: 20
Circles per division: 20
Number of iterations: 20
Divisions to use in next iteration: 50%
Composite Surfaces: Disabled
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Material Properties

Material: AGB liner layer
Strength Type: Undrained
Unit Weight: 19 kN/m3
Cohesion Type: Constant
Cohesion: 45 kPa
Water Surface: None

Material: Subgrade Fill
Strength Type: Undrained
Unit Weight: 18 kN/m3
Cohesion Type: Constant
Cohesion: 45 kPa

Water Surface: None

Material: Rock subgrade
Strength Type: Infinite strength
Unit Weight: 24 kN/m3

List of All Coordinates

Material Boundary

-0.000	121.000
18.000	121.000
25.917	121.000

Material Boundary

25.917	121.000
34.000	135.000

Material Boundary

18.000	121.000
32.000	135.000

External Boundary

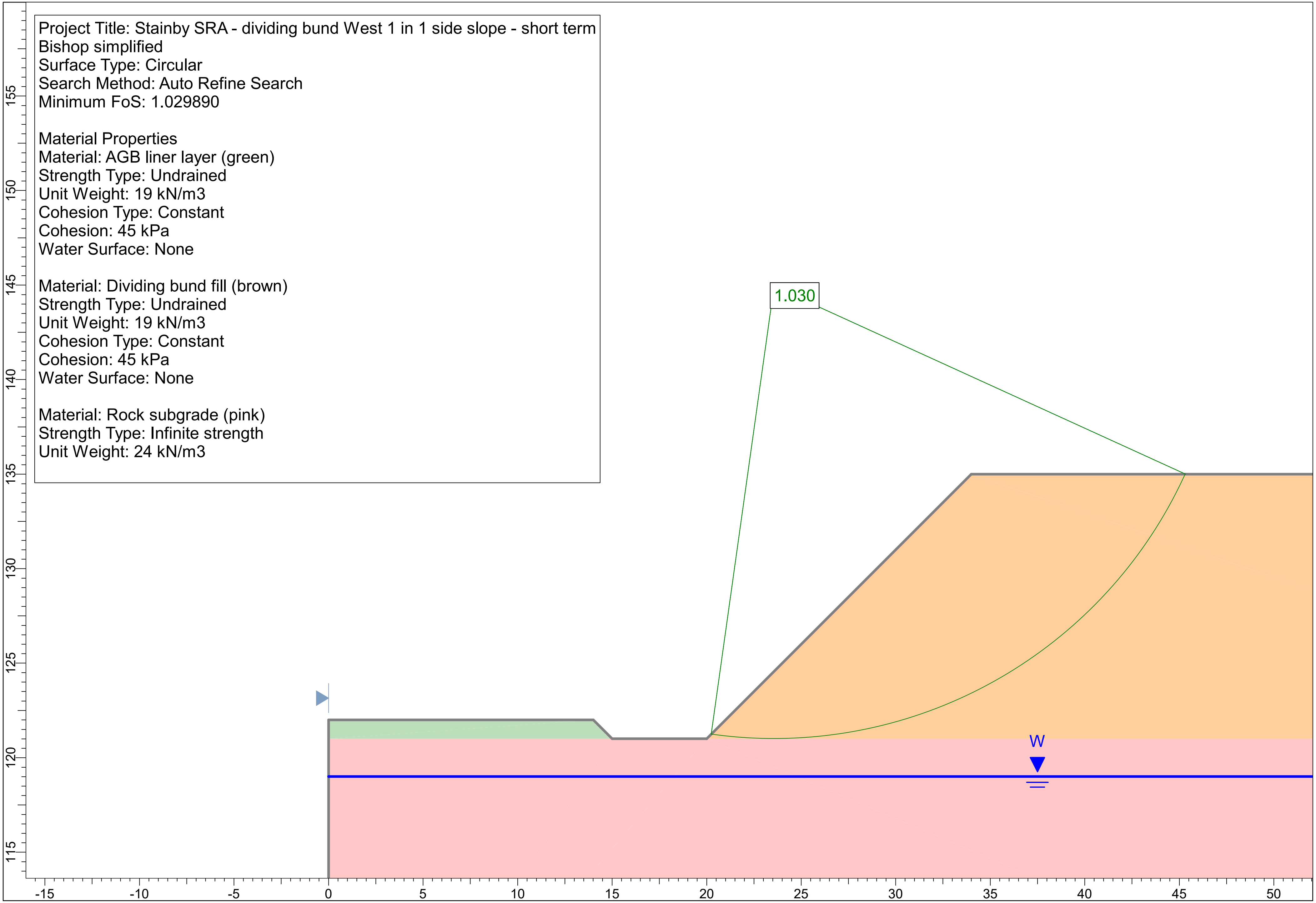
75.000	97.759
75.000	135.000
34.000	135.000
32.000	135.000
30.586	135.000
18.000	122.414
0.000	122.414
-0.000	121.000
0.000	97.759

Water Table

0.000	119.000
75.000	119.000

Appendix C – SLIDE slope stability analysis output sheets

Dividing Bund


Project Title: Stainby SRA - dividing bund West 1 in 1 side slope - short term
Bishop simplified
Surface Type: Circular
Search Method: Auto Refine Search
Minimum FoS: 1.029890
Material Properties
Material: AGB liner layer (green)
Strength Type: Undrained
Unit Weight: 19 kN/m3
Cohesion Type: Constant
Cohesion: 45 kPa
Water Surface: None
Material: Dividing bund fill (brown)
Strength Type: Undrained
Unit Weight: 19 kN/m3
Cohesion Type: Constant
Cohesion: 45 kPa
Water Surface: None
Material: Rock subgrade (pink)
Strength Type: Infinite strength
Unit Weight: 24 kN/m3
1.030
W
155
150
145
140
135
130
125
120
115
-15
-10
-5
0
5
10
15
20
25
30
35
40
45
50

Slide Analysis Information

Document Name

File Name: Stainby 1in1 dividing bund sideslope ST.sli

Project Settings

Project Title: Stainby SRA - dividing bund W 1 in 1 side slope - short term
Failure Direction: Right to Left
Units of Measurement: SI Units
Pore Fluid Unit Weight: 9.81 kN/m3
Groundwater Method: Water Surfaces
Data Output: Standard
Calculate Excess Pore Pressure: Off
Allow Ru with Water Surfaces or Grids: Off
Random Numbers: Pseudo-random Seed
Random Number Seed: 10116
Random Number Generation Method: Park and Miller v.3

Analysis Methods

Analysis Methods used:
Bishop simplified

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50

Surface Options

Surface Type: Circular
Search Method: Auto Refine Search
Divisions along slope: 20
Circles per division: 20
Number of iterations: 20
Divisions to use in next iteration: 50%
Composite Surfaces: Disabled
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Material Properties

Material: AGB liner layer
Strength Type: Undrained
Unit Weight: 19 kN/m3
Cohesion Type: Constant
Cohesion: 45 kPa
Water Surface: None

Material: Dividing bund fill
Strength Type: Undrained
Unit Weight: 19 kN/m3
Cohesion Type: Constant
Cohesion: 45 kPa

Water Surface: None

Material: Rock subgrade
Strength Type: Infinite strength
Unit Weight: 24 kN/m3

List of All Coordinates

Material Boundary

-0.000	121.000
15.000	121.000

Material Boundary

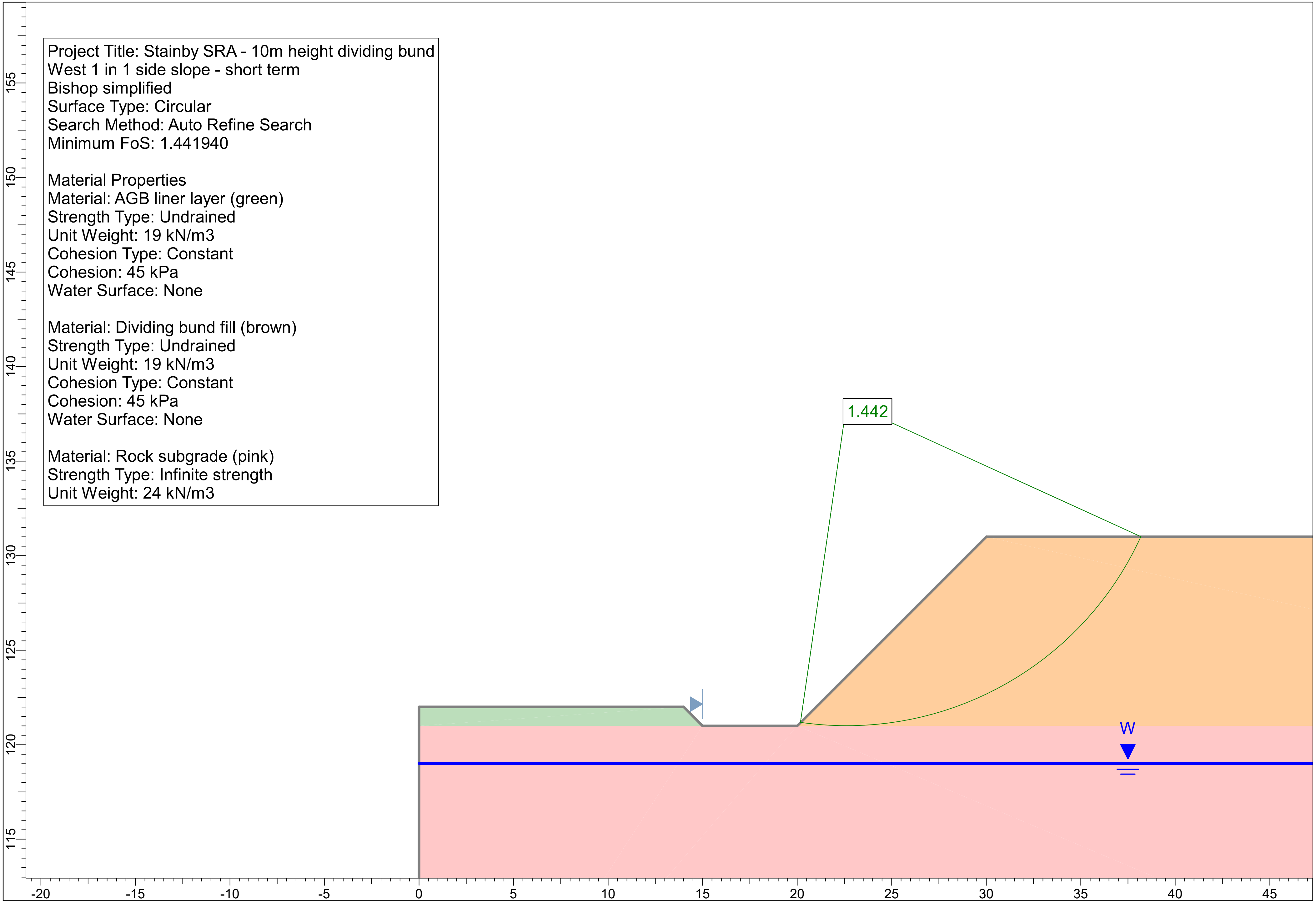
20.000	121.000
75.000	121.000

External Boundary

75.000	97.759
75.000	121.000
75.000	135.000
34.000	135.000
20.000	121.000
15.000	121.000
14.000	122.000
-0.000	122.000
-0.000	121.000
0.000	97.759

Water Table

0.000	119.000
75.000	119.000


Project Title: Stainby SRA - 10m height dividing bund
West 1 in 1 side slope - short term
Bishop simplified
Surface Type: Circular
Search Method: Auto Refine Search
Minimum FoS: 1.441940
Material Properties
Material: AGB liner layer (green)
Strength Type: Undrained
Unit Weight: 19 kN/m3
Cohesion Type: Constant
Cohesion: 45 kPa
Water Surface: None
Material: Dividing bund fill (brown)
Strength Type: Undrained
Unit Weight: 19 kN/m3
Cohesion Type: Constant
Cohesion: 45 kPa
Water Surface: None
Material: Rock subgrade (pink)
Strength Type: Infinite strength
Unit Weight: 24 kN/m3
1.442
W
155
150
145
140
135
130
125
120
115
-20
-15
-10
-5
0
5
10
15
20
25
30
35
40
45

Slide Analysis Information

Document Name

File Name: Stainby 1in1 10m high dividing bund sideslope ST.sli

Project Settings

Project Title: Stainby SRA - 10m height dividing bund W 1 in 1 side slope - short term
Failure Direction: Right to Left
Units of Measurement: SI Units
Pore Fluid Unit Weight: 9.81 kN/m3
Groundwater Method: Water Surfaces
Data Output: Standard
Calculate Excess Pore Pressure: Off
Allow Ru with Water Surfaces or Grids: Off
Random Numbers: Pseudo-random Seed
Random Number Seed: 10116
Random Number Generation Method: Park and Miller v.3

Analysis Methods

Analysis Methods used:
Bishop simplified

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50

Surface Options

Surface Type: Circular
Search Method: Auto Refine Search
Divisions along slope: 20
Circles per division: 20
Number of iterations: 20
Divisions to use in next iteration: 50%
Composite Surfaces: Disabled
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Material Properties

Material: AGB liner layer
Strength Type: Undrained
Unit Weight: 19 kN/m3
Cohesion Type: Constant
Cohesion: 45 kPa
Water Surface: None

Material: Dividing bund fill
Strength Type: Undrained
Unit Weight: 19 kN/m3
Cohesion Type: Constant
Cohesion: 45 kPa

Water Surface: None

Material: Rock subgrade
Strength Type: Infinite strength
Unit Weight: 24 kN/m3

List of All Coordinates

Material Boundary

-0.000	121.000
15.000	121.000

Material Boundary

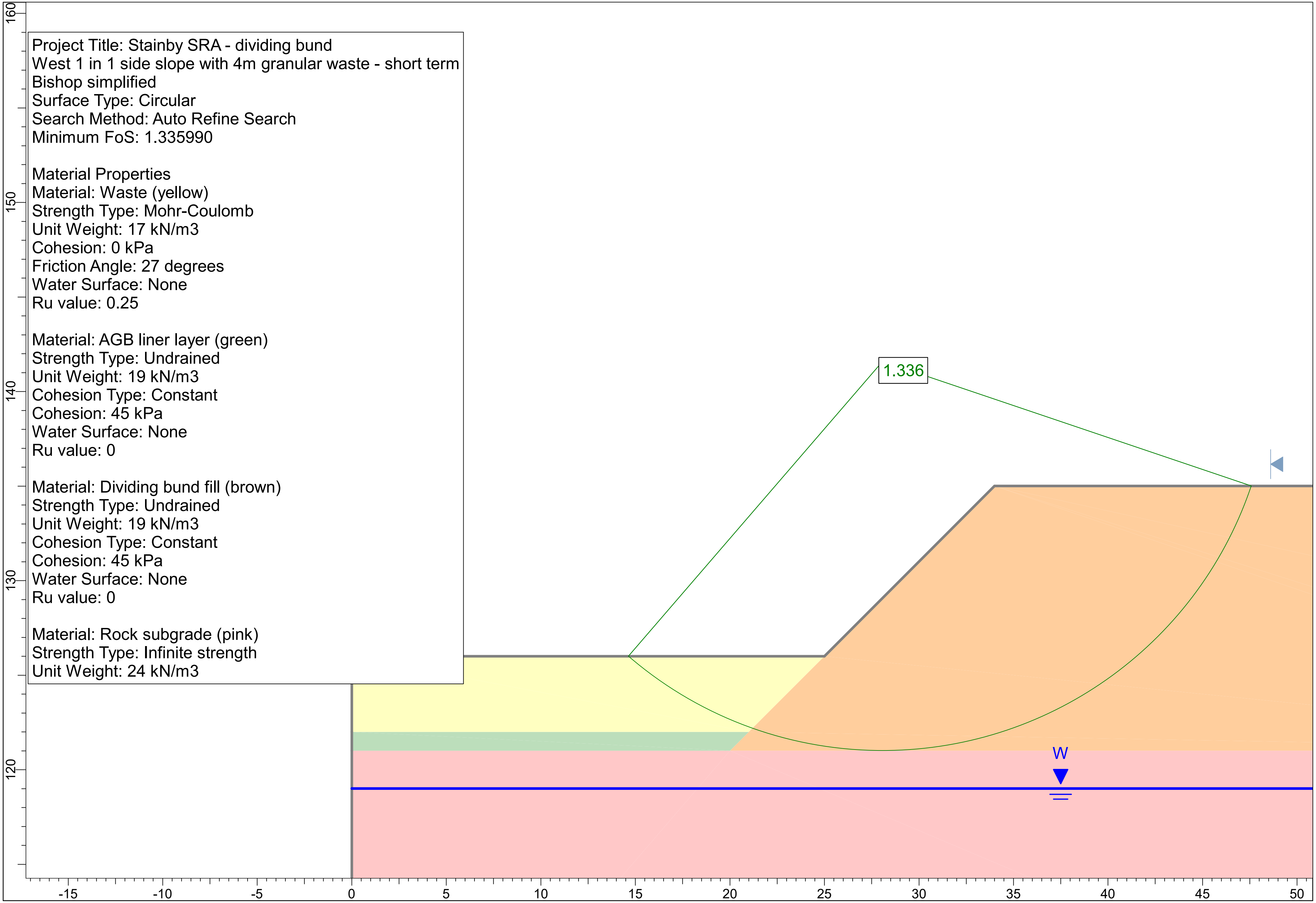
20.000	121.000
75.000	121.000

External Boundary

75.000	97.759
75.000	121.000
75.000	131.000
30.000	131.000
20.000	121.000
15.000	121.000
14.000	122.000
-0.000	122.000
-0.000	121.000
0.000	97.759

Water Table

0.000	119.000
75.000	119.000



Project Title: Stainby SRA - dividing bund
West 1 in 1 side slope with 4m granular waste - short term
Bishop simplified
Surface Type: Circular
Search Method: Auto Refine Search
Minimum FoS: 1.335990
Material Properties
Material: Waste (yellow)
Strength Type: Mohr-Coulomb
Unit Weight: 17 kN/m3
Cohesion: 0 kPa
Friction Angle: 27 degrees
Water Surface: None
Ru value: 0.25
Material: AGB liner layer (green)
Strength Type: Undrained
Unit Weight: 19 kN/m3
Cohesion Type: Constant
Cohesion: 45 kPa
Water Surface: None
Ru value: 0
Material: Dividing bund fill (brown)
Strength Type: Undrained
Unit Weight: 19 kN/m3
Cohesion Type: Constant
Cohesion: 45 kPa
Water Surface: None
Ru value: 0
Material: Rock subgrade (pink)
Strength Type: Infinite strength
Unit Weight: 24 kN/m3
1.336
W
160
150
140
130
120
-15
-10
-5
0
5
10
15
20
25
30
35
40
45
50

Slide Analysis Information

Document Name

File Name: Stainby 1in1 dividing bund sideslope 3m waste ST.sli

Project Settings

Project Title: Stainby SRA - dividing bund W 1 in 1 side slope with 4m granular waste - short term
Failure Direction: Right to Left
Units of Measurement: SI Units
Pore Fluid Unit Weight: 9.81 kN/m3
Groundwater Method: Water Surfaces
Data Output: Standard
Calculate Excess Pore Pressure: Off
Allow Ru with Water Surfaces or Grids: On
Random Numbers: Pseudo-random Seed
Random Number Seed: 10116
Random Number Generation Method: Park and Miller v.3

Analysis Methods

Analysis Methods used:
Bishop simplified

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50

Surface Options

Surface Type: Circular
Search Method: Auto Refine Search
Divisions along slope: 20
Circles per division: 20
Number of iterations: 20
Divisions to use in next iteration: 50%
Composite Surfaces: Disabled
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Material Properties

Material: Waste
Strength Type: Mohr-Coulomb
Unit Weight: 17 kN/m3
Cohesion: 0 kPa
Friction Angle: 27 degrees
Water Surface: None
Ru value: 0.25

Material: AGB liner layer
Strength Type: Undrained
Unit Weight: 19 kN/m3

Cohesion Type: Constant
Cohesion: 45 kPa
Water Surface: None
Ru value: 0

Material: Dividing bund fill
Strength Type: Undrained
Unit Weight: 19 kN/m3
Cohesion Type: Constant
Cohesion: 45 kPa
Water Surface: None
Ru value: 0

Material: Rock subgrade
Strength Type: Infinite strength
Unit Weight: 24 kN/m3

List of All Coordinates

Material Boundary

20.000	121.000
75.000	121.000

Material Boundary

-0.000	121.000
20.000	121.000

Material Boundary

20.000	121.000
21.000	122.000
25.000	126.000

Material Boundary

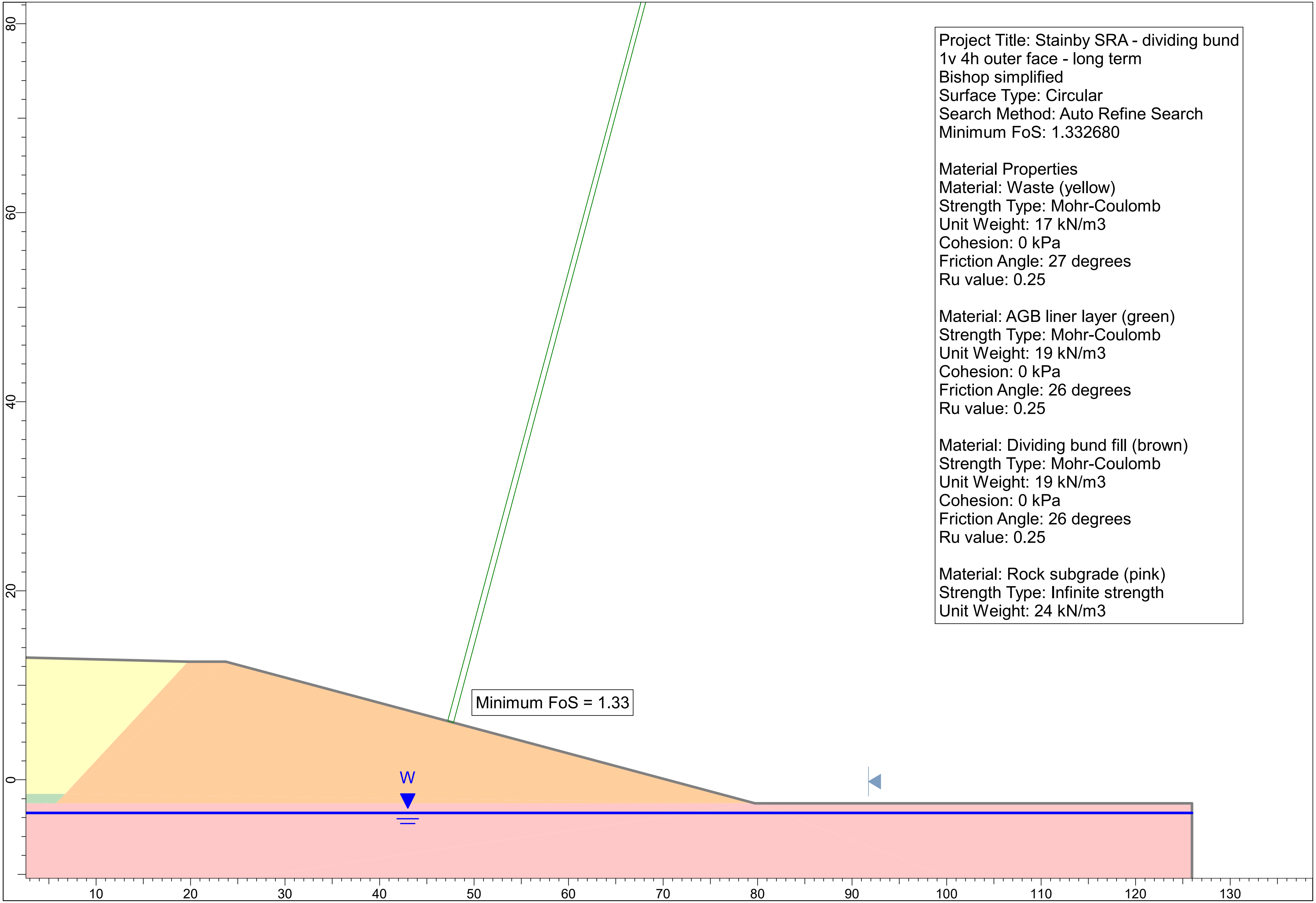
0.000	122.000
21.000	122.000

External Boundary

75.000	97.759
75.000	121.000
75.000	122.000
75.000	126.000
75.000	135.000
34.000	135.000
25.000	126.000
0.000	126.000
0.000	122.000
-0.000	121.000
0.000	97.759

Water Table

0.000	119.000
75.000	119.000



Project Title: Stainby SRA - dividing bund
1v 4h outer face - long term
Bishop simplified
Surface Type: Circular
Search Method: Auto Refine Search
Minimum FoS: 1.332680
Material Properties
Material: Waste (yellow)
Strength Type: Mohr-Coulomb
Unit Weight: 17 kN/m3
Cohesion: 0 kPa
Friction Angle: 27 degrees
Ru value: 0.25
Material: AGB liner layer (green)
Strength Type: Mohr-Coulomb
Unit Weight: 19 kN/m3
Cohesion: 0 kPa
Friction Angle: 26 degrees
Ru value: 0.25
Material: Dividing bund fill (brown)
Strength Type: Mohr-Coulomb
Unit Weight: 19 kN/m3
Cohesion: 0 kPa
Friction Angle: 26 degrees
Ru value: 0.25
Material: Rock subgrade (pink)
Strength Type: Infinite strength
Unit Weight: 24 kN/m3
Minimum FoS = 1.33
W
80
60
40
20
0
10
20
30
40
50
60
70
80
90
100
110
120
130

Slide Analysis Information

Document Name

File Name: Stainby dividing bund LT target FoS 1.3 phi25 ru 0.25 1in3 inner 1in4 outer.sli

Project Settings

Project Title: Stainby SRA - dividing bund 1v 4h outer face - long term
Failure Direction: Left to Right
Units of Measurement: SI Units
Pore Fluid Unit Weight: 9.81 kN/m3
Groundwater Method: Ru Coefficient
Data Output: Standard
Calculate Excess Pore Pressure: Off
Allow Ru with Water Surfaces or Grids: Off
Random Numbers: Pseudo-random Seed
Random Number Seed: 10116
Random Number Generation Method: Park and Miller v.3

Analysis Methods

Analysis Methods used:
Bishop simplified

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50

Surface Options

Surface Type: Circular
Search Method: Auto Refine Search
Divisions along slope: 25
Circles per division: 20
Number of iterations: 20
Divisions to use in next iteration: 50%
Composite Surfaces: Disabled
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Material Properties

Material: Waste
Strength Type: Mohr-Coulomb
Unit Weight: 17 kN/m3
Cohesion: 0 kPa
Friction Angle: 27 degrees
Ru value: 0.25

Material: AGB liner layer
Strength Type: Mohr-Coulomb
Unit Weight: 19 kN/m3
Cohesion: 0 kPa
Friction Angle: 26 degrees

Ru value: 0.25

Material: Dividing bund fill
Strength Type: Mohr-Coulomb
Unit Weight: 19 kN/m3
Cohesion: 0 kPa
Friction Angle: 26 degrees
Ru value: 0.25

Material: Rock subgrade
Strength Type: Infinite strength
Unit Weight: 24 kN/m3

List of All Coordinates

Material Boundary

-40.000	-2.500
5.735	-2.500

Material Boundary

-40.000	-1.500
6.735	-1.500

Material Boundary

6.735	-1.500
19.735	12.500

Material Boundary

5.735	-2.500
79.735	-2.500

Material Boundary

5.735	-2.500
6.735	-1.500

External Boundary

-40.000	-20.000
125.976	-20.000
125.976	-2.500
79.735	-2.500
23.735	12.500
19.735	12.500
-40.000	14.000
-40.000	-1.500
-40.000	-2.500

Water Table

-40.000	-3.500
125.976	-3.500