STABILITY RISK ASSESSMENT REPORT

SITE: RESTORATION WORKS AT ZIG ZAG QUARRY, ALLER, NEWTON ABBOT, DEVON

Issue Record			
Issue	Date	Reason	Prepared by
Rev0	12/06/2024		Tim Green
Rev1	06/09/2024		Tim Green
Rev2	23/01/2026	Inclusion of SI works, CSM, ESSD and HRA works	Tim Green

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Geotechnical Consultancy Services
GeoSLOPE Stability Report

Our Ref: **TJG/SRA/G043.Zig Zag Quarry.Rev2** 23rd January 2026

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Re: Stability Risk Assessment – Former quarry restoration works
Zig Zag Quarry (Harleyford Aggregates Ltd), Aller, Newton Abbot, Devon.

Introduction

Slope Stability Southwest (SSSW) have been requested to undertake a Stability Risk Assessment (SRA) for a proposed restoration scheme at the Zig Zag Quarry site at Aller, near Newton Abbot in Devon. These works are to be undertaken on behalf of Haleyford Aggregates Ltd (the site operator) and BT Jenkins Ltd (the works contractor).

Report objectives

The objective of this report is to provide a Stability Risk Assessment of the proposed quarry restoration works, in accordance with the relevant guidance provided by the Environment Agency.[1]

Contact Details and report context

Site operator: Harleyford Aggregates Ltd.
Site address: Zig Zag Quarry (Harleyford Aggregates Ltd), Aller, Newton Abbot, Devon.
Contractor (restoration works): BT Jenkins Ltd.

The site is located off Torquay Road and The South Devon Expressway, to the south of Newton Abbot and to the immediate north of Kingskerwell in Devon. The Zig Zag Quarry is a former sand and gravel aggregate quarry working on the Aller Gravel Formation. The site covers an area approximately 10 hectares in size (site extent) and is at an elevation of approximately 30 metres and 80 metres above Ordnance Datum (m OD (sealevel)) on the western boundary (adjacent to Torquay Road) and the eastern boundary of the site respectively.

Planning permission for the restoration of the site was granted in October 2016 to allow for the '*progressive restoration (of the site) requiring the importation of 285,000 tonnes of inert waste material over a five-year period*'.

Subsequent to this, a planning application was granted by Devon County Council (DCC) in March 2023 (DCC/4339/2023) to change the restoration and aftercare proposals at the quarry from the

[1] Landfill operators: environmental permits (published Jan 2020, updated Jan 2024) - https://www.gov.uk/guidance/landfill-operators-environmental-permits

previously approved scheme. The revised and updated proposal allows for the '*Importation of inert waste for the purpose of filling the void as part of the restoration scheme following the future cessation of quarrying activities*'. The main changes with the revised and updated proposal are:

- To bring forward the cessation of quarrying activities (extraction) from 2027 to early 2024, and
- To import up to ~1.5m tonnes for an enhanced restoration scheme, to be undertaken over a period of 10 years (up from 285,000t of imported material under the previous application).

The importation of inert waste to the site for use in the restoration scheme is to be undertaken under a Waste Recovery Permit. The restoration area will lie within the boundary of the quarry and will comprise the backfilling of the quarry void space with imported inert waste as well as overburden and site won materials (residual sands and clays from the quarry extraction and processing operations).

Refer to Figure 01 for a site plan.

Refer to Appendix A for restoration plan and sections.

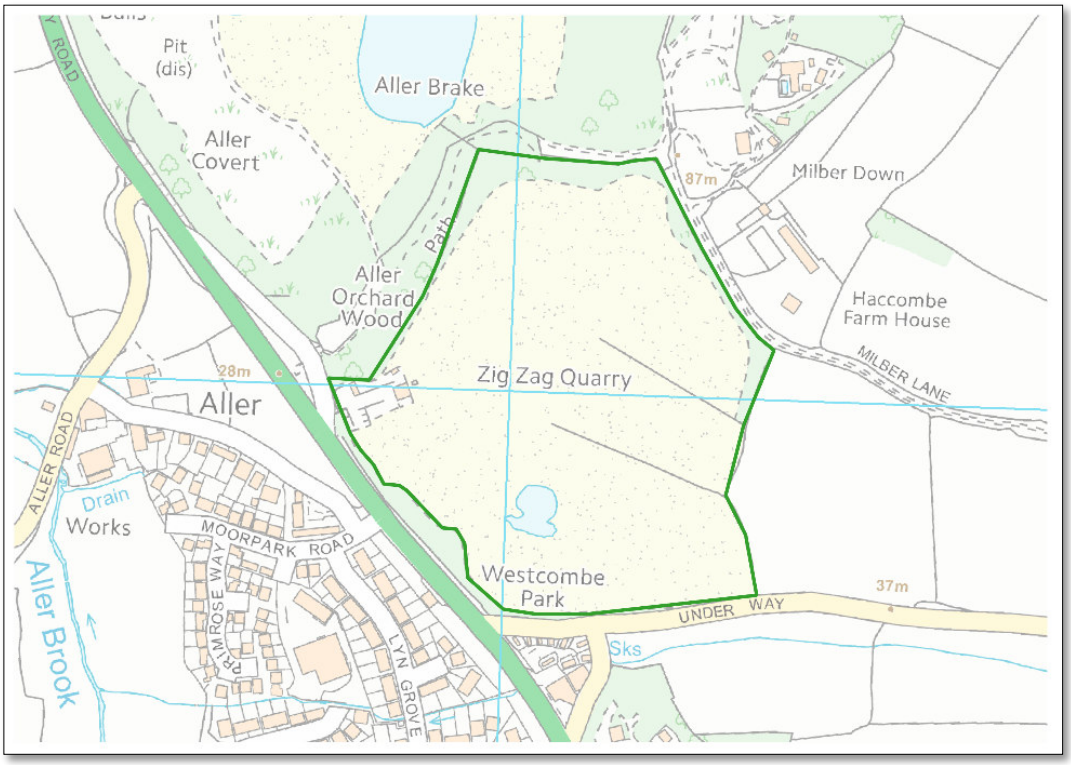

Figure 01: Site location plan, Zig Zag Quarry outline (green)

Works previously undertaken

Stability Risk Assessment

A Stability Risk Assessment report was previously undertaken on the Zig Zag Quarry by Key GS Ltd in November 2019[2]. This report was in response to the previous application for the restoration of the site, as granted in October 2016 (now superseded).

Site Investigation Works

Groundwater monitoring boreholes were drilled by Apex Drilling Services Ltd in March 2024. 4No. boreholes were drilled to depths of < 52 m. The objective off the boreholes was to enable monitoring of groundwater quality upgradient and downgradient of the site.

A second investigation was carried out by Horizon on 19 June 2024 to provide additional data on the ground conditions at the site. The investigation comprised 6No. machine-dug trial pits to depths of between 2.7 and 3.6 m bgl. The ground conditions encountered may be summarised as follows:

- *Made Ground (site won): Depth to top 0 m, depth to base 1.5 – 3.0 m*.
- *Made Ground (imported restoration soils)*: *Depth to top 0 m, depth to base 1.4 m (base not proven)*.
- The Aller Gravel Formation: *Depth to top 0 – 2.7 m, depth to base 2.7 – 3.6 m*.

2No. additional boreholes were drilled in November 2025 under the supervision of Horizon Consulting Engineers Ltd. The boreholes were drilled to depths of 19.0 and 20.5 metres bgl respectively, the objective of these works were to investigate the extent of chloride impacts identified in previous phases of investigation.

The boreholes encountered Made Ground to a depth of 0.60 and 1.0 m bgl, overlying sand and gravels of the Aller Gravel Formation, to depths of 11.5 and 10.5 m bgl and underlain by Upper Greensand Formation. Groundwater strikes were recorded at depths of between 6.5 and 14.5 m bgl.

Conceptual Site Model

A Conceptual Site Model (CSM) was carried out by Horizon Consulting Engineers Ltd, who were commissioned by BT Jenkins Ltd on behalf of the Operator (Harleyford Aggregates Ltd). Report Reference HCE0269.CSM.Rev3. Issued 21st November 2025.

[2] Zig Zag Quarry Restoration Stability Risk Assessment Report. Key GS Ltd. Report Ref 19-290-R-001. Nov 2019.

Environmental Setting and Site Design Report

An Environmental Setting and Site Design Report was carried out by Horizon Consulting Engineers Ltd, who were commissioned by BT Jenkins Ltd on behalf of the Operator (Harleyford Aggregates Ltd). Report Reference HCE0269.ESSD.Rev2. Issued 21st November 2025.

Hydrological Risk Assessment

A Hydrological Risk Assessment Report was carried out by Horizon Consulting Engineers Ltd, who were commissioned by BT Jenkins Ltd on behalf of the Permit Holder (Harleyford Aggregates Ltd). Report Reference HCE0269.HRA Issued 21st November 2025.

Desk study

Published geology

Published geology indicate the prevailing geology underlying the quarry site to be flint and chert gravels of the Aller Gravel Formation.[3] There are no records of superficial soils underlying the property, though superficial soils comprising alluvium (clay, silts sand and gravels) are recorded to the west of the property on the other side of Torquay Road.[4]

There are no recorded faults or linear geological structural features recorded underlying the site, the nearest is a northwest to southeast striking fault structure (inferred – displacement not recorded) running to the west of, and approximately parallel with Torquay Road, located at a distance of 105 metres at the closest point.[3]

Artificial or Made Ground

There is no recorded artificial or Made Ground within the site or within the vicinity of the site, however the quarry has now been partially restored using site won and imported materials. The site won material may be described as sands and gravels. The imported material was sourced from local development sites under CL:AIRE Definition of Waste Code Practice.

Much of the imported material was sourced from greenfield sites and testing was undertaken to confirm the requirements of the Waste Acceptance Criteria (WAC). Chemical testing was also undertaken to ensure the imported material were in accordance with the criteria set out in the Works Management Plan (WMP) and the CL:AIRE Definition of Waste Code Practice.

Site investigation works were also undertaken by Horizon Consulting Engineers Ltd in August 2024 [5]. One of the objectives of these works weas to establish the ground conditions across the site. The report made the following observations:

- *Site won material* comprised: Predominantly Aller Gravel Fm, granular material with silty sandy matrix, used to make up levels and create access roads.
- *Imported material:* Predominantly comprised a layer of topsoil (generally < 0.5 m in thickness) overlying cohesive soils, which has been imported and compacted during restoration works.

Hydrology

There is a pond located within the southern part of the site, as recorded on the Ordnance Survey dataset, and there are ponds recorded around Aller Brake and Royal Aller Vale Quarry located to the north of the quarry site extents.

[3] British Geological Survey dataset – Sheet 339 Newton Abbot 1:50,000 (1997)
[4] British Geological Survey dataset – Sheet 339 Newton Abbot 1:50,000 (1997) Superficial
[5] Zig Zag Quarry Conceptual Site Model. Horizon Consulting Engineers Ltd. Aug 2024. Report Ref HCE0269.CSM

There are no running freshwater features (watercourses) recorded within the site extents of the quarry site. The nearest watercourse is named 'Beer's Brook' and is located running parallel with the southern boundary of the site, on the other side of Under Way Road, and located approximately 35 metres from the site boundary at the closest point. Beer's Brook discharges in a westerly direction and joins Aller Brook on the western side of Aller, at a point approximately 325 metres to the west of the site.

Historical records: Landslides

According to the BGS Landslides Database[6], there are no recorded landslide events located within the quarry site, though there are two separate records of landslide activity that appear to be orientated around Harpins Brake and Kerswell Hill, located 160 metres and 700 metres southeast of the site.

These landslide events are recorded as Landslide ID 753 and 754 respectively (date unknown) in the publication Geomorphological Servies Ltd (published 1988)[7]. It is considered likely that these landslide incidents refer to geomorphological striations that are observable on the hillside and on aerial imagery on Harpins Brake and Kerswell Hill, rather than conventional landslides or incidents of rockfall.

Historical records: Ordnance Survey

Table 1: Summary of historical Ordnance Survey datasets.[8]

Date of OS dataset	Changes to the site	Changes to the surrounding area
1886	Undeveloped site, predominantly orchards and woodland annotated as 'Aller Orchard Wood' with open fields and agricultural land on the eastern part of the site. There is a small area annotated 'Old Sand Pit' located approximately adjacent to the entrance of the site. There are no ponds or watercourses within the site.	The surrounding area is extensively undeveloped and comprises open agricultural lands (fields and woodland). Aller is annotated as a farm complex around a Manor House, the area is extensively undeveloped as a residential area. To the west of the site, Torquay Road and Aller Road are annotated, with the Torquay Branch Rail line demarked further to the west and orientated north to south. Aller Farm is annotated to the south of the site, with a separate 'Gravel Pit' and 'Sand Pit' located around Harpins Brake to the south of the site.
1906	No significant changes.	No significant changes. Further residential development to the west and south of the site around Aller.
1938	No significant changes.	No significant changes. Further residential development to the west and south of the site around Aller.

[6] http://mapapps2.bgs.ac.uk/geoindex/home.html (accessed 30/05/24)
[7] Applied Earth Surface Mapping for Planning and Development. Torbay, Devon. Geomorphological Services Ltd. (1988).
[8] National Library of Scotland. Devonshire (CIX.SE Newton Abbot)–Published 1886, 1906, 1938, 1951-62

1951 to 1962	'Zig Zag Quarry' annotated within the western part of the site, but workings appear to be limited to the western part of the site. The workings include a small building and some infrastructure adjacent to the entrance of the site. The remainder of the site is annotated 'Aller Orchard Wood'.	Torquay Road has been developed on the western boundary of the site, and there is further development within Aller, including residential and industrial (factory).
1999 to 2023 (aerial imagery)[9]	Zig Zag Quarry is operational with surface excavation over the full extent of the site.	Further residential development to the west and south of the site around Aller. Ponds are present within Aller Brake to the north of the site.

Flood Risk

The site is within Flood Zone 1. Land within Flood Zone 1 has a low probability of flooding from rivers and the sea, in any year land has between a < 0.1% chance of flooding from rivers the sea. [10]

A Flood Risk Assessment was undertaken on the site by RMA Environmental Ltd in January 2023[11]. The report made the following statement with regards to the risk of flooding from groundwater:

'The groundwater level is likely to be below the base of the quarry and the quarry has been worked dry. There are no specific records of groundwater flooding in the vicinity of the site and no ground lowering is proposed. Given the significant estimated unsaturated zone, it is considered that the groundwater risk from the site is ***low****.'*

A Hydrogeological Risk Assessment was also undertaken of the site by JH Groundwater Ltd in August 2024.[12] The report made the following statements with regards to groundwater flow and levels:

'It is understood the site has always been works dry ands the water management has been focussed on surface water runoff. Groundwater levels have been estimated based on assumed hydraulic conductivity between aquifer units and using an estimated conservative hydraulic gradient. The elevation of groundwater is estimated to be 11.5 metres beneath the southwestern edge of the quarry, rising to between 14.5 and 20 metres on the northeastern edge. An annual variation in groundwater is expected, but this is not expected to be significant.'

[9] Google Earth Imagery (CPM Systems) Date 1999 to 2022 (accessed 30/05/2024).
[10] https://flood-map-for-planning.service.gov.uk/location (accessed 30/05/2024).
[11] Flood Risk Assessment and Surface Water Drainage Strategy – Zig Zag Quarry. RMA Environmental Ltd. Report Ref: RMA-C2403. January 2023.
[12] Zig Zag Quarry Restoration. Hydrogeological Risk Assessment. JH Groundwater Ltd. Ref 1260. August 2024.

Conceptual site model

The approved restoration scheme allows for the early cessation of extraction (early 2024), followed by the commencement of the phased restoration works, whereby up to ~1.5m tonnes of inert waste materials may be imported to the site under a Waste Recovery Plan.

It is proposed to undertake the restoration works in sequential phases whereby imported material will be bought to the site area of each phase using existing internal haul roads and tracks, the material will then be unloaded and moved into position by bulldozer, deposited in horizontal layers from the base of the site upwards and benched into the existing sideslopes of the quarry and previous phase(s) of restoration works.

It is understood the restoration works will be undertaken in accordance with recognised standards and best practice for earthworks. This will include:

- The inspection and assessment of all imported material to ensure the imported material is in accordance with the planning conditions and specifications of the Waste Recovery Permit.
- To ensure the material is placed and compacted in horizontal layers and compacted in accordance with the Construction Management Plan and established best practice, and
- The control of surface water and run-off during the construction works and restoration profiling to ensure the imported material and restoration works are not subject to saturation or erosion due to run-off.

Partial restoration of the eastern and northern part of the site has already been undertaken, the levels in this area are close to the proposed restoration contours. There are no boreholes within the Aller Gravel Formation or Upper Greensand within or adjacent to the site. The details of the underlying geology, depths of the various strata and details of the groundwater are all unknown.

The following report is based on the existing ground conditions at the time of writing, makes assumptions on the conceptual site models going forward, and relates to the stability of the proposed final restoration landform as presented in those site models.

<u>Basal Sub-grade model</u>

The base of the proposed restoration scheme will be within the remnants of the Aller Gravel Formation. This is a river terrace gravel comprising well graded flint and chert gravels with a slit / clay / sand matrix. The Aller Gravel Formation is underlain by the Upper Greensand and strata of the Exeter Group. The base of the excavated quarry workings (final quarry void) is anticipated to be between 39m and 43m aOD and be sub-horizontal. Due to the lack of site investigation data available for the site, the exact makeup of the underlying strata and the relative thicknesses are unknown.

All existing stockpiles and vegetation will be removed from the basal area prior to development.

Side slope sub-grade model

The side slopes will vary in gradient from the previously restored areas along the northern and eastern margin of the site, which have been formed at a gradient of between 1v in 2h and 1v in 1.5h (in some areas).

The western and northwestern margins of the quarry site, those areas within the Aller Gravel Formation are much steeper. A design gradient of 70° to the horizontal will be assumed for the excavated sand and gravel faces. The site is above the groundwater table hence groundwater exclusion systems are not required.

Basal and side slope engineered system

Where parts of the site footprint have already been restored, this restoration material has been described as being generally cohesive and interpreted to be of generally low permeability. It is therefore proposed that where this restored material is greater that 1.0 metres in thickness the placed material may be considered as a geological barrier (subject to further confirmatory permeability testing to confirm these soils are of suitable quality to provide protection equivalent to a layer 1.0 m thick with a permeability of less than or equal to 1 $x10^{-7}$ m/s). It is proposed that new restoration material may then be placed over these previously restored areas to complete the restoration profile.

In areas where previously restored material has not been placed, or where existing restoration is less than 1.0 metres in thickness, the use of compacted indigenous of greenfield derived imported material is proposed in order to form a suitable geological barrier before placement of other materials. This geological barrier will then extend across the base of the site and the side slopes of the existing quarry. Where the waste tapers to less than 1.0 m thick, any deposited waste will be formed of suitable liner / barrier material, placed and compacted under CQA procedures. An indicative cross-section showing the basal liner is included Appendix A (Drawing 0269.109).

Details of these earthworks, including identification of source material, placement and testing to confirm material suitability will be set out in the Construction Quality Assurance (CQA) report.

Due to the inert nature of the imported materials, no leachate management system is considered necessary.

Waste mass

The permitted wastes which will be accepted as part of the restoration scheme will include imported inert wastes and will be classified in the proposed Waste Recovery Plan. The waste will also include overburden and residual clays from the mineral extraction. The waste will be subject to inspection on arrival and acceptance to the site and as the material is placed. The waste material will be predominantly granular, any organic, putrescible, excessively cohesive or otherwise deleterious material will not be accepted. The proposed permitted wastes are as follows:

- 01 04 08 Waste gravel and crushed rocks other than those mentioned in 01 04 07.
- 01 04 09 Waste sand and clays.
- 17 05 04 Soils and stones including chalk and other than those mentioned in 17 05 03.

Due to the inert nature of the waste material, leachate and gas abstraction measures are not proposed. The depth of waste deposited within the development is to be a maximum of c. 30 m reducing to 0 m at the south-western limit.

Although the imported waste material, overburden and residual clays will be relatively dry and tipped in such a way as to shed water, a Ru value of 0.2 will be applied to the waste material to allow for an element of pore water pressure within the waste mass.

The site is above the groundwater table hence groundwater exclusion systems are not required.

Capping system model

Due to the inert nature of the waste materials to be accepted at the site and as it is not anticipated that there will be a requirement to collect leachate or gas, there is no proposed engineered barrier / capping system other than the placing of low permeable material in the top 0.5m of waste if available. It is proposed that the site will be covered with topsoil and restored primarily to wooded and grassed land with some areas restored to agriculture.

Stability Risk Assessment

Risk classification – basal subgrade

The basal subgrade will be formed by the remnant bedrock gravels of the Aller Gravel Formation and the underlying bedrock of the Upper Greensand Formation. The principal risk factor to the stability of the restoration works are considered to be:

- *Bearing capacity of the basal subgrade:* The basal subgrade comprises bedrock and may therefore be considered to have sufficient bearing capacity to accommodate the loads imposed by the restoration works. The subgrade in this case has been effectively surcharged by the mass of overlying material (gravel and overburden) that has been removed by the quarrying process. Any loads imposed by the restoration works may be considered as net loads only.

- *Settlement / compressibility of the basal subgrade:* The basal subgrade material is granular and is not considered compressible or susceptible to consolidation settlement. The basal subgrade material has been effectively surcharged by the mass of overlying material (gravel and overburden) that has been removed by the quarrying process). Any loads imposed by the restoration works may be considered as net loads only and therefore the risk of significant or excessive ground movement (settlement) of the basal subgrade is considered to be very low.

- *Potential increase in groundwater flooding:* Changes to groundwater and drainage regimes has the potential to redirect, slow or increase the flow rate and direction of water resulting in adverse impacts to both surface and groundwater within the subgrade. The permeability of the imported material is lower than the indigenous materials. Furthermore, there are no proposals for infiltration drainage. Overall groundwater recharge is therefore anticipated to be lower than at present. Whilst there is anticipated to be a hydraulic connection between the local geological formations and local surface watercourses, the geological setting, groundwater levels and elevation of the restoration means that the risk of groundwater flooding remains low to negligible.

The identified risk to the basal subgrade may be classified as 'simple', no further geotechnical analysis of the basal subgrade is required.

Risk classification – side slope subgrade

The sideslopes to the north and northwest of the site will be formed within the bedrock gravels of the Aller Gravel Formation. The principal risk factor to the stability of the restoration works in the north and northwest of the site are considered to be:

- *Bearing capacity of the sidewall subgrade:* The sidewall subgrade comprises bedrock gravels and may therefore be considered to have sufficient bearing capacity to accommodate the loads imposed by the restoration works. The subgrade in this case has been effectively surcharged by the mass of overlying material (gravel and overburden) that has been removed

by the quarrying process). Any loads imposed by the restoration works may be considered as net loads only.

- *Slope instability of the sidewall subgrade:* The sidewalls are steeply sloping and are likely be subject to physical erosional processes (wind and rain) where exposed, which may lead to slope face instability and shallow ravelling type failure over an extended period of time. However as the restoration progresses and the imported waste material is placed against the exposed sidewall, this will act as a support to the slope face and remove exposure to physical weathering, thus increasing the factor of safety. The risk of slope instability to the sidewall once the restoration works are complete is considered to be very low.

The side slopes to the north and eastern margins of the site on the areas that have already been subject to partial restoration are constructed of a mixture of imported and site won inert materials, including overburden and residual clays. These slopes are a gradient of between 1v in 2h and 1v in 1.5h. The principal risk factor to the stability of the restoration works in the north and eastern of the site are considered to be:

- *Slope instability of the sidewall subgrade:* The side slopes within the areas of existing partial restoration are showing signs of surface erosion and slope face instability. The proposed works will reduce the slope face gradients to a maximum gradient of 1v in 3h. The imported waste material placed against the sidewall will also act as a support to the slope face and remove exposure to any future physical weathering, thus increasing the factor of safety. The risk of slope instability to the sidewall once the restoration works are complete is considered to be very low.

The identified risk to the sidewall subgrade may be classified as 'simple' no further geotechnical analysis of the side wall subgrade is required.

Risk classification – basal and side slope engineered system

The basal and side slope engineered system is to comprise a geological barrier, in excess of 1.0 metres in thickness and constructed either of previously imported restoration material (as imported under the previous phase of restoration works) and / or compacted indigenous or imported greenfield derived materials. The principal risk factor to the stability of the basal and side slope engineered system are considered to be:

- Slope instability of the engineered sidewall system: The placement of imported restoration material is to be undertake sequentially in horizontal lifts and compacted in-situ. The risk of instability to the side slope engineered system is therefore considered to be very low.

Risk classification – waste mass screening

The waste materials will be placed in compacted layers of a thickness appropriate for the material being deposited. During placement of the material, uncontained slopes to the south-west are to be no steeper than 1v in 3h (18°), with the waste placed to a maximum height of 30 metres.

Due to the inert nature of the wastes accepted at the site and the method of emplacement, no significant settlement is predicted to take place.

Given the unknown pore water pressures anticipated within the waste under long-term conditions, further geotechnical analysis is required. The analyses will comprise a slope stability assessment of the restoration profiles, under both temporary and permanent state scenarios, and will conservatively assume pore water pressures to replicate long-term conditions (Ru value of 0.1).

Lifecycle phases

The extent of the development boundary and its location in relation to the surrounding land are shown on drawing numbers Ref 0269.601 – 603, which are presented in Appendix A at the back of this report.

There are three main phases of development for the site, phases 1, 2 and 3 generally placing material from the north to the south in approximately horizontal layers, with a maximum slope face gradient (for temporary works) of 1 in 3. Those areas of the site which have previously been restored will be incorporated into the phased restoration, with the subsequent phases (layers) of material placed directly against the existing sideslope profiles.

It is intended that the waste will be built up in layers and not end tipped, and restoration will occur progressively as suitable material becomes available.

Due to the inert nature of the waste material, leachate and gas abstraction measures are not proposed.

Data summary

Slope Stability Southwest have been provided with the following site-specific geotechnical data:

- Zig Zag Quarry Restoration. Hydrogeological Risk Assessment. JH Groundwater Ltd. Ref 1260. August 2024.
- Zig Zag Quarry Restoration – Stability Risk Assessment Report. Key GS. November 2019.
- Aller Vale Quarry Silt Lagoon Restoration – Stability Risk Assessment Report. Key GS. January 2020.
- Flood Risk Assessment and Surface Water Drainage Strategy – Zig Zag Quarry. RMA Environmental Ltd. January 2023.
- Zig Zag Quarry Restoration – Environmental Statement (Chapter 3: The Proposed Development). Aardvark EM Ltd. February 2023.
- Zig Zag Quarry Restoration – Environmental Statement (Chapter 5: Assessment Methodology). Aardvark EM Ltd. February 2023.
- Zig Zag Quarry – Construction Environmental Management Plan (CEMP). Western Ecology Ltd. March 2023.
- Geotechnical Assessment Report – Zig Zag Quarry. SGS Ltd. September 2015.

Limited laboratory testing of inert waste was undertaken by KGS as part of the previous Stability Risk Assessment for the restoration of the site. 2No laboratory samples of inert waste were sent to Ground Engineering Ltd in Peterborough for Peak and Residual Shear Box Testing (by direct shear box test). The results are available in Appendix B.

Due to the likely variable and heterogenous nature of the waste mass, the material parameters for the waste mass material have been confirmed using the back analysis of a slope stability assessment, based on an increased slope face gradient of 1v in 2.5h and a conservative FoS of 1.3.

Justification for modelling approach and software

Oasys Slope – slope stability analysis software has been used to assess the stability of the stability of the proposed restoration works.

Oasys Slope performs two-dimensional limit equilibrium analysis based on the Bishop's method of slices. The works may be undertaken using partial factors in accordance with Eurocode (EC-7) or utilising Factor of Safety (FoS) whereby the ratio of resisting forces (stabilising) and disturbing forces (destabilising) are calculated to assess whether the slopes are marginally stable (FoS of 1.0), stable (Fos >1.0) of potentially unstable (FoS <1.0).

Analysis of the circular failure mechanisms have been undertaken using vertical slice limit equilibrium (Bishop's) method, the analysis has been undertaken in terms of effective stress in terms of both the worst case temporary and permanent case scenario. In each model the lowest FoS (worst case) is presented.

Justification for geotechnical parameters selected for analyses

The material parameters presented in Table 2 have been derived on the basis of published and / or assumed values and have been assigned to both existing ground conditions encountered onsite (subgrade materials) and any materials to be imported to site, including the waste mass.

The angle of friction has been derived on the basis of a moderately conservative assessment of in-situ density of the material based on visual assessment and observation of the material on site. The Aller Gravel Formation has been assessed as *dense (SPT = 45);* the Upper Greensand Formation has been assessed as *medium dense (SPT = 25);* and the previously restored and waste mass have been assessed as *loose (SPT = 5)*. As presented in Table 2.

Table 2: Summary of material parameters

Stratum	Material Parameter	Characteristic Value	Rationale
Waste mass	**Effective unit weight (γ')**	20	Published value (Tomlinson[11])
	Angle of friction, φ' (°)	28	SPT N correlation (SPT N = 5) (Peck[12]))
	Cohesion / shear strength (kN/m²)	2	Published value
Basal and side slope engineered system	**Effective unit weight (γ')**	20	Published value (Tomlinson[11])
	Angle of friction, φ' (°)	28	SPT N correlation (SPT N = 5) (Peck[12]))
	Cohesion / shear strength (kN/m²)	2	Published value
Aller Gravel Fm	**Effective unit weight (γ')**	20	Published value (Tomlinson[13])
	Angle of friction, φ' (°)	40	SPT N correlation (SPT N = 45) (Peck[14]))
	Cohesion / shear strength (kN/m²)	100	Published value
Upper Greensand	**Effective unit weight (γ')**	20	Published value (Tomlinson[11])
	Angle of friction, φ' (°)	35	SPT N correlation (SPT N = 25) (Peck[12]))
	Cohesion / shear strength (kN/m²)	100	Published value
Previously restored area	**Effective unit weight (γ')**	20	Published value (Tomlinson[11])
	Angle of friction, φ' (°)	28	SPT N correlation (SPT N = 5) (Peck[12]))
	Cohesion / shear strength (kN/m²)	2	Published value

Parameters selected for basal subgrade analysis: Refer to Table 2 for material parameters for Aller Gravel Formation and Upper Greensand Formation (basal subgrade).

[13] Foundation Design and Construction (7th Edition). MJ Tomlinson (2001).
[14] Peck, Hanson and Thornburn, Foundation Engineering, 2nd ed. 1974, John Wiley and Sons.

The groundwater level is below the floor of the quarry and therefore the stability assessment will be undertaken assuming fully drained conditions.

Parameters selected for side slope subgrade analysis: Refer to Table 2 for material parameters for Aller Gravel Formation and Upper Greensand Formation (side slope subgrade), and also the previously restored area.

The groundwater level is below the floor of the quarry and therefore the stability assessment will be undertaken assuming fully drained conditions. An Ru value of 0.2 will be applied to the material to allow for an element of pore water pressure within the previously restored area.

Parameters selected for basal engineered system analysis: Refer to Table 2 for material parameters for basal engineered system analysis.

Parameters selected for side slope engineered system analysis: Refer to Table 2 for material parameters for side slope engineered system analysis.

Parameters selected for waste mass analysis: Refer to Table 2 for material parameters for the imported waste mass material.

The waste material is likely to be of mixed and variable origin and is likely to be heterogenous in nature. The indicative shear strength value for this material has been derived on the basis of laboratory testing (shear box testing), and on the empirical relationship between shear strength and in-situ density.

Due to the likely variable and heterogenous nature of the waste mass, the material parameters for the waste material have been confirmed using the back analysis of a slope stability assessment, based on an increased slope face gradient of 1v in 2.5h and a conservative FoS of 1.3.

The groundwater level is below the floor of the quarry and therefore the stability assessment will be undertaken assuming fully drained conditions. An Ru value of 0.2 will be applied to the material to allow for an element of pore water pressure within the waste mass.

Select appropriate factors of safety

For the purpose of this analysis, material parameters will be modelled in an unmodified state (no partial factors applied), and the Factor of Safety will then be applied at the end of the analysis to allow for any uncertainty.

Factor of Safety selected for basal subgrade analysis: NOT APPLICABLE

Factor of Safety selected for side slope subgrade analysis: NOT APPLICABLE

Factor of Safety selected for basal lining system analysis: NOT APPLICABLE

Factor of Safety selected for side slope lining system analysis: NOT APPLICABLE

Factor of Safety selected for waste mass analysis: During the construction phase of the restoration works (temporary works) the key receptors will be construction workers and site operatives, a Factor of Safety of 1.2 is considered acceptable.

When considering the long terms stability of the final restoration profile (permanent works), the principal receptors are likely to be site users (members of the public) and site maintenance operatives (gardeners etc), a Factor of Safety of 1.3 is considered to be appropriately conservative.

Sensitivity analysis

Sensitivity analysis of basal subgrade analysis: NOT APPLICABLE

Sensitivity analysis of side slope subgrade analysis: NOT APPLICABLE

Sensitivity analysis of basal lining system analysis: NOT APPLICABLE

Sensitivity analysis of side slope lining system analysis: NOT APPLICABLE

Sensitivity analysis of waste mass: Sensitivity analysis of the waste mass has been carried out utilising back analysis of the slope stability assessment, with a slope face modelled at an increased slope face gradient of 1v in 2.5h and a conservative FoS of 1.3. This back analysis was used to confirm material, pore water and modelling parameters for the stability analysis.

Stability Assessment

The stability analysis of the waste mass is presented in Appendix C. The analysis was modelled on the maximum slope height and maximum slope face gradient for both the temporary (short term) and permanent (long term) states. The models were created based on the cross sections presented in Appendix A.

Stability assessment of basal subgrade analysis: NOT APPLICABLE

Stability assessment of side slope subgrade analysis: NOT APPLICABLE

Stability assessment of basal lining system analysis: NOT APPLICABLE

Stability assessment of side slope lining system analysis: NOT APPLICABLE

Stability assessment of waste mass analysis: The stability of the waste mass has been analysed at its maximum height, assuming a Ru value of 0.2 for the waste mass in the long-term case, and drained conditions in the short-term case.

- Long-term case (permanent works) - Analyses for the long-term case gave a FoS in excess of 1.3, using shear strength parameters as indicated in Table 2.

- Short-term case (temporary works) – As the short-term slope gradients are the same as those in the worstcase long-term scenario and they will be without pore water pressures, the short-term case will be more stable and have an increased FoS.

The above results demonstrate that an adequate FoS will be attained for the waste mass in the long-term case and that, provided correctly constructed with suitable strength and condition materials, the restored slopes should remain stable.

Monitoring

Monitoring requirements for the basal subgrade analysis: NOT APPLICABLE

Monitoring requirements for the side slope subgrade analysis: NOT APPLICABLE

Monitoring requirements for the basal lining system analysis: NOT APPLICABLE

Monitoring requirements for the side slope lining system analysis: NOT APPLICABLE

Monitoring requirements for the waste mass: The temporary waste slopes should be managed by the Site Rules; they should ensure that the upper surface of the slopes are graded to allow water to run off and prevent water to pond behind the crest of the slopes and that adequate stand-offs are maintained behind the crest and at the toe of the slopes.

An inspection regime should therefore be incorporated into the Site Rules to monitor the stability and integrity of the waste slopes as works progress. The inspections should be undertaken on a daily basis by a competent person, likely to be the Site Manager.

Any areas of apparent instability should be regraded or backfilled with waste mass prior to access being permitted to those areas; if issues are ongoing, working practices should be reviewed or specific geotechnical advice be sought as appropriate.

Conclusion

Slope Stability Southwest Ltd have been commissioned by Harleyford Aggregates Limited (HAL), the site operator, to undertake a Stability Risk Assessment for the proposed restoration scheme at Zig Zag Quarry in order to assess the stability of the proposed restoration works and the final ground profile.

The stability analyses undertaken demonstrate that adequate Factors of Safety (long-term stability) will be attained for the proposed structure provided it is correctly constructed with suitable strength and condition materials.

It is assumed that all works with regards to the restoration of the site will be undertaken in accordance with the Construction management Plan and Site Rules, all works should be undertaken in accordance with recognised standards and best practice for earthworks. This should include:

- The inspection and assessment of all imported material to ensure the imported material is in accordance with the planning conditions and specifications of the Waste Recovery Permit.
- To ensure the material is placed and compacted in horizontal layers and compacted in accordance with the Construction Quality Assurance Plan, Construction Management Plan and established best practice, and
- The control of surface water and run-off during the construction works and restoration profiling to ensure the imported material and restoration works are not subject to saturation or erosion due to run-off.

Furthermore, CQA procedures (Construction Quality Assurance) will be followed with respect to the construction works, with the short-term stability of the structures managed by appropriate Site Rules.

Yours faithfully

for **Slope Stability Southwest**

Tim Green – Chartered Engineering Geologist. BSc, MSc, FGS, CGeol, APMP.

Limitations

1. This report has been produced in compliance with the agreed scope of works between Slope Stability Southwest (SSSW) and the client (**BT Jenkins Ltd**).
2. This report is confidential to the client(s) named on the report and the client's solicitor and/or agent(s) and does not confer of purport to confer any benefits or any right pursuant to the Contracts (Rights of 3rd Parties) Act 1999. It may not be reproduced or further distributed without the permission of Slope Stability Southwest. We shall not be under any liability to any undisclosed party who has not been named on the report. The report may be reassigned to a new client by ourselves, on payment of an appropriate administration fee).
3. The scope of this report is limited to the current proposed development site boundaries. No assurances may be extended outside of this area and SSSW accept no responsibility for the use of this report for any purpose or any project except that for which is was commissioned and prepared.
4. The conclusions and advice provided in this report are based on:
    a. Current best practice and legislation (SSSW accept no responsibility or liability for any change in best practice guidance or statute). In the event of additional information becoming available, improved practice or changes in legislation, then amendment and re-interpretation of this report may be necessary.
    b. Sound engineering judgement by qualified and experienced engineers. This does not take into account the perceptions of other involved and interested parties.
5. Any information and data supplied by third parties has been interpreted in accordance with guidance notes and limitations provided by those third parties. Although this information has been reviewed and is considered relevant, no guarantee can be given to its accuracy and SSSW can give no assurance to the accuracy of data supplied by third parties. In addition, interpretation of historic datasets should be considered as indicative only.
6. The findings of this appraisal report are advisory and based on a visual site inspection undertaken on a specific date. Should conditions on site change as a result of further development, severe weather conditions, animal activity or other activity or circumstances, then Slope Stability Southwest should be notified, and a re-appraisal of ground conditions may be required.
7. The findings of this report are based on a walkover survey and inspection of the site. The works undertaken are extensively non-intrusive and do not represent (nor are they intended to represent) a full and comprehensive investigation of the nature and state of the ground conditions or bedrock underlying the site (should such works (intrusive ground investigation) be required, it may be undertaken under a separate scope of works). The findings of this report should not be used for design or construction purposes.
8. Unless otherwise stated, comments made relating to groundwater are based on observations made at the time of site assessment. Groundwater may vary as a result of seasonal effects or other variable factors.

Appendices:

Appendix A1: Phased Restoration plan

Appendix A2: Phased Restoration Plan – Sections

Appendix B: Laboratory Test Results

Appendix C: Slope Stability Analysis Results

Appendix A1: Phased Restoration plan

- **Zig Zag Quarry Restoration- Phase 1 Plan Proposed. Ref 0269.601 Date May 2024 Produced by Horizon Consulting Engineers Ltd.**

- **Zig Zag Quarry Restoration- Phase 2 Plan Proposed. Ref 0269.602 Date May 2024 Produced by Horizon Consulting Engineers Ltd.**

- **Zig Zag Quarry Restoration- Restoration Plan proposed without basins. Ref 0269.603 Date May 2024 Produced by Horizon Consulting Engineers Ltd**

- **Zig Zag Quarry Restoration- Restoration Plan proposed with basins. Ref 0269.604 Date May 2024 Produced by Horizon Consulting Engineers Ltd**

- **Zig Zag Quarry Restoration- Indicative liner and side slope engineering – Environmental setting and site design. Ref 0269.109. Date Sep 2024. Produced by Horizon Consulting Engineers Ltd**

PHASE 1 CUT / FILL
FILL 580,000 m^3
CUT 30,000 m^3
NET FILL 550,000 m^3

PERMIT BOUNDARY

SITE BOUNDARY

EXISTING STOCKPILES TO BE RELOCATED
OR INCORPORATED INTO WASTE MASS

EXISTING WASH PLANT TO REMAIN OPERATIONAL
FOR DURATION OF PHASE 1 WORKS

EXISTING CEMENT BAGGING PLANT TO REMAIN
OPERATIONAL FOR DURATION OF PHASE 1 WORKS

EXISTING BOUNDARY LEVEL TO BE CONFIRMED,
CONTRACTOR TO GRADE IMPORTED FILL TO
EXISTING GROUND LEVEL AT SITE BOUNDARY

QUARRY WORKS HAVE BEEN UNDERTAKEN SINCE 2022 LIDAR SURVEY, CONTRACTOR TO ENSURE PROPOSED SURFACE TIES INTO EXISTING AT SUITABLE GRADE NO STEEPER THAN 1:3

PROPOSED BASIN AND ASSOCIATED
DRAINAGE INFRASTRUCTURE CONSTRUCTED
IN ACCORDANCE WITH APPROVED PLANS

A

B

84.0
82.0
80.0
78.0
76.0
74.0
72.0
70.0
68.0
66.0
64.0
62.0
60.0
58.0
56.0
54.0
52.0
50.0
48.0
46.0
44.0

NOTES: GENERAL

1. DO NOT SCALE FROM THIS DRAWING
2. ALL DIMENSIONS SHOWN ARE IN METRES UNLESS STATED OTHERWISE
3. THIS DRAWING SHALL BE READ IN CONJUNCTION WITH ALL RELEVANT SCHEME DRAWINGS AND SPECIFICATIONS
4. COMPOSITE MODEL REF, 220628 PROVIDED BY 4DES COMPARED WITH PROPOSED MODEL USED FOR VOLUMETRIC CALCULATIONS AS PER APPROVED PLANNING DRAWINGS. ASSUMPTIONS MADE IN COMPOSITE MODEL HAVE NOT BEEN VALIDATED, CIRCA 100,000m^3 VOLUME REMOVED WHEN COMPARED TO JUNE 2022 LIDAR MODEL REF 240221

Rev	Description	Drn	Chk	Date
A	Updated to include permit boundary	JH	AL	19.01.26

REVISIONS

Preliminary Issue	30.05.24	Submitted for S104	
Planning Issue		Issued for Tender	
Submitted for S38		Issued for Construction	
Submitted for S278		As Built	

DRAWING STATUS

Horizon Consulting Engineers
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JENKINS LTD

JOB TITLE
ZIG ZAG RESTORATION

DRAWING TITLE
PHASE 1 PLAN
PROPOSED

DATE MAY '24 DRAWN GB CHECKED HT

DRAWING No. 0269.601 REV. – SCALE AS SHOWN @ A1

PHASE 2 CUT / FILL
FILL 163,000 m^3
CUT 2,000 m^3
NET FILL 161,000 m^3

PERMIT BOUNDARY

SITE BOUNDARY

EXISTING BOUNDARY LEVEL TO BE CONFIRMED, CONTRACTOR TO GRADE IMPORTED FILL TO EXISTING GROUND LEVEL AT SITE BOUNDARY

EXISTING CEMENT BAGGING PLANT TO REMAIN OPERATIONAL FOR DURATION OF PHASE 2 WORKS

EXISTING STOCKPILES TO BE RELOCATED OR INCORPORATED INTO WASTE MASS

QUARRY WORKS HAVE BEEN UNDERTAKEN SINCE 2022 LIDAR SURVEY, CONTRACTOR TO ENSURE PROPOSED SURFACE TIES INTO EXISTING AT SUITABLE GRADE NO STEEPER THAN 1:3

PROPOSED BASIN AND ASSOCIATED DRAINAGE INFRASTRUCTURE CONSTRUCTED IN ACCORDANCE WITH APPROVED PLANS

A

A

B

B

NOTES: GENERAL

1. DO NOT SCALE FROM THIS DRAWING
2. ALL DIMENSIONS SHOWN ARE IN METRES UNLESS STATED OTHERWISE
3. THIS DRAWING SHALL BE READ IN CONJUNCTION WITH ALL RELEVANT SCHEME DRAWINGS AND SPECIFICATIONS
4. COMPOSITE MODEL REF, 220628 PROVIDED BY 4DES COMPARED WITH PROPOSED MODEL USED FOR VOLUMETRIC CALCULATIONS AS PER APPROVED PLANNING DRAWINGS. ASSUMPTIONS MADE IN COMPOSITE MODEL HAVE NOT BEEN VALIDATED, CIRCA 100,000m^3 VOLUME REMOVED WHEN COMPARED TO JUNE 2022 LIDAR MODEL REF 240221

Rev	Description	Drn	Chk	Date
A	Updated to include permit boundary	JH	AL	19.01.26

REVISIONS

Preliminary Issue	30.05.24	Submitted for S104	
Planning Issue		Issued for Tender	
Submitted for S38		Issued for Construction	
Submitted for S278		As Built	

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JOB TITLE
ZIG ZAG RESTORATION

DRAWING TITLE
PHASE 2 PLAN
PROPOSED

DATE: MAY '24 | DRAWN: GB | CHECKED: HT
DRAWING No: 0269.602 | REV: – | SCALE: AS SHOWN @ A1

FINAL RESTORATION PHASE CUT / FILL
FILL 107,000 m^3
CUT <1,000 m^3
NET FILL 107,000 m^3

TOTAL CUT / FILL
FILL 860,000 m^3
CUT 10,000 m^3
NET FILL 850,000 m^3

PERMIT BOUNDARY

SITE BOUNDARY

EXISTING BOUNDARY LEVEL TO BE CONFIRMED, CONTRACTOR TO GRADE IMPORTED FILL TO EXISTING GROUND LEVEL AT SITE BOUNDARY

QUARRY WORKS HAVE BEEN UNDERTAKEN SINCE 2022 LIDAR SURVEY, CONTRACTOR TO ENSURE PROPOSED SURFACE TIES INTO EXISTING AT SUITABLE GRADE NO STEEPER THAN 1:3

BASINS OMITTED FROM FINAL RESTORATION ON THE ASSUMPTION THAT AN ALTERNATIVE DRAINAGE STRATEGY, DESIGN BY OTHERS, IS ACCEPTABLE

NOTES: GENERAL

1. DO NOT SCALE FROM THIS DRAWING
2. ALL DIMENSIONS SHOWN ARE IN METRES UNLESS STATED OTHERWISE
3. THIS DRAWING SHALL BE READ IN CONJUNCTION WITH ALL RELEVANT SCHEME DRAWINGS AND SPECIFICATIONS
4. COMPOSITE MODEL REF, 220628 PROVIDED BY 4DES COMPARED WITH PROPOSED MODEL USED FOR VOLUMETRIC CALCULATIONS AS PER APPROVED PLANNING DRAWINGS. ASSUMPTIONS MADE IN COMPOSITE MODEL HAVE NOT BEEN VALIDATED, CIRCA 100,000m^3 VOLUME REMOVED WHEN COMPARED TO JUNE 2022 LIDAR MODEL REF 240221

Rev	Description	Drn	Chk	Date
A	Updated with permit boundary	JH	AL	19.01.26

REVISIONS

Preliminary Issue	21.06.24	Submitted for S104	
Planning Issue		Issued for Tender	
Submitted for S38		Issued for Construction	
Submitted for S278		As Built	

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JOB TITLE
ZIG ZAG RESTORATION

DRAWING TITLE
RESTORATION PLAN
PROPOSED
WITHOUT BASINS

DATE	DRAWN	CHECKED
MAY '24	GB	HT

DRAWING No.	REV.	SCALE
0269.603	–	AS SHOWN @ A1

FINAL RESTORATION PHASE CUT / FILL
FILL 68,000 m^3
CUT 2,000 m^3
NET FILL 66,000 m^3

TOTAL CUT / FILL
FILL 811,000 m^3
CUT 34,000 m^3
NET FILL 777,000 m^3

PERMIT BOUNDARY

SITE BOUNDARY

EXISTING BOUNDARY LEVEL TO BE CONFIRMED, CONTRACTOR TO GRADE IMPORTED FILL TO EXISTING GROUND LEVEL AT SITE BOUNDARY

QUARRY WORKS HAVE BEEN UNDERTAKEN SINCE 2022 LIDAR SURVEY, CONTRACTOR TO ENSURE PROPOSED SURFACE TIES INTO EXISTING AT SUITABLE GRADE NO STEEPER THAN 1:3

PROPOSED BASIN AND ASSOCIATED DRAINAGE INFRASTRUCTURE CONSTRUCTED IN ACCORDANCE WITH APPROVED PLANS

A

A

B

B

NOTES: GENERAL

1. DO NOT SCALE FROM THIS DRAWING
2. ALL DIMENSIONS SHOWN ARE IN METRES UNLESS STATED OTHERWISE
3. THIS DRAWING SHALL BE READ IN CONJUNCTION WITH ALL RELEVANT SCHEME DRAWINGS AND SPECIFICATIONS
4. COMPOSITE MODEL REF, 220628 PROVIDED BY 4DES COMPARED WITH PROPOSED MODEL USED FOR VOLUMETRIC CALCULATIONS AS PER APPROVED PLANNING DRAWINGS. ASSUMPTIONS MADE IN COMPOSITE MODEL HAVE NOT BEEN VALIDATED, CIRCA 100,000m^3 VOLUME REMOVED WHEN COMPARED TO JUNE 2022 LIDAR MODEL REF 240221

Rev	Description	Drn	Chk	Date
A	Updated with permit boundary	JH	AL	19.01.26

REVISIONS

Preliminary Issue	30.05.24	Submitted for S104	
Planning Issue		Issued for Tender	
Submitted for S38		Issued for Construction	
Submitted for S278		As Built	

DRAWING STATUS

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JOB TITLE
ZIG ZAG RESTORATION

DRAWING TITLE
RESTORATION PLAN
PROPOSED
WITH BASINS

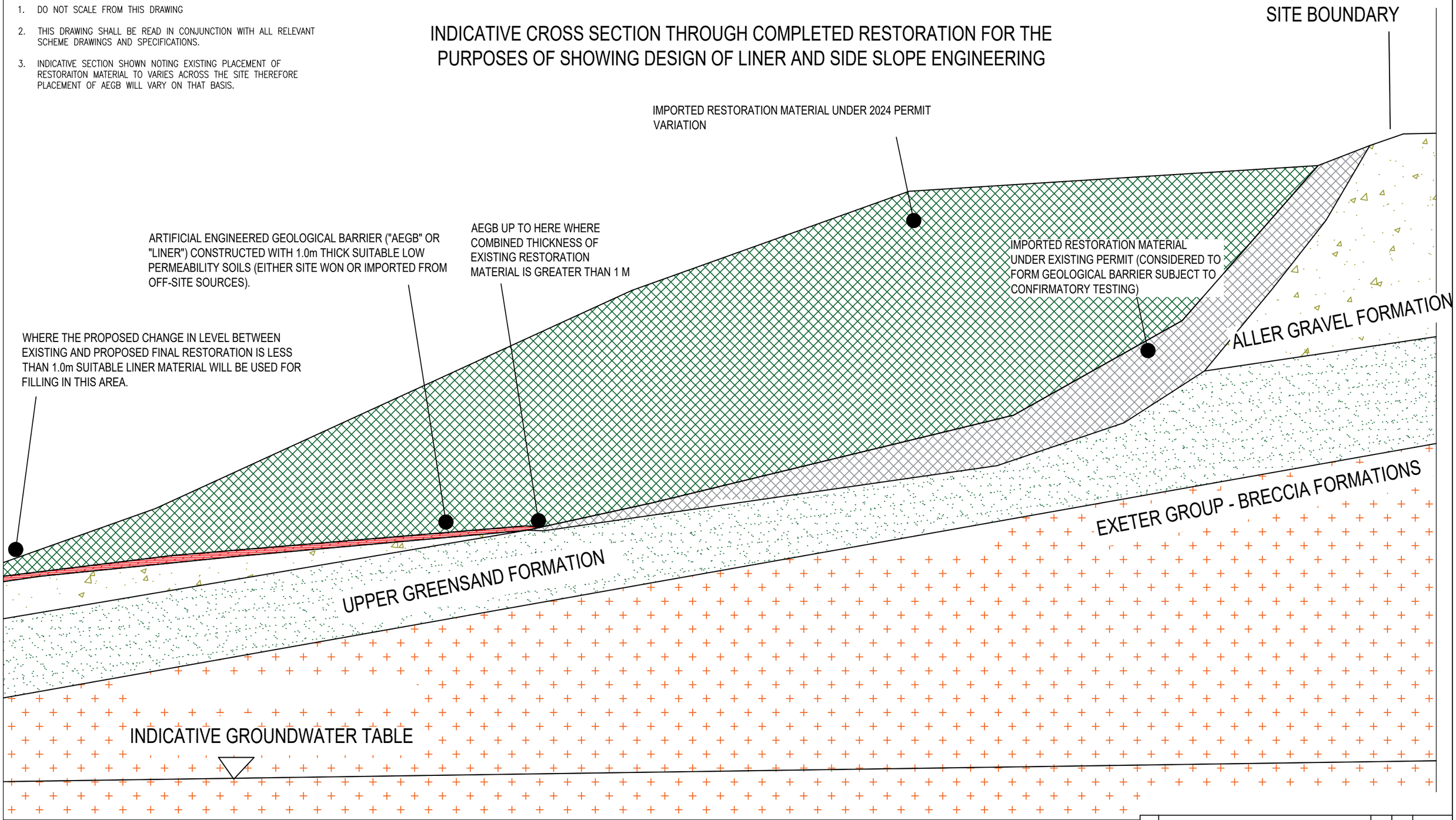
DATE	DRAWN	CHECKED
MAY '24	GB	HT

DRAWING No.	REV.	SCALE
0269.604	–	AS SHOWN @ A1

NOTES: GENERAL

1. DO NOT SCALE FROM THIS DRAWING
2. THIS DRAWING SHALL BE READ IN CONJUNCTION WITH ALL RELEVANT SCHEME DRAWINGS AND SPECIFICATIONS.
3. INDICATIVE SECTION SHOWN NOTING EXISTING PLACEMENT OF RESTORAITON MATERIAL TO VARIES ACROSS THE SITE THEREFORE PLACEMENT OF AEGB WILL VARY ON THAT BASIS.

INDICATIVE CROSS SECTION THROUGH COMPLETED RESTORATION FOR THE PURPOSES OF SHOWING DESIGN OF LINER AND SIDE SLOPE ENGINEERING



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BT JENKINS LTD

JOB TITLE
ZIG ZAG QUARRY
KINGSKERSWELL

DRAWING TITLE
INDICATIVE LINER AND SIDE SLOPE ENGINEERING
ENVIRONMENTAL SETTING AND SITE DESIGN

Rev	Description	Drn	Chk	Date

REVISIONS

Preliminary		Approval		Tender		Const.	

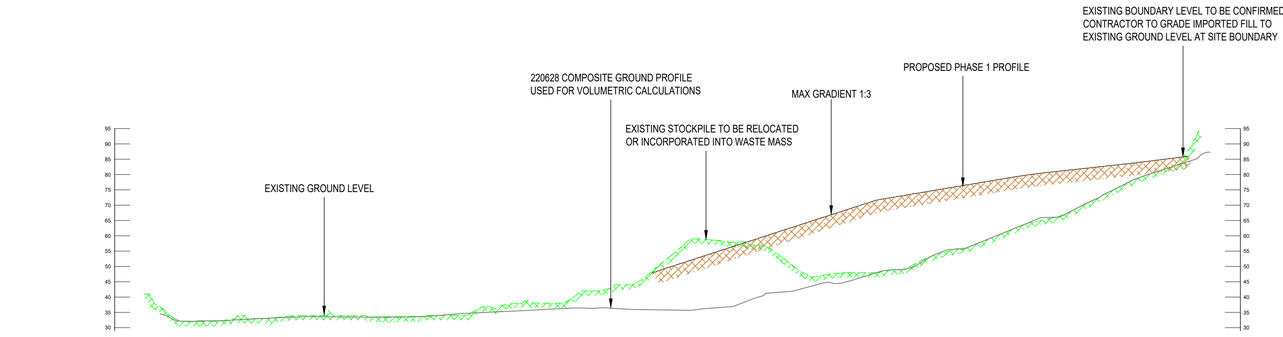
DRAWING STATUS

DATE	DRAWN	CHECKED	ISSUE CHECKBOX
SEP '24	JH	AL	

DRAWING No.	REV	SCALE	
0269.109	–	NTS	@ A3

Appendix A2: Phased Restoration Plan – Sections

Zig Zag Quarry Restoration- Sections Proposed. Ref 0269.605 and 606 (Sheets 1 & 2) Date May 2024
Produced by Horizon Consulting Engineers Ltd



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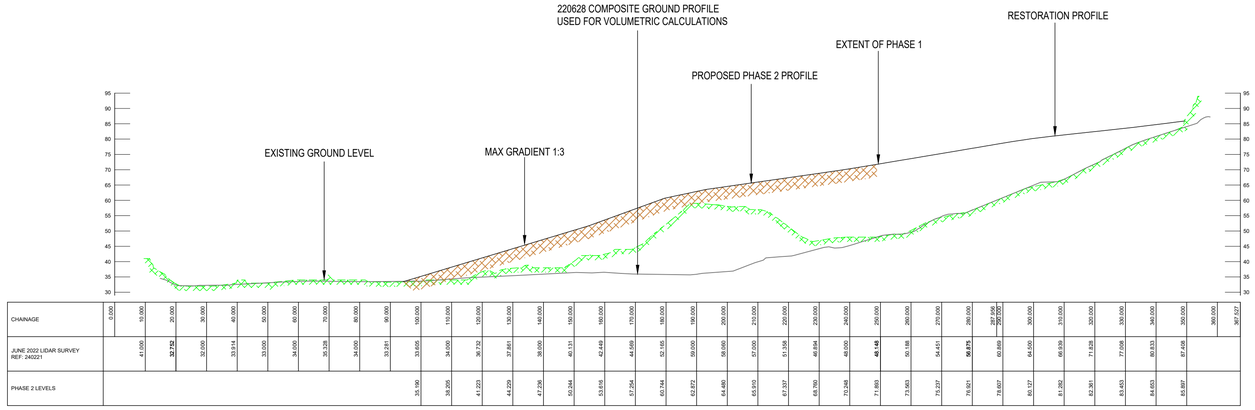
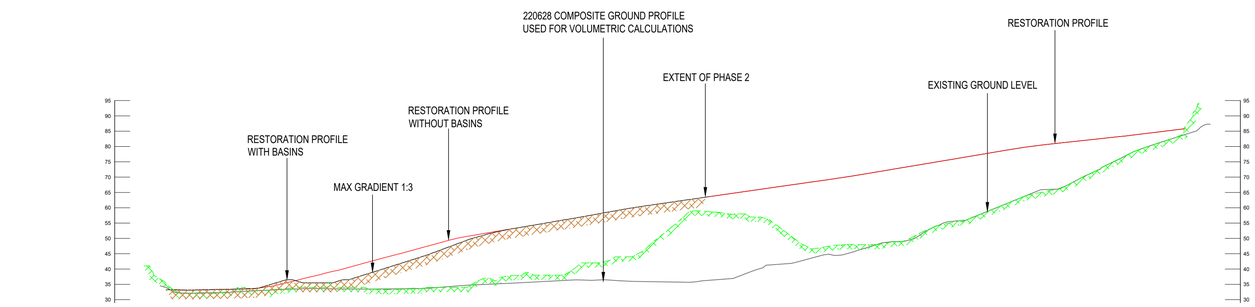
JUNE 2022 LIDAR SURVEY REF: 240221		41.000	**32.752**	32.000	33.914	33.000	34.000	35.328	34.000	33.281	33.695	34.000	36.732	37.881	38.000	40.131	42.449	44.659	52.165	59.000	58.090	57.000	51.358	46.894	48.000	**45.148**	50.188	54.451	**66.875**	76.921	78.607	80.127	81.282	82.361	83.453	84.653	85.897	87.408	
PHASE 1 LEVELS																			49.464	52.644	50.985	50.123	62.363	65.654	68.843	71.993	73.903	75.237	76.921	78.607	80.127	81.282	82.361	83.453	84.653	85.897			

SECTION A-A' PHASE 1
SCALE 1:1000 HORIZ / 1:1000 VERT



CHAINAGE	0.000	10.000	20.000	30.000	40.000	50.000	60.000	70.000	80.000	90.000	100.000	110.000	120.000	130.000	140.000	150.000	160.000	170.000	180.000	190.000	200.000	210.000	220.000	230.000	240.000	250.000	260.000	267.595	267.595	280.000	290.000	300.000	310.000	320.000	330.000	340.000	350.000	360.000	367.527
JUNE 2022 LIDAR SURVEY REF: 240221		41.000	**32.752**	32.000	33.914	33.000	34.000	35.328	34.000	33.281	33.695	34.000	36.732	37.881	38.000	40.131	42.449	44.659	52.165	59.000	58.090	57.000	51.358	46.894	48.000	**45.148**	50.188	54.451	**66.875**	76.921	78.607	80.127	81.282	82.361	83.453	84.653	85.897	87.408	
PHASE 2 LEVELS																			35.190	38.295	41.223	44.229	47.298	50.244	53.616	57.254	60.744	63.973	64.480	65.910	67.337	68.760	70.348	71.993	73.903	75.237	76.921	78.607	80.127	81.282	82.361	83.453	84.653	85.897			

SECTION A-A' PHASE 2
SCALE 1:1000 HORIZ / 1:1000 VERT



CHAINAGE	0.000	10.000	20.000	30.000	40.000	50.000	60.000	70.000	80.000	90.000	100.000	110.000	120.000	130.000	140.000	150.000	160.000	170.000	180.000	190.000	200.000	210.000	220.000	230.000	240.000	250.000	260.000	265.876	270.000	280.000	290.000	300.000	310.000	320.000	330.000	340.000	350.000	360.000	367.527
JUNE 2022 LIDAR SURVEY REF: 240221		41.000	**32.752**	32.000	33.914	33.000	34.000	35.328	34.000	33.281	33.695	34.000	36.732	37.881	38.000	40.131	42.449	44.659	52.165	59.000	58.090	57.000	51.358	46.894	48.000	**45.148**	50.188	54.451	**66.875**	76.921	78.607	80.127	81.282	82.361	83.453	84.653	85.897	87.408	
FINAL RESTORATION LEVELS			33.241	33.780	33.451	34.226	36.459	38.074	41.531	44.259	46.836	49.615	51.524	53.194	54.879	56.591	58.390	60.141	61.604	63.044	64.480	65.911	67.337	68.781	70.236	71.680	73.540	75.236	76.921	78.611	80.136	81.284	82.380	83.431	84.653	85.894			
FINAL RESTORATION LEVELS WITH ATTENUATION BASINS			33.207	33.753	33.472	34.498	36.928	38.500	37.636	40.786	43.949	47.044	50.066	53.201	54.866	56.602	58.390	60.134	61.655	63.044	64.480	65.910	67.337	68.760	70.348	71.993	73.903	75.237	76.921	78.607	80.127	81.282	82.361	83.453	84.653	85.897			

SECTION A-A' FINAL RESTORATION
SCALE 1:1000 HORIZ / 1:1000 VERT

KEY:

EXITING GROUND SURFACE

PROPOSED FILL MATERIAL

NOTES: GENERAL

1. DO NOT SCALE FROM THIS DRAWING
2. ALL DIMENSIONS SHOWN ARE IN METRES UNLESS STATED OTHERWISE
3. THIS DRAWING SHALL BE READ IN CONJUNCTION WITH ALL RELEVANT SCHEME DRAWINGS AND SPECIFICATIONS
4. REFER TO DRAWING 0269.601 FOR SECTION LINE LOCATIONS
5. JUNE 2022 LIDAR SURVEY, REF 240221 AND COMPOSITE MODEL REF, 220628 PROVIDED BY 4DES

Rev	Description	Drn	Chk	Date
REVISIONS				

Preliminary Issue	30.05.24	Submitted for S104	
Planning Issue		Issued for Tender	
Submitted for S38		Issued for Construction	
Submitted for S278		As Built	
DRAWING STATUS			

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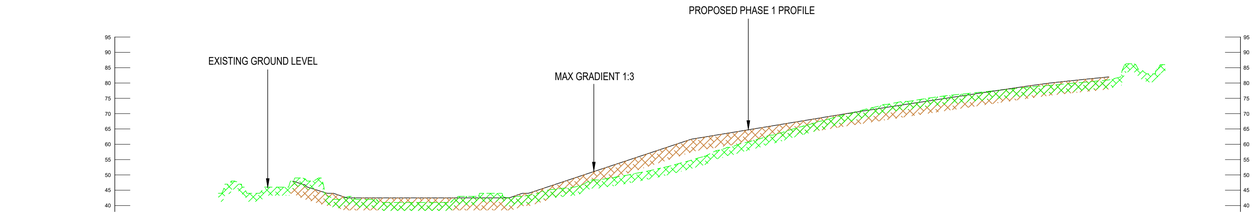
BY JENKINS LTD

JOB TITLE
ZIG ZAG RESTORATION

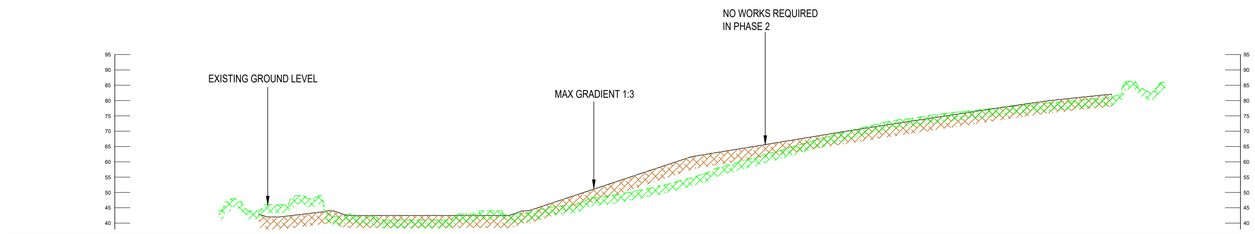
DRAWING TITLE
SECTIONS PROPOSED SHEET 1

DATE	DRAWN	CHECKED
MAY '24	GB	HT
DRAWING No.	REV	SCALE
0269.605	–	AS SHOWN @ A1



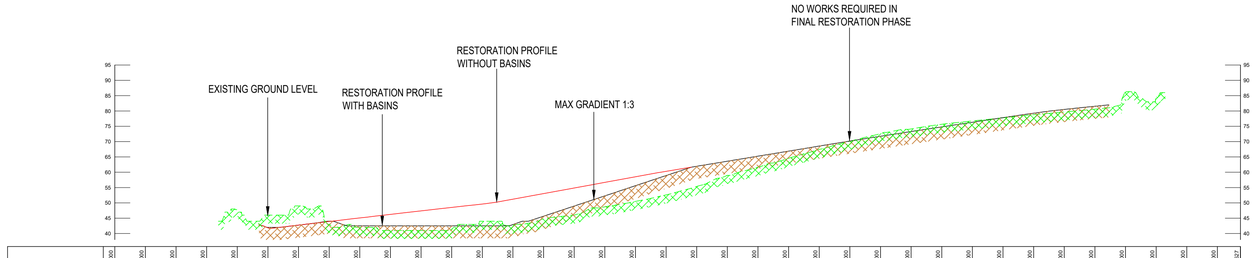
CHAINAGE	0.000	10.000	20.000	30.000	40.000	50.000	60.000	70.000	80.000	90.000	100.000	110.000	120.000	130.000	140.000	150.000	160.000	170.000	180.000	190.000	200.000	210.000	220.000	230.000	240.000	250.000	260.000	270.000	280.000	290.000	300.000	310.000	320.000	330.000	340.000	350.000	360.000	367.527
JUNE 2022 LIDAR SURVEY REF: 240221					47.755	48.000	49.000	43.000	42.000	41.000	41.000	**41.355**	44.000	42.741	44.799	46.022	48.711	50.487	52.613	55.367	58.980	61.670	64.563	67.475	70.128	72.657	74.145	75.666	76.745	77.796	78.807	79.677	80.564	**80.125**	84.500				
PHASE 1 LEVELS							47.380	44.000	42.500	42.500	42.000	42.000	42.000	42.500	42.829	45.652	48.978	52.398	55.607	58.927	61.955	63.693	65.247	66.899	68.551	70.183	71.744	73.284	74.864	76.520	77.815	79.278	80.564	81.539						

SECTION B-B' PHASE 1
SCALE 1:1000 HORIZ / 1:1000 VERT



CHAINAGE	0.000	10.000	20.000	30.000	40.000	50.000	60.000	70.000	80.000	90.000	100.000	110.000	120.000	130.000	140.000	150.000	160.000	170.000	180.000	190.000	200.000	210.000	220.000	230.000	240.000	250.000	260.000	270.000	280.000	290.000	300.000	310.000	320.000	330.000	340.000	350.000	360.000	367.527
JUNE 2022 LIDAR SURVEY REF: 240221					47.755	48.000	49.000	43.000	42.000	41.000	41.000	**41.355**	44.000	42.741	44.799	46.022	48.711	50.487	52.613	55.367	58.980	61.670	64.563	67.475	70.128	72.657	74.145	75.666	76.745	77.796	78.807	79.677	80.564	**80.125**	84.500				
PHASE 2 LEVELS						42.000	42.746	44.000	42.500	42.500	42.000	42.000	42.500	42.500	42.829	45.652	48.978	52.398	55.607	58.927	61.955	63.693	65.247	66.899	68.551	70.183	71.744	73.284	74.864	76.520	77.815	79.278	80.564	81.539						

SECTION B-B' PHASE 2
SCALE 1:1000 HORIZ / 1:1000 VERT



CHAINAGE	0.000	10.000	20.000	30.000	40.000	50.000	60.000	70.000	80.000	90.000	100.000	110.000	120.000	130.000	140.000	150.000	160.000	170.000	180.000	190.000	200.000	210.000	220.000	230.000	240.000	250.000	260.000	270.000	280.000	290.000	300.000	310.000	320.000	330.000	340.000	350.000	360.000	367.527
JUNE 2022 LIDAR SURVEY REF: 240221					47.755	48.000	49.000	43.000	42.000	41.000	41.000	**41.355**	44.000	42.741	44.799	46.022	48.711	50.487	52.613	55.367	58.980	61.670	64.563	67.475	70.128	72.657	74.145	75.666	76.745	77.796	78.807	79.677	80.564	**80.125**	84.500	85.000			
FINAL RESTORATION LEVELS						42.000	42.746	44.000	42.500	42.500	42.000	42.000	42.500	42.500	42.829	45.652	48.978	52.398	55.607	58.927	61.955	63.693	65.247	66.899	68.550	70.185	71.747	73.281	74.851	76.520	77.816	79.304	80.556	81.541						
FINAL RESTORATION LEVELS WITH ATTENUATION BASINS						41.647	42.746	43.935	42.500	42.500	46.343	47.950	48.516	48.650	51.710	53.032	54.693	56.688	58.519	60.303	61.955	63.693	65.247	66.899	68.550	70.185	71.747	73.281	74.851	76.520	77.816	79.304	80.556	81.541						

SECTION B-B' FINAL RESTORATION
SCALE 1:1000 HORIZ / 1:1000 VERT

KEY:

- EXITING GROUND SURFACE
- PROPOSED FILL MATERIAL

NOTES: GENERAL

1. DO NOT SCALE FROM THIS DRAWING
2. ALL DIMENSIONS SHOWN ARE IN METRES UNLESS STATED OTHERWISE
3. THIS DRAWING SHALL BE READ IN CONJUNCTION WITH ALL RELEVANT SCHEME DRAWINGS AND SPECIFICATIONS
4. REFER TO DRAWING 0269.601 FOR SECTION LINE LOCATIONS
5. JUNE 2022 LIDAR SURVEY, REF 240221 AND COMPOSITE MODEL REF, 220628 PROVIDED BY 4DES

Rev	Description	Drn	Chk	Date
REVISIONS				

Preliminary Issue	30.05.24	Submitted for S104	
Planning Issue		Issued for Tender	
Submitted for S38		Issued for Construction	
Submitted for S278		As Built	
DRAWING STATUS			

Horizon Consulting Engineers
The Dairy Barn, Westpoint Crt, Sidmouth Rd, Exeter EX5 1DJ
T: 01392 363364
www.horizon-ce.co.uk

BY JENKINS LTD

JOB TITLE
ZIG ZAG RESTORATION

DRAWING TITLE
SECTIONS
PROPOSED
SHEET 2

DATE MAY '24 | DRAWN GB | CHECKED HT

DRAWING No. 0269.606 | REV – | SCALE AS SHOWN @ A1

Appendix B: Laboratory Test Results

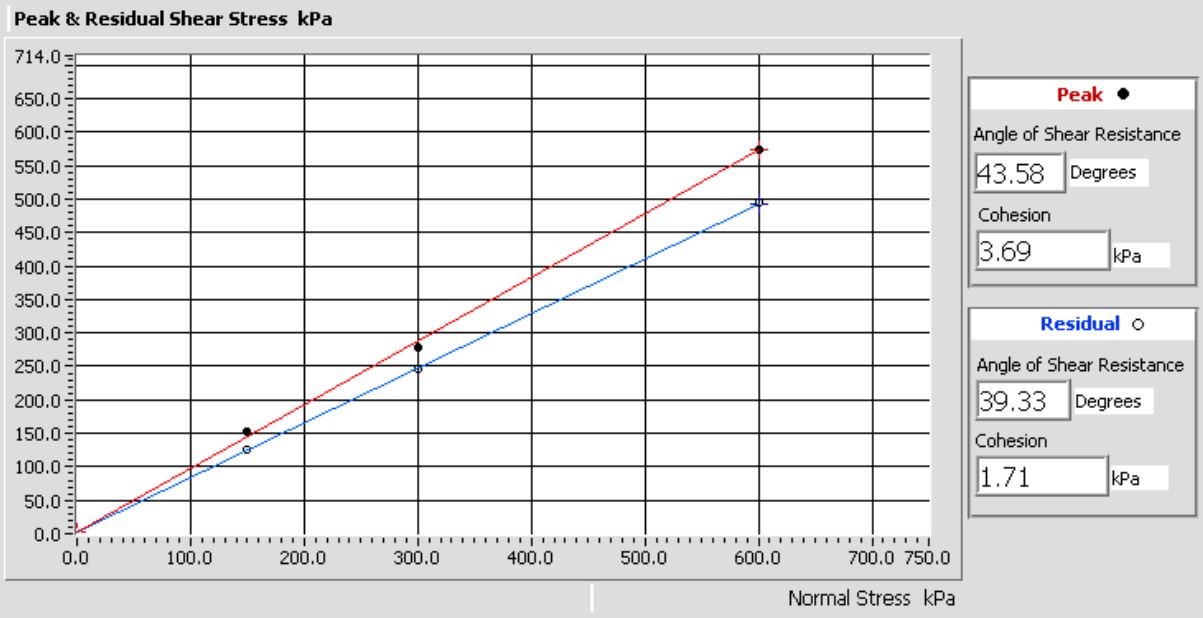
Shear Strength by Direct Shear (Small Shear Box)

GROUND ENGiNEERiNG LTD

Client	Key GeoSolutions Ltd	**Lab Ref**	PL6829-1-1
Project	IKEA	**Job**	L9728
Borehole	Not Given	**Sample**	S1

Test Summary				
Reference	A	B	C	
Applied Normal Stress	150.0 kPa	300.0 kPa	600.0 kPa	
Peak Strength	152.4 kPa	277.2 kPa	574.6 kPa	
Corresponding Horizontal Displacement	9.507 mm	8.723 mm	13.417 mm	
Residual Shear Stress	126.3 kPa	245.0 kPa	494.2 kPa	
Rate(s) of Shear Displacement	Stage 1: 0.0160mm/min Stage 2: 0.0160mm/min Stage 3: 0.0160mm/min	Stage 1: 0.0120mm/min Stage 2: 0.0600mm/min	Stage 1: 0.0120mm/min Stage 2: 0.0240mm/min Stage 3: 0.0240mm/min	
Final Height	19.36 mm	20.16 mm	17.67 mm	
Cumulative Displacement	27.447 mm	20.511 mm	29.174 mm	
Number of Traverses	3	2	3	

Peak & Residual Shear Stress vs Normal Stress



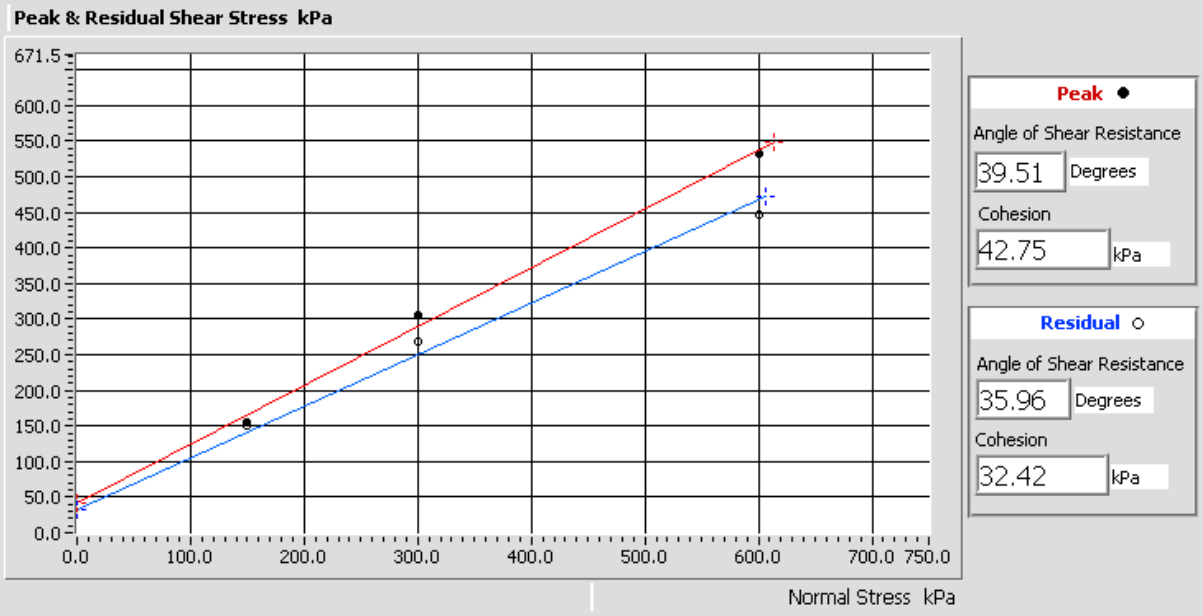
Shear Strength by Direct Shear (Small Shear Box)

GROUND ENGiNEERiNG LTD

Client	Key GeoSolutions Ltd	Lab Ref	PL6829-1-2
Project	Willows	Job	L9728
Borehole	Not Given	Sample	S1

Test Summary				
Reference	A	B	C	
Applied Normal Stress	150.0 kPa	300.0 kPa	600.0 kPa	
Peak Strength	155.3 kPa	306.6 kPa	531.7 kPa	
Corresponding Horizontal Displacement	5.723 mm	20.472 mm	24.264 mm	
Residual Shear Stress	149.5 kPa	267.6 kPa	446.7 kPa	
Rate(s) of Shear Displacement	Stage 1: 0.0240mm/min Stage 2: 0.0240mm/min	Stage 1: 0.0240mm/min Stage 2: 0.0240mm/min Stage 3: 0.0240mm/min Stage 4: 0.0240mm/min	Stage 1: 0.0240mm/min Stage 2: 0.0240mm/min Stage 3: 0.0240mm/min	
Final Height	22.05 mm	21.04 mm	19.76 mm	
Cumulative Displacement	15.409 mm	30.620 mm	26.268 mm	
Number of Traverses	2	4	3	

Peak & Residual Shear Stress vs Normal Stress



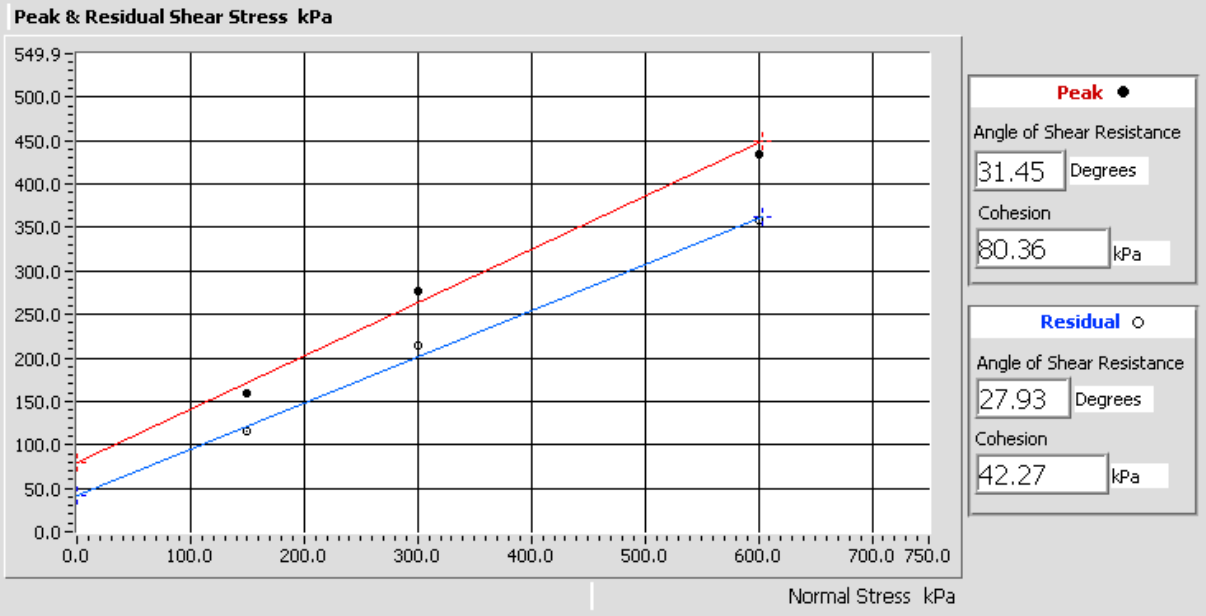
Shear Strength by Direct Shear (Small Shear Box)

GROUND ENGiNEERiNG LTD

Client	Key GeoSolutions Ltd	Lab Ref	PL6829-1-3
Project	ZZ1	Job	L9728
Borehole	Not Given	Sample	ZZ1

Test Summary				
Reference	A	B	C	
Applied Normal Stress	150.0 kPa	300.0 kPa	600.0 kPa	
Peak Strength	159.3 kPa	276.6 kPa	434.4 kPa	
Corresponding Horizontal Displacement	18.666 mm	7.358 mm	19.620 mm	
Residual Shear Stress	114.8 kPa	213.8 kPa	358.9 kPa	
Rate(s) of Shear Displacement	Stage 1: 0.0240mm/min Stage 2: 0.0240mm/min	Stage 1: 0.0360mm/min Stage 2: 0.0360mm/min Stage 3: 0.0360mm/min	Stage 1: 0.0360mm/min Stage 2: 0.0360mm/min Stage 3: 0.0360mm/min	
Final Height	21.85 mm	22.09 mm	20.56 mm	
Cumulative Displacement	20.037 mm	30.625 mm	30.190 mm	
Number of Traverses	2	3	3	

Peak & Residual Shear Stress vs Normal Stress



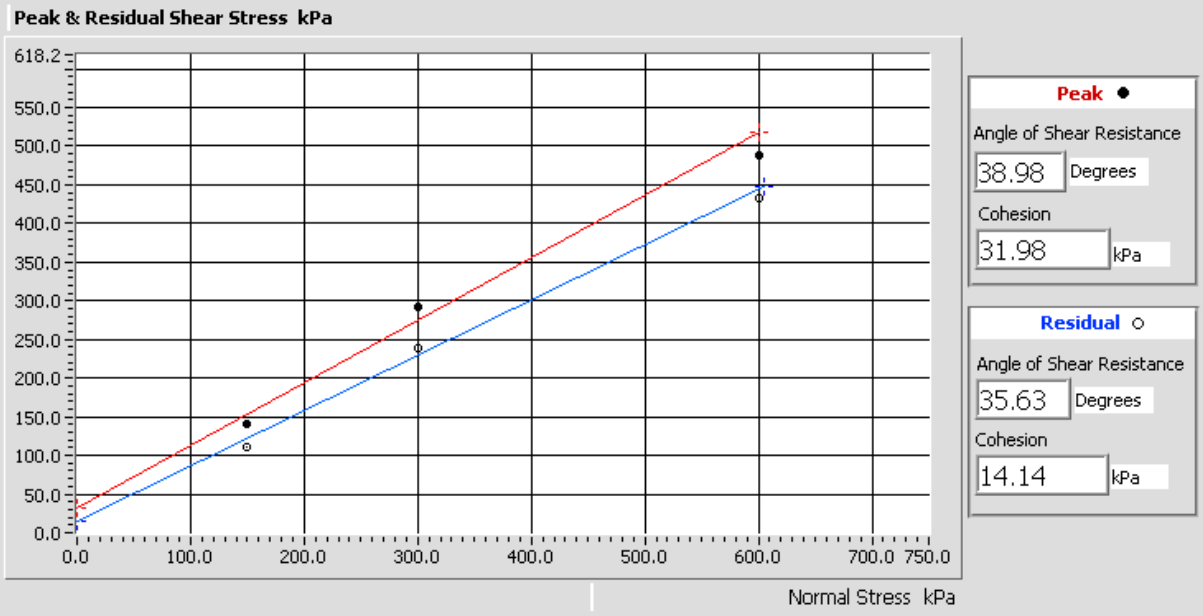
Shear Strength by Direct Shear (Small Shear Box)

GROUND ENGINEERING LTD

Client	Key GeoSolutions Ltd	Lab Ref	PL6829-1-4
Project	ZZ2	Job	L9728
Borehole	Not Given	Sample	ZZ2

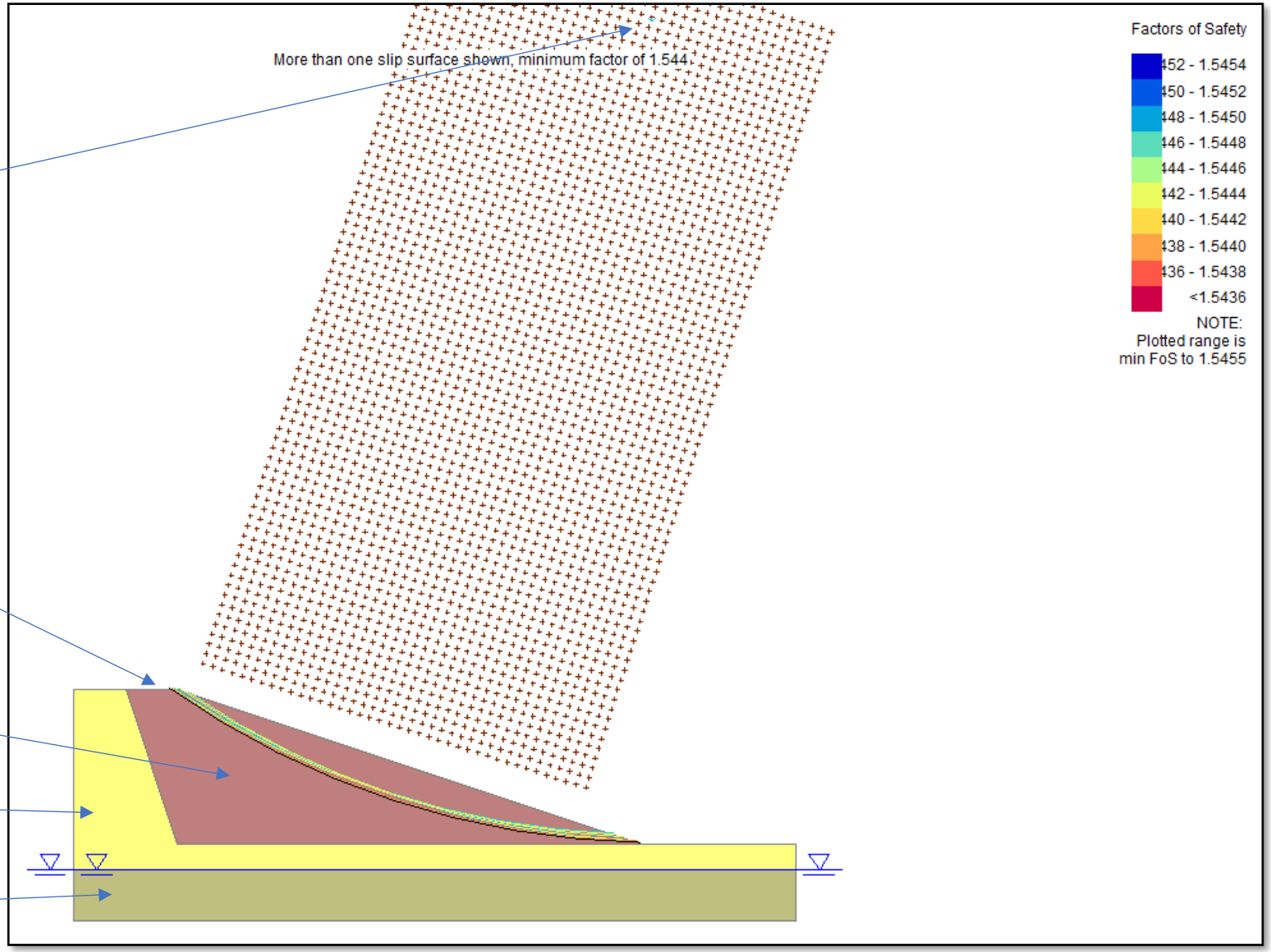
Test Summary				
Reference	A	B	C	
Applied Normal Stress	150.0 kPa	300.0 kPa	600.0 kPa	
Peak Strength	141.1 kPa	291.2 kPa	487.1 kPa	
Corresponding Horizontal Displacement	8.333 mm	9.626 mm	29.826 mm	
Residual Shear Stress	111.5 kPa	238.1 kPa	432.9 kPa	
Rate(s) of Shear Displacement	Stage 1: 0.0360mm/min Stage 2: 0.0360mm/min Stage 3: 0.0360mm/min	Stage 1: 0.0600mm/min Stage 2: 0.0600mm/min Stage 3: 0.0600mm/min Stage 4: 0.0121mm/min	Stage 1: 0.0240mm/min Stage 2: 0.0286mm/min Stage 3: 0.0240mm/min	
Final Height	20.25 mm	18.80 mm	20.43 mm	
Cumulative Displacement	30.171 mm	39.183 mm	29.826 mm	
Number of Traverses	3	4	3	

Peak & Residual Shear Stress vs Normal Stress



Appendix C: Slope Stability Analysis Results

Minimum recorded Fos – **1.544**



Slip circle

Waste Mass

Aller Gravel Fm

Upper Greensand Fm

Slope Stability Assessment model at 1v3h – Restoration profile (permanent and temporary works).

Specification

Slip Type: CIRCULAR
Direction of slip: Downhill
Minimum slip weight [kN/m] :0.00000
Type of analysis: STATIC
Factor of safety on: SHEAR STRENGTH
Minimum number of slices 25
Method: Bishop(Variably inclined interslice forces)
Maximum number of iterations: 300
Reinforcement: NONE

Material Properties

No	Description	Unit Weight		Shear Strength Parameters		
		Above GWL	Below GWL	Condition	Phi or Phi0	c or c0'
		[kN/m3]	[kN/m3]		[°]	[kN/m²]
1	WASTE MASS	20.000	10.000	Drained	28.000	2.0000
2	ALLER GRAVEL	20.000	10.000	Drained	40.000	10.000
3	UPPER GREENSAND	20.000	10.000	Drained	35.000	10.000

Slip Surface Specification

Circle centre specification:
Bottom left of grid: x = 5.00000 m y = 35.00000 m
Inclination of grid: -18.00000 deg
(positive anticlockwise direction about bottom left of grid)
Centres on grid: 40 in x direction at 2.00000m spacing
60 in y direction at 2.00000m spacing
Grid extended to find minimum FoS
Initial radius of circle 1.00000 m
Incremented by 1.00000 m until all possible circles considered

Slope Stability Assessment model at 1v3h – Restoration profile (permanent and temporary works) - tabulated output.

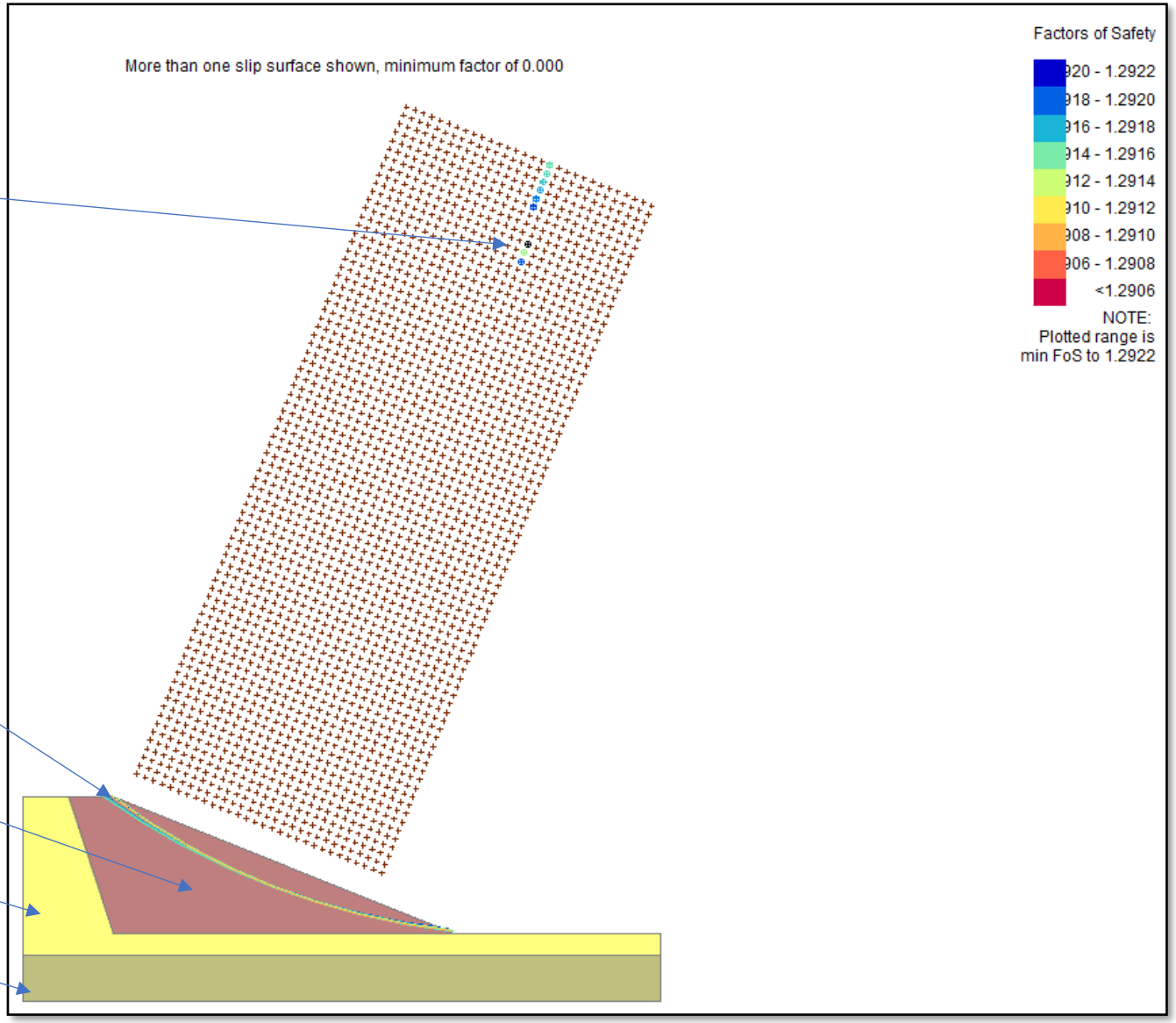
Minimum recorded Fos – **1.292**

Slip circle

Waste Mass

Aller Gravel Fm

Upper Greensand Fm



Slope Stability Assessment model at 1v2.5h – sensitivity analysis to check parameters.

Specification

Slip Type: CIRCULAR
Direction of slip: Downhill
Minimum slip weight [kN/m] :0.00000
Type of analysis: STATIC
Factor of safety on: SHEAR STRENGTH
Minimum number of slices 25
Method: Bishop(Variably inclined interslice forces)
Maximum number of iterations: 300
Reinforcement: NONE

Material Properties

No	Description	Unit Weight		Shear Strength Parameters		
		Above GWL	Below GWL	Condition	Phi or Phi0	c or c0'
		[kN/m3]	[kN/m3]		[°]	[kN/m²]
1	WASTE MASS	20.000	10.000	Drained	28.000	2.0000
2	ALLER GRAVEL	20.000	10.000	Drained	40.000	10.000
3	UPPER GREENSAND	20.000	10.000	Drained	35.000	10.000

Slip Surface Specification

Circle centre specification:
Bottom left of grid: x = 5.00000 m y = 35.00000 m
Inclination of grid: -22.00000 deg
(positive anticlockwise direction about bottom left of grid)
Centres on grid: 30 in x direction at 2.00000m spacing
80 in y direction at 2.00000m spacing
Initial radius of circle 1.00000 m
Incremented by 1.00000 m until all possible circles considered

Slope Stability Assessment model at 1v2.5h – sensitivity analysis to check parameters (tabulated output).