Stability Risk Assessment

Swanworth Quarry

February 2025

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3	27/02/25	O Ellson	L McDermott	A Manns	Updated Figure 2.1 and site location plan

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Contents

1 Introduction

1.1 Background

J Suttle Transport Ltd (Suttles) has commissioned Mott MacDonald to undertake a Stability Risk Assessment (SRA) to support a waste recovery application for the Northern extension of the Swanworth Quarry, located on the Isle of Purbeck, Dorset. This report forms part of supporting information for an Environmental Permit Application for the site.

This report has been completed in conjunction with all relevant documentation, as required by The Environmental Permitting (England and Wales) Regulations 2020. It is not a standalone document and factual data related to the site, its setting, and the receiving environment are located in the Application Documents and referred to in this document. All drawings referred to in this SRA are to be found in the Application Documents.

The SRA has been prepared as a preliminary assessment of stability and geotechnical risks associated with the proposed inert infilling at the site as part of a waste recovery operation.

2 Contact Details and Report Context

Table 2-1 provides the details of the proposed operator and agent who completed the risk assessment:

Table 2-1: Contact details

	Name	Address
Proposed operator	Suttle Stone Quarries	Swanworth Quarry, Worth Matravers, Swanage, Dorset, BH19 3LE
Stability risk assessment completed by	Mott MacDonald	Mott MacDonald House, 8-10 Sydenham Road, Croydon CR0 2EE

2.1 Site Details

The site is located close to the southern coast of the Isle of Purbeck peninsula, Dorset, some 630 metres (m) northwest of Worth Matravers, 1.67 kilometres (km) southwest of Kingston and 3.3 km south of Corfe Castle.

The extension area is located northwest of the current quarry site. The existing quarry is bound by agricultural fields to the east and south, and a Coombe[1] and woodland to the west and north. The current entrance to the quarry is west of an unnamed public road that runs south of the B3069 (West St) and is located at British National Grid Reference 397283E, 078672N.

The red line boundary and surrounding features to the existing quarry and the proposed extension are shown in Drawing 3359-4-4-4LV-0001 S5-P2, which is included in Section 15. An arial photograph showing the red line boundary of the existing quarry and the proposed extension can be found in Figure 2-1.

[1] Short valley or hollow

Figure 2-1: Aerial photograph shows the site's existing permitted boundary and the new proposed permitted boundary for the extension area

Source: David Jarvis Associates (2025)[2]

2.2 Proposed Works

Mineral extraction (Limestone) and restoration within the Proposed Extension will be undertaken in a manner equivalent to that of recent historical workings undertaken at the Site. Three main phases of mineral extraction and progressive restoration are planned which are anticipated to realise 2.4 million tonnes of saleable aggregate over a period of 19 to 20 years. The geology for the area is described in Section 3.2. Processing of blasted Limestone will be undertaken using the existing fixed plant which will remain in its current location.

The planned infill will be placed within the extraction landform, seeking to return ground levels to prevailing (predevelopment) elevations. The infill will be placed concurrent to extraction, over three phases of operation. The overall extraction and restoration program is expected to take around 27 years and will include a total infill placement in the extension of 1,424,049 m^3 of inert material. The infill material will comprise 658,942 m^3 of imports from the main quarry, some 570,667 m^3 of imported inert waste and 194,441 m^3 of on-site derived processed extractive waste. This is in addition to material required to restore the main quarry site. The imported infill material used to facilitate the restoration landform will comprise classified inert wastes from sources similar to the operation currently consented for the existing Site. Upon completion of works, all plant and machinery will be removed and the restoration finalised to create a combination of agriculture and wildlife habitats.

[2] David Jarvis Associates (2025) Swanworth Quarry – Aerial photograph. Drawing number LV-0002. Last reviewed February 2025.

2.3 References

The following references have been utilised in preparation of this report:

1. Environment Agency (2003). Stability of Landfill Lining Systems, Environment Agency R&D Technical Report P1-385 / TR1 and TR2;
2. Environment Agency. Earthworks in landfill engineering LFE4, Design, construction and quality assurance of earthworks in landfill engineering;
3. Waste Recovery Plan, 374179 | 1 | B, Mott MacDonald, 21 December 2017;
4. Hydrogeological Risk Assessment, B/SL/SWTH_HRA/21, BCL, December 2021;
5. Swanworth Quarry Geological Report, 00144-200113/GEW/r0, QuarryDesign, January 2020;
6. Hydrological & Hydrogeological Impact Assessment, BCL, 6th May 2020;
7. British Standard BS EN ISO 14689:2018 Geotechnical investigation and testing – Identification, description and classification of rock; and
8. Geological Society, London, Engineering Geology Special Publications. Volume 21, Chapter 4. Properties of clay materials, soils and mudrocks, Pages 73 – 138.

3 Stability Conceptual Site model

3.1 Historical Information

Information for the ground conditions has been obtained from previous exploratory hole logs (open hole boreholes, some of which with rotary core follow-on: BH2019-1 to 9; and trial pits TP2019-1 to 3) contained within the 'Swanworth Quarry Geological Report' by Quarry Design in January 2020 (Ref 00144-200113/GEW/r0).

3.2 Geology and Ground Conditions

The geology of the district has been characterised by reference to the following:

- BGS maps, publications and borehole logs; and
- geological logs of mineral evaluation boreholes drilled at the Site.

The site investigation proved a thickness of Portland Stone Formation of between 18 m and 28 m and an 'overburden' material of thickness 0.3 m to 16.1 m (average ~3 m), described as 'Boulders and Clay'. This material may be Limestone with extremely closed spaced joints infilled with clay, noting that the geological map of the area does not indicate any significant superficial geology at the site.

The overburden material thickness is greater in the Northwest around BH2019-01. This could be a zone with deeper weathered Portland Stone with extremely closely spaced joints or it could be correlated with the Purbeck Group as the boundary has been mapped nearby. However, the Purbeck Group has not been observed in BH2019-02.

The Portland Stone within the boreholes has generally been described as 'medium strong, light grey, fine grained Limestone with occasional nodular and banded chert'. Borehole drilling recovery was described as generally good. Both Portland Freestone and Portland Chert are members of the Portland Stone Formation. Siltstones and Sandstones were encountered at depth, correlating with the Portland Sand Formation. The level of chert bands within the boreholes was generally irregular, making the mapping of these marker horizons inconclusive.

The exploratory holes show the base of the Portland Stone Formation to be between 92 mAOD and 102 mAOD. Considering the spatial variation, this would appear to indicate that the base dips ~2° towards the southwest.

The quarry excavation depth has been planned to retain 2 m to 4 m of Portland Chert immediately overlying the Portland Sand. The Portland Sand will remain unquarried.

3.3 Groundwater

The floor of the existing quarry and planned floor of the Proposed Extension (which will remain 2 m to 4 m above the base of the Portland Chert Member) both reside above the local level of groundwater.

The groundwater level data collected from five piezometers, which includes 4-hourly logged data collected over the course of over 12 months, shows that a minimum of circa 13 m will be maintained between the base of planned extraction within the Proposed Extension and the level of groundwater contained within underlying strata.

The data also shows that the spatial average standoff (i.e. distance between base of quarry and the underlying groundwater table) from the floor of proposed extraction to the maximum recorded level of groundwater will be approximately 16 m.

3.4 Basal Sub-Grade Model

The proposed quarry will extract Portland Stone to a level of approximately 99 mAOD at the deepest excavation point. The base is virtually flat with a slope gradient less than 1:15 (vertical:horizontal).

The basal sub-grade comprises Portland Stone Formation which has generally been described as 'medium strong, light grey, fine grained Limestone with occasional nodular and banded chert'. The basal subgrade is considered to be relatively non-compressible.

The proposed extension will be maintained above groundwater table and therefore groundwater inflows will not occur. Pore fluid pressure expected at the base is equal to zero.

3.5 Side Slopes Sub-Grade Model

The walls to the proposed quarry comprise Portland Stone. It is proposed to fill against the quarry faces which are to be excavated at an angle between 75° and 80° as determined by the Operator. Face heights will be between 10 m and 12 m, with intermediate benches. The bench width shall be governed by the minimum rock trap requirement. In the overburden materials, slopes are designed with a gradient of 1v:2h (26°) to ensure long-term stability as determined by the Operator. If required to maintain side slope stability, shallower slopes shall be formed.

The side slopes of the planned infill are considered to be stable since the infill will be placed within the extraction landform, seeking to return ground levels to prevailing (predevelopment) elevations.

The proposed extension will be maintained above the groundwater table and therefore groundwater inflows will not occur (noting perched groundwater may be encountered). Hence pore fluid pressures and long terms perched groundwater seepage through the side slopes of the quarry excavation are expected to be negligible.

3.6 Basal and Side Engineered System

A "Hydrogeological Risk Assessment" was developed by BCL Consultant Hydrologists Limited in December 2021. This identified that a clay liner would be installed with an attenuating effect equivalent to a barrier of permeability 1×10^{-7} metres per second [m/s] at 1 m thickness and placed with a minimum shear strength of 50 kPa.

It is anticipated that the source for this material will be quarried on site. This material is understood to have a clay content and is expected to achieve a compacted permeability and shear strength of an engineered clay layer, as defined in the "Earthworks in landfill engineering (LFE4)", Environment Agency[3]. In the event that there is insufficient material of suitable quality to form this layer on site, an alternative source that meets the required specification will be found.

[3] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/321501/LFE4_earthworks_on_landfill_sites.pdf

3.7 Waste Mass Model

As described in Section 2.2, the total infill will comprise 1,424,049 m^3 of inert material, including 658,942 m^3 of imports from the main quarry, some 570,667 m^3 of imported inert waste and 194,441 m^3 of on-site derived processed extractive waste. The imported infill material will likely be variable, but is expected to comprise classified inert wastes from sources similar to the operation currently consented for the existing Site.

3.8 Pore Fluid Pressures

As per Section 3.3, the groundwater table is anticipated to be no closer than 13 m to the base of the excavation for the Proposed Extension. Therefore, groundwater pressures acting at the excavation base and outside the side slopes are expected to be negligible.

There is no evidence of perched leachate adjacent to the Proposed Extension. Therefore, leachate pressures acting behind the side slopes are also foreseen to be negligible.

In consideration of the ground conditions: i) the excavation of the Proposed Extension is not anticipated to generate negative groundwater pressures; and ii) likewise, the backfilling process is not anticipated to generate excess groundwater water pressures. On the basis of the foregoing, groundwater conditions are not considered to adversely influence or govern the temporary stability of the Proposed Extension.

4 Stability Risk Assessment

Issues relating to stability and integrity of each component are considered by means of preliminary screening review to determine whether further geotechnical stability analysis may be required. The preliminary screening review is presented in the following sub-sections.

4.1 Basal Sub-Grade Screening

The basal sub-grade shall be formed within the Portland Stone Formation, typically described as 'medium strong, light grey, fine grained Limestone'. Site settlement as a result of compressibility and loading of the basal subgrade from the infill is considered negligible with no detrimental impact upon the proposed development. The unit weight of the infill material is not foreseen to exceed the unit weight of the material removed and hence, there would be no net increase in load on the ground, relative to the existing pre-quarry excavation conditions. Further assessment of this component is not required.

4.2 Side Slopes Sub-Grade Screening

The side slope subgrade is formed of Portland Stone Formation. The subgrade side slopes are steep, but the planned infill will be placed within the extraction landform, seeking to return ground levels to prevailing (predevelopment) elevations.

Hence the resultant geometry of infilled site is considered to be stable, as also evidenced from the existing quarry. As such, this component is not considered to require further assessment.

4.3 Basal Engineered System Screening

The one metre thick engineered clay layer with target permeability of 1 x 10^{-7}m/s and a minimum shear strength of 50 kPa will be formed from material excavated and stockpiled on site. The stockpile will comprise a mix of rejected stone, which is mixed with the surface geology materials (overburden) that will have clay content sufficient to provide the required permeability and undrained shear strength. The engineered layer will be subject to a Construction Quality Assurance system to demonstrate that both the source and the placed material meet the overall target permeability specification stated above and meet the general requirements for material specification taking account of, "Earthworks in landfill engineering (LFE4)", Environment Agency[3]. As identified in Section 3.6, in the event that there is insufficient material of suitable quality to form this layer on site, an alternative source that meets the required specification will be found.

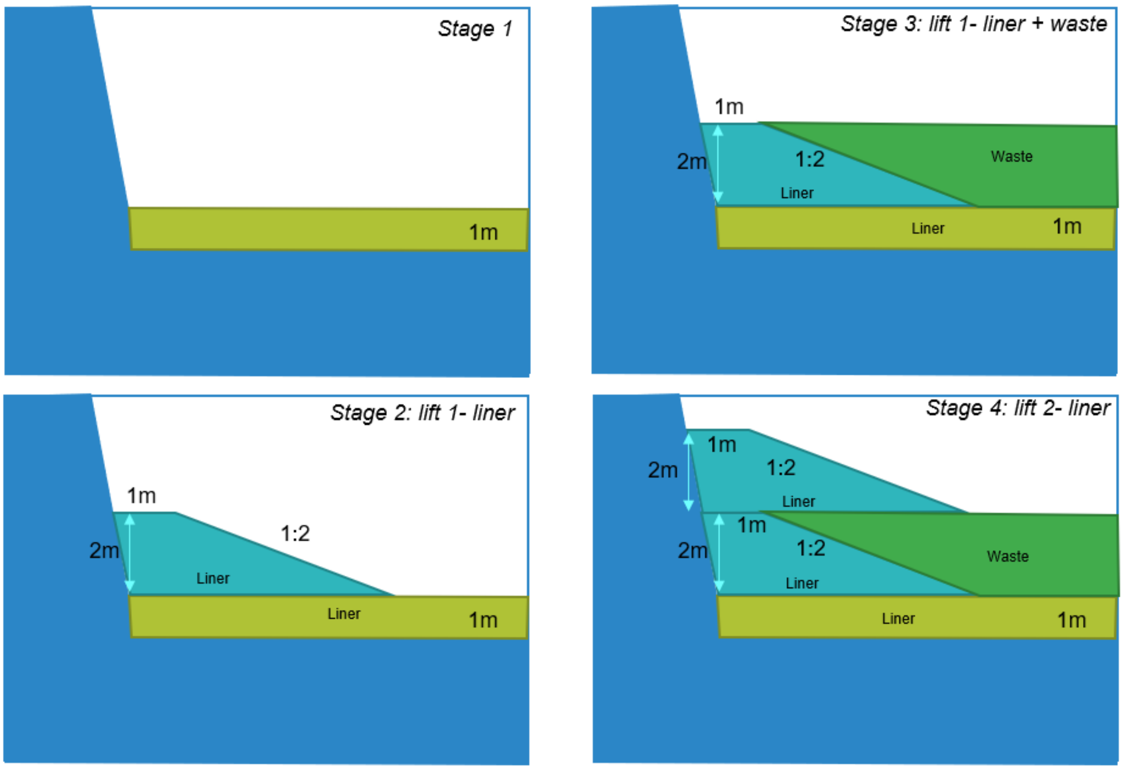
The data also show that the spatial average standoff from the floor of proposed extraction to the maximum recorded level of groundwater will be approximately 16 m. Hence the base will not be subjected to basal heave resulting from groundwater pressures. The basal slope gradient is less than 1:15, therefore considered stable.

4.4 Side Slope Engineered System Screening

The one metre thick engineered clay layer with a compacted target permeability of 1 x 10^{-7} m/s and a minimum undrained shear strength of 50 kPa will be taken from material excavated and stockpiled on site. The stockpile will comprise a mix of a rejected stone, which is mixed with the surface geology materials, which have a high clay content. The engineered layer will be subject to a Construction Quality Assurance system to demonstrate that both the source and the placed material meet the above requirements.

Side slope lining system will be constructed using a current design procedure followed in the UK referred to as the “Christmas Tree” system (reference 1, section 2.3) and as shown in Figure 4-1. The side slope lining will be built up in 2 metre lifts and 1(V):2(H) slope where inert waste will be placed against it. Any temporary slope during construction should not exceed 1(V):2(H). The proposed slope will ensure a FOS of 1.6 as required for the long-term stability (see Appendix A for the analysis output for this scenario.

Figure 4-1: Envisaged construction sequence



4.5 Waste Mass Screening

The inert waste will be laid in horizontal layers no greater than 2 m in thickness and compacted which is considered to be stable. No further assessment is required for this component.

5 Lifecycle Phases

The worst-case scenario during the process of infilling the excavation is when the side slope lining is required to stand for limited periods following initial profiling.

It is, however, considered that the nature of the materials at the base and in the side slopes and the material to be used as the side slope lining will allow for stable temporary slopes to be achieved as long as slope angles defined in the preceding sections of this report are maintained.

• Phasing of Subgrade Slopes.	• Not required
• Phasing of engineered fill and waste placement (rate of construction).	• Not required
• Waste mass geometry (height/outer slope inclination/crest width) vs. time.	• Not applicable
• Leachate management.	• Not applicable
• Landfill gas management.	• Not applicable
• Daily cover characteristics.	• Not applicable
• Temporary capping characteristics.	• Not applicable

6 Data Summary

The anticipated geotechnical properties for the materials at the site have been determined and used in the appraisal of the stability of the planned infill. Due to the absence of site-specific testing data, these are based on published information and engineering judgement from experience with similar materials. The properties of the sub grade material along the side slopes and base are presented below:

Table 6-1: Geotechnical properties of the materials used in the assessment

Material	Fractured Portland Stone	Portland Stone	Clay Liner
Description	Weathered limestone and clay bands	Medium strong, light grey, fine grained Limestone with occasional nodular and banded chert.	Rejected stone mixed with the surface geology materials such as Kimmeridge Clay
Material unit weight	22 kN/m^3	24 kN/m^3	18 kN/m^3
Drained shear strength of soils and rocks	12.5-25 MPa *(BS EN ISO 14689−1:2003)*	UCS=25-50 MPa *(BS EN ISO 14689−1:2003)*	$\Phi'_{cv=}$ 28^o c' = 1 kPa
Undrained shear strength of cohesive soils	Not applicable	Not applicable	s_u = 50 kPa (minimum requirement)
Groundwater pressures	0	0	0
Excess pore water pressure dissipation characteristics of cohesive soils	0	0	0
Consolidation characteristics of soils and waste	Not required	Not required	Not required
Permeability characteristics of soils and waste	Not required	Not required	1 x 10^{-7} m/s
Discontinuity characteristics of rock masses	Very fractured with clay infill	Clay infill is present in places. No persistence data available.	Not applicable
Geotechnical parameters for any ground improvement methods you adopted, for example soil reinforcement	Not required	Not required	Percentage fines < 63 μm: ⩾ 20 % but with a minimum clay content (particles < 2 μm) of 8 %.
Stiffness characteristics of soil and waste	Not required	Not required	Not required
In situ horizontal stresses in the waste	Not required	Not required	Not required

7 Justification for Modelling Approach and Software

7.1 Basal Sub-Grade

Not required. The modelling approach is classified as 'simple' (in the context of the Environment Agency Landfill operators: environmental permits Landfill operators: environmental permits - Plan the environmental setting of your site - Guidance - GOV.UK (www.gov.uk)) as the base is considered stable.

7.2 Side Slopes Sub-Grade

Not required. The modelling approach is classified as 'simple' (in the context of the Environment Agency Landfill operators: environmental permits Landfill operators: environmental permits - Plan the environmental setting of your site - Guidance - GOV.UK (www.gov.uk)) as the side slopes are considered stable.

7.3 Basal Engineered System

Not required. The modelling approach is classified as 'simple' (in the context of the Environment Agency Landfill operators: environmental permits Landfill operators: environmental permits - Plan the environmental setting of your site - Guidance - GOV.UK (www.gov.uk)) as the basal lining system is considered stable.

7.4 Side Slope Engineered System

The method of analysis was based on limit equilibrium principles and included checks on global slope stability, predominantly passing through the toe and shallow circular failures affecting only the surface.

For analysis, the programme SLOPE/W (GeoStudio 2021.3, Version 11.2.0) was used which incorporates a search routine for identifying the critical surface with the lowest factors of safety against instability. For this stability review it was considered that GLE/Morgenstern and Price method was appropriate for analysis.

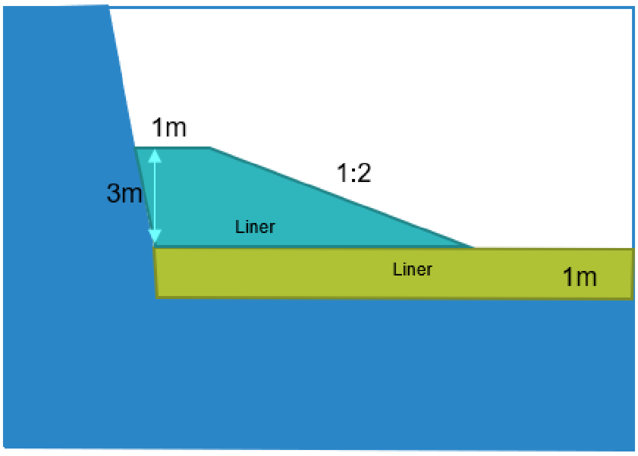
7.5 Waste Mass

Not required. The modelling approach is classified as 'simple' (in the context of the Environment Agency Landfill operators: environmental permits Landfill operators: environmental permits - Plan the environmental setting of your site - Guidance - GOV.UK (www.gov.uk)) as the waste mass is considered stable.

8 Justification of geotechnical parameters selected for analyses

For the analysis of the side slope engineered system, the stage at which a layer of clay lining is constructed and prior to placing the inert waste is considered as worst case.

Figure 8-1: Worst case analysed: long term- liner slope



The slope has been analysed with drained shear strength parameters to ensure it can remain stable for limited periods following initial profiling.

The undrained shear strength indicated in Table 6-1 for the clay lining is based on the minimum required in the Environmental Agency Specification[3] and based on typical values estimated for the contents expected in the liner. The lining will comprise a mix of a rejected stone, which is mixed with the surface geology materials such as Kimmeridge Clay, which has high clay content. Characteristic parameters used in the analysis are summarised in Table 6-1.

Pragmatic material properties are assumed for the analysis of the side slope engineered system.

9 Selection of appropriate factors of safety

Global factors of safety (FOS) for long term stability of excavated slopes of between 1.3 and 1.5 are proposed (reference 1). All analyses are undertaken using effective stress parameters to model slopes that may be required to stand for limited periods following initial profiling.

10 Sensitivity Analysis

Sensitivity analyses are not considered required for any of the primary components since the modelling approach is classified as 'simple' (in the context of the Environment Agency Landfill operators: environmental permits Landfill operators: environmental permits - Plan the environmental setting of your site - Guidance - GOV.UK (www.gov.uk)) for basal subgrade, side slope subgrade, basal engineered system and waste mass components. Furthermore, the side slope engineered system has been analysed using a simple slope stability model.

11 Assessment

The results of the clay liner stability analysis are presented within Appendix A and summarised in Table 11-1.

Table 11-1: Summary of Stability Analysis for Clay Liner: Drained Analysis

Method	Slope Gradient	Stratum	Factor of Safety
Effective Stress: Circular failure surface	1:2	Clay Liner	1.6

12 Monitoring

The Stability Risk Assessment has developed risk-based monitoring objectives and schedules. This section provides the technical rationalisation for the design of a monitoring programme to focus monitoring effort on actual risks.

12.1 Basal Sub-Grade Monitoring

Monitoring scheme. Visual inspection.

12.2 Side Slopes Sub-Grade Monitoring

Monitoring scheme. Visual inspection.

12.3 Basal and Side Slope Lining System Monitoring

Monitoring scheme. Visual inspection. Construction Quality Assurance Plan for lining construction.

12.4 Waste Mass Monitoring

Monitoring scheme. Visual inspection.

13 Conclusion

This SRA has provided a preliminary assessment of the six principal components of the stability Site conceptual model (Section 2) in accordance with the Environment Agency (2020).

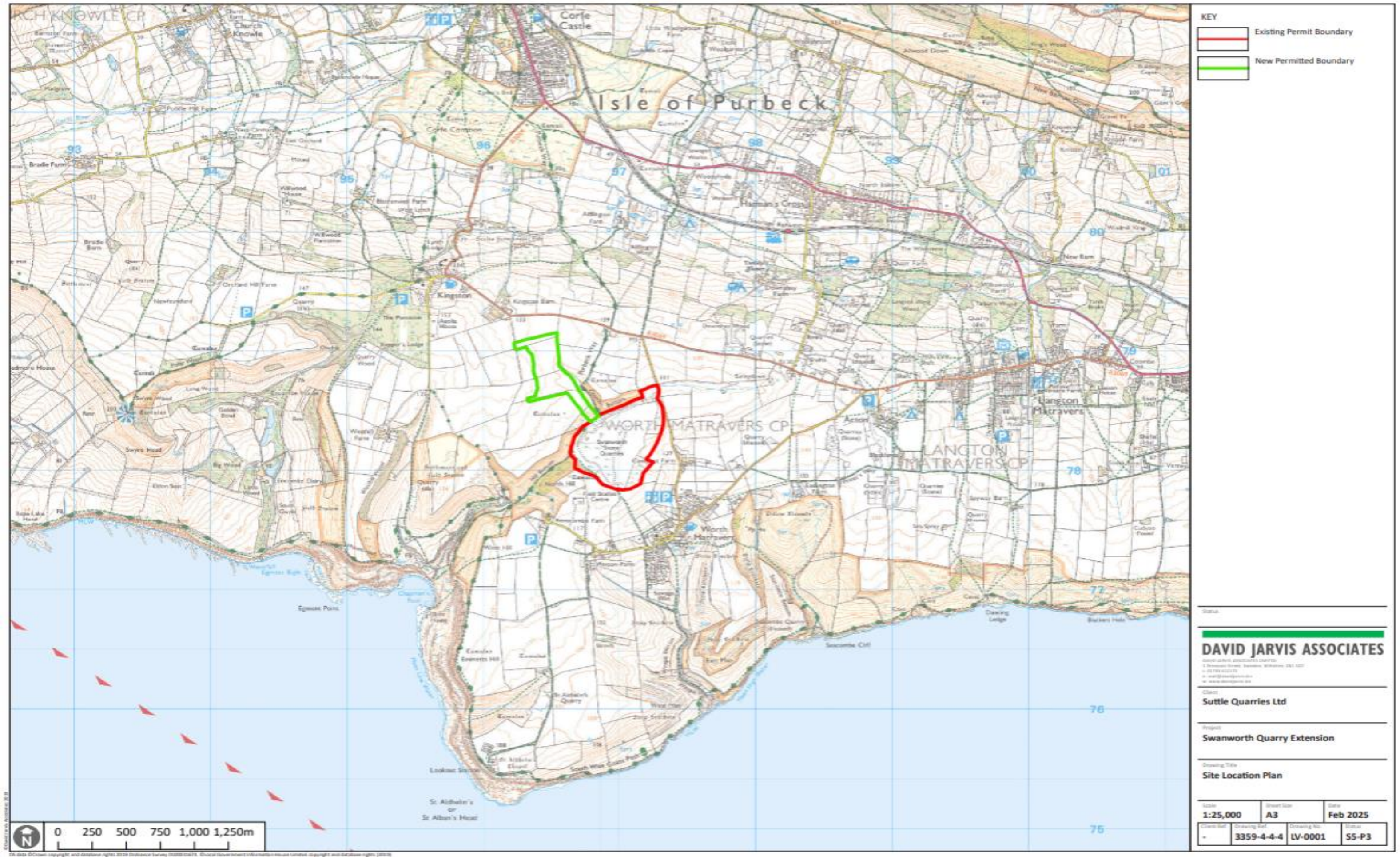
The stability assessments indicate that the subgrade, engineered fill, Engineered Clay Liner and waste mass should remain stable during the process of reinstating the ground level to prevailing (predevelopment) elevations. Likewise, groundwater is not considered to adversely impact on either the construction or performance of the Proposed Extension.

14 Tables

Tables

15 Site Location Plan 3359-4-4-4 LV-0001 S5-P2

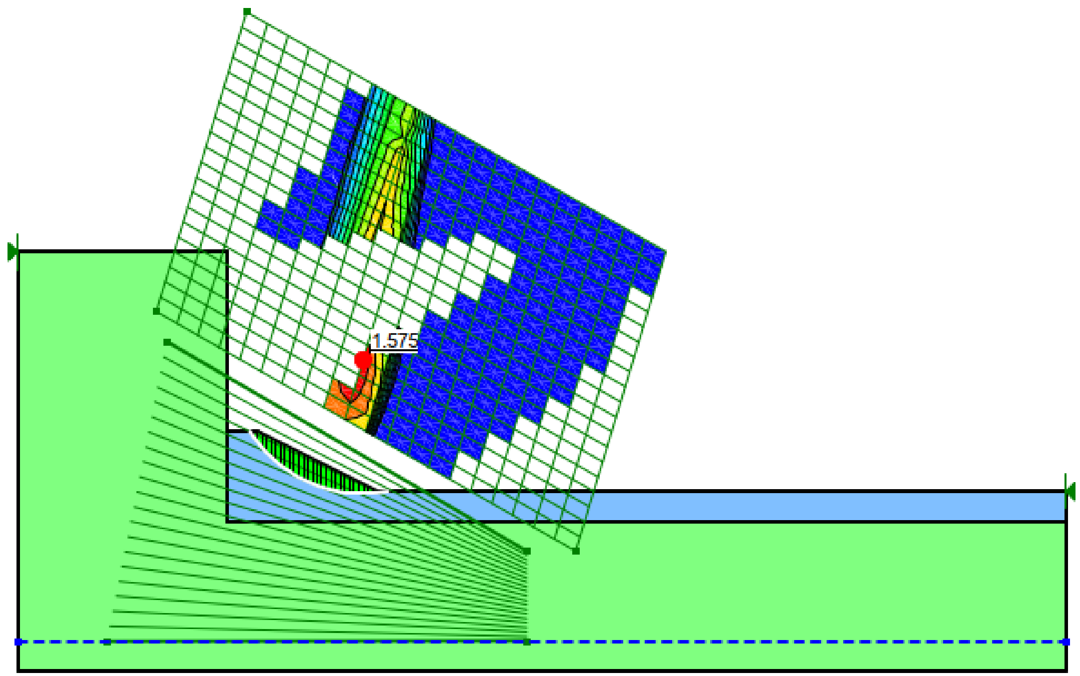
The following drawing was included as part of the Environmental Impact Assessment and Planning Application seeking approval for a Lateral Extension to Swanworth Quarry and to Extend the End Date. Planning reference 6/2020/0321 July 2022. This drawing was updated in February 2025 to show the boundary of the currents site’s permitted boundary and the new proposed permitted boundary for the extension area in different colours.



Source: David Jarvis Associates (2025)[4]

[4] David Jarvis Associates (2025) Site location plan. Drawing number LV-0001. Last reviewed February 2025.

A. Results of the Clay Liner Slope Stability Analyses



Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)
	Bedrock	Bedrock (Impenetrable)				
	Clay Liner Drained CHAR	Mohr-Coulomb	18	1	28	0

GeoStudio	Swanworth Quarry Stability Risk Assessment.gsz	
	Clay liner- Long term analysis	NM
	14/06/2023	Drained Characteristic