# ENVIRONMENTAL PERMIT VARIATION APPLICATION
# STABILITY RISK ASSESSMENT

## CROSS LEYS QUARRY
## LEICESTER ROAD
## THORNHAUGH
## PETERBOROUGH
## PE8 6NH

**Document Reference: MG1002/10.R0**
**November 2024**

**Project Quality Assurance**
**Information Sheet**

***ENVIRONMENTAL PERMIT VARIATION APPLICATION***
***STABILITY RISK ASSESSMENT***
***CROSS LEYS QUARRY, LEICESTER ROAD, THORNHAUGH, PETERBOROUGH, PE8 6NH***

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# CROSS LEYS QUARRY,
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# PETERBOROUGH,
# PE8 6NH

## ENVIRONMENTAL PERMIT VARIATION APPLICATION

## STABILITY RISK ASSESSMENT

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## 1.0 INTRODUCTION

1.1.1 Sirius Environmental Limited (Sirius) were commissioned by Mick George Limited to prepare a Stability Risk Assessment (SRA) to support an Environmental Permit Variation Application (EPVA) to facilitate the restoration of Cross Leys Quarry via the import and permanent deposit of suitable non-degradable wastes. This SRA considers potential stability and integrity issues that could arise with the placement of the Artificially Established Geological Barrier (AEGB) and imported restoration materials as part of the approved scheme of restoration for Cross Leys Quarry.

1.1.2 The layout of the restoration scheme along with cross-sections through the restoration scheme are shown on **Drawing No. MG1000/12/10**.

1.1.3 The proposed generalised phasing of the restoration scheme is shown in the Drawing No. Series **CL 5/1 to CL5/5** included within the main application submission.

1.1.4 Cross Leys Quarry is located off the A47 in Thornhaugh, Peterborough, with the site entrance at National Grid Reference TF 062 999.

Mick George Limited,
Leicester Road,
Thornhaugh,
Peterborough,
PE8 6NH.

## 2.0 STABILITY ASSESSMENT MODEL

2.1.1 For this Stability Assessment (SA), the stability and integrity issues below are required to be assessed:-

- The stability of the Artificially Established Geological barrier (AEGB) and the imported restoration soils, during the construction of the AEGB and the placement of the imported restoration soils; and
- The integrity of the Artificially Established Geological barrier (AEGB) for the restoration scheme, during its construction and following the subsequent placement of the imported restoration soils.

2.1.2 The stability of the imported restoration soils and the integrity of the AEGB were assessed using the finite element analysis software PLAXIS 2D, which is widely used for the analysis of deformation, stability and integrity in geotechnical engineering.

2.1.3 The section used within the PLAXIS model comprises one section, **Section A-A**, which runs from south-west to north-east through the quarry and associated restoration scheme. The section position is shown on **Drawing MG1002/SRA/01** and presented in Appendix SA2. The analysis results for **Section A-A** are presented in this report, with the analysis printouts contained within the relevant appendices.

2.1.4 It has been assumed that the restoration material in each phase of filling will be placed over a period of several months. The maximum rates at which the soils are placed will be determined in this stability analyses to ensure that the stability of the restoration profile is maintained.

2.1.5 The restoration proposals include for the construction of a 500mm thick AEGB across basal areas of the disused quarry where this is comprising exposed limestone bedrock. Area of the site which have already been partially backfill will not require the construction of an AEGB. The principal purpose of the AEGB is to provide attenuation to any potential leachate pollutants due to the limited natural attenuation offered by the fracture limestone bedrock aquifer.

2.1.6 The restoration scheme is to be progressed in several generic phases, with temporary soils flanks being constructed on the edge of each phase while to next phase of AEGB is being constructed. Two restoration soils phases have been modelled across **Section A-A**, with the soils flanks constructed at gradients of 1 in 3, to determine the rate at which the soils may be placed to ensure the stability is maintained.

2.1.7 The proposed restoration scheme includes Phase 1, Phase 2a, Phase 2b and Phase 3, as shown in the SLR **Drawing No. Series CL5/1 to 5/5**. Along **Section A-A**, the 1$^{st}$ phase of restoration within the model corresponds with Phase 1 of the restoration soils scheme, and the 2$^{nd}$ phase of the restoration within the model corresponds with Phase 3 of the restoration soils scheme.

## 3.0 MODEL PARAMETERS

3.1.1 The soil and rock elements used in the modelling have been selected based upon information from the Environmental Setting & Site Design (ESSD) Report *(Doc. Ref.: MG1002/06)* and Sirius' design experience with similar fill and lining materials.

3.1.2 The existing aggregate and crushed concrete from the onsite stockpiles is to be utilised as engineered fill alongside site-won soils, to support the restoration scheme.

3.1.3 The permeability of the AEGB was set at a value of $1x10^{-8}$m/s. Whilst the target permeability requirement for this material will be a minimum of $1x10^{-7}$m/s, in reality the AEGB will be compacted to a lower permeability hence the use of $1x10^{-8}$m/s in the modelling to ensure this is representative of site conditions.

3.1.4 The key parameters used in the PLAXIS model for the soil and rock elements are presented in **Table 1**. The full set of model parameters used in the PLAXIS modelling are presented within **Appendix SRA1.**

**Table 1: Effective Stress Material Parameters**

| Material | Unit Weight | Effective Cohesion | Effective Angle of Friction | Permeability | $E_{50}$ | $E_{oed}$ | $E_{ur}$ | power |
|---|---|---|---|---|---|---|---|---|
| | kN/m² | kN/m² | ° | m/s | kN/m² | kN/m² | kN/m² | (m) |
| Limestone | 20.0 - 21.0 | 5 | 35 | $1x10^{-5}$ | 30,000 | 30,000 | 90,000 | 0.75 |
| Engineered Site-Won Fill | 18.0 – 18.0 | 5 | 25 | $1x10^{-8}$ | 5,000 | 5,000 | 10,000 | 1.0 |
| AEGB | 19.0 – 20.0 | 5 | 25 | $1x10^{-8}$ | 8,000 | 8,000 | 24,000 | 1.0 |
| Restoration Soil | 18.0 – 19.0 | 5 | 25 | $1x10^{-8}$ | 4,000 | 4,000 | 12,000 | 0.9 |

# 4.0 ANALYSIS

## 4.1 Finite Element Model Analysis – Stability

4.1.1 Phi C reduction runs (safety analyses) were run to assess the stability of the AEGB and the restoration infill materials during each stage of the development at Cross Leys Quarry. These analyses utilise the 'Phi-C reduction' technique, meaning that the strength parameters of the soils are reduced until failure. This allows for the calculation of a Factor of Safety (FOS) for each of the phases in the model.

4.1.2 The Factors of Safety obtained from the safety analyses, for the relevant phases in the modelling along with the failure modes, are shown in **Table 2** below. Graphical printouts showing the failure mechanisms, along with PLAXIS calculations sheets, are presented in **Appendix SRA2.**

**Table 2: Summary of Effective Stress Phi C Stability Analyses**

| Phase Description | Critical Failure Mode Identified during Analysis | Factor of Safety |
|---|---|---|
| Excavate | Circular Failure through Existing Site-Won Fill in South-West of Site | 1.845 |
| Engineered Fill | Circular Failure through Existing Site-Won Fill in South-West of Site | 5.122 |
| AEGB for Phase 1 | Circular Failure through Existing Site-Won Fill in South-West of Site | 5.072 |
| Imported Restoration Fill – Phase 1 (temporary soils flank) | Circular Failure through Temporary Soils Flank in South-West of Site | 1.561 |
| AEGB for Phase 3 | Circular Failure through Temporary Soils Flank in South-West of Site | 1.681 |
| Imported Restoration Fill – Phase 3 (temporary soils flank) | Circular Failure through Temporary Soils Flank in North-East of Site | 1.380 |
| Imported Restoration Soils – Phase 3 Complete | Circular Failure through Completed Soils Flank in North-East of Site | 2.124 |
| Wait 2 years | Circular Failure through Completed Soils Flank in North-East of Site | 3.075 |

## 4.2 Finite Element Model Analysis – Integrity

4.2.1 Integrity analyses were run to assess the integrity of the AEGB during the construction works and the placement of the imported restoration soils. The integrity of the AEGB relates to shear strains that develop in the material. Strains within the AEGB can be directly analysed within the finite element model.

4.2.2 A summary of the maximum shear strains in the AEGB are presented in **Table 3** below.

**Table 3: Summary of Maximum Shear Strains for AEGB**

| Construction / Infilling Activity | Maximum Shear Strain (%) |
|---|---|
| AEGB for Phase 1 | 0.396 |
| Imported Restoration Fill – Phase 1 (temporary soils flank) | 7.522 |
| AEGB for Phase 3 | 7.484 |
| Imported Restoration Fill – Phase 3 (temporary soils flank) | 7.043 |
| Wait 2 Years | 7.055 |
| Shear Strain Guidance Limit (Arch et al, 1996) | 10% |
| Lowest Factor of Safety | 1.33 |

## 5.0 ASSESSMENT OF RESULTS

5.1.1 The timings for the placement of the imported restoration soils which were utilised in this stability and integrity analyses were adjusted in order to achieve satisfactory factors of safety for the AEGB and imported restoration soils. For stability, the minimum required factor of safety is FOS = 1.3, which is industry standard factor of safety for slope stability. For integrity, the recommended maximum shear strain in the AEGB is 10% (based on the work of Arch et al, 1996). Sirius also adopt a minimum factor of safety for strain of FOS = 1.3 in relation to the 10% limit.

5.1.2 For the purposes of this SRA, it has been assumed that all the phases (Phase 1, Phase 2a, Phase 2b and Phase 3) will be completed over similar durations of time. The infilling phase timings required to satisfy the stability and integrity requirements above (as implement in the stability integrity analyses presented in Section 4.1 and Section 4.2) are presented in **Table 4** below.

**Table 4: Phase Timings Determined from Stability and Integrity Analyses**

| Restoration Soil Placement Phase | Phase Times (in months) for Restoration Soils Scheme at Temporary Soils Slope Gradients |
|---|---|
| Phase 1 | 8 months |
| Phase 2a and 2b | 8 months |
| Phase 3 | 8 months |

5.1.3 The results of the PLAXIS stability analyses for the AEGB and imported restoration soils **(Table 2)** reported a lowest Factors of Safety of FOS=1.380. This factor of safety is reported when the temporary soils flanks is constructed within Phase 3 of the restoration scheme, when the temporary flank has a gradient of 1 in 3. The failure of this phase is through the temporary soils flank as to be expected. Therefore, all the Factors of Safety reported for this stability assessment are found to be above the minimum required FOS=1.3. Consequently, the stability results for the proposed restoration scheme are deemed to be acceptable, provided that the recommended slope gradients and infilling/construction timings, as presented in this stability assessment, are not exceeded.

5.1.4 The potential instability of the temporary soils flanks is largely due to the build-up of excess positive pore water pressures due to the restoration material likely to principally consist of cohesive (low permeability) material. The loading within the soils caused by the placement of the material leads to the development of excess positive pore water pressures, without an immediate increase in effective stress (and thus strength) in the soil. This leads to the potential instability of the temporary soil flanks in the short-term due to no increase in the effective shear strength of the material. As the excess pore water pressure start to dissipate following placement of the soils, the effective stress in the soil increases and the slopes become more stable. Placement of the low permeability cohesive soils faster than the phase timings recommended in this stability assessment would lead to increased excess pore water pressures (and lower effective stresses), leading to less stable slopes; it is recommended that the soils are not placed faster than the recommended timings in Table 4 above.

5.1.5 The maximum shear strains recorded from the analysis of the AEGB are shown in Table 3. The maximum shear strain anticipated in the AEGB is 7.522%. This occurs during the infilling of Phase 1 to achieve the approved restoration profile. Comparing the worst-case shear strain of 7.522% against the recommended 10% limit provides a factor of safety of FOS=1.33. This is greater than the minimum required FOS=1.3, which shows the integrity of the AEGB shall be maintained and the permeability of the AEGB shall continue to be in accordance with the requirements stated in the HRA for the site.

5.1.6 The maximum shear strain occurs in the AEGB directly below the temporary soils flank of Phase 1. The assessment of the shear strains show that the construction and infilling proposals at the site do not diminish the permeability of the liner and therefore can commence without effecting the integrity of the AEGB.

5.1.7 Graphical presentation of the shear strains are presented in Appendix SA3.

## 6.0 CONCLUSION

6.1.1 This stability assessment has considered the potential stability and integrity issues associated with the scheme of restoration for Cross Leys Quarry. The assessments have focused on the stability of temporary waste slopes and the stability and integrity of the AEGB. All the factors of safety found from the assessments for stability and integrity are deemed to be acceptable.

6.1.2 This stability assessment has found that the temporary soil flanks shall not be constructed at gradients steeper than 1:3 and they must constructed not quicker than 8 months.

6.1.3 Should the parameters of the soils and bedrock be found to be significantly different from those presented in this report, or the proposed slope gradients and phase timings utilised significantly deviate from those presented in this report, then further stability assessment work will be required.

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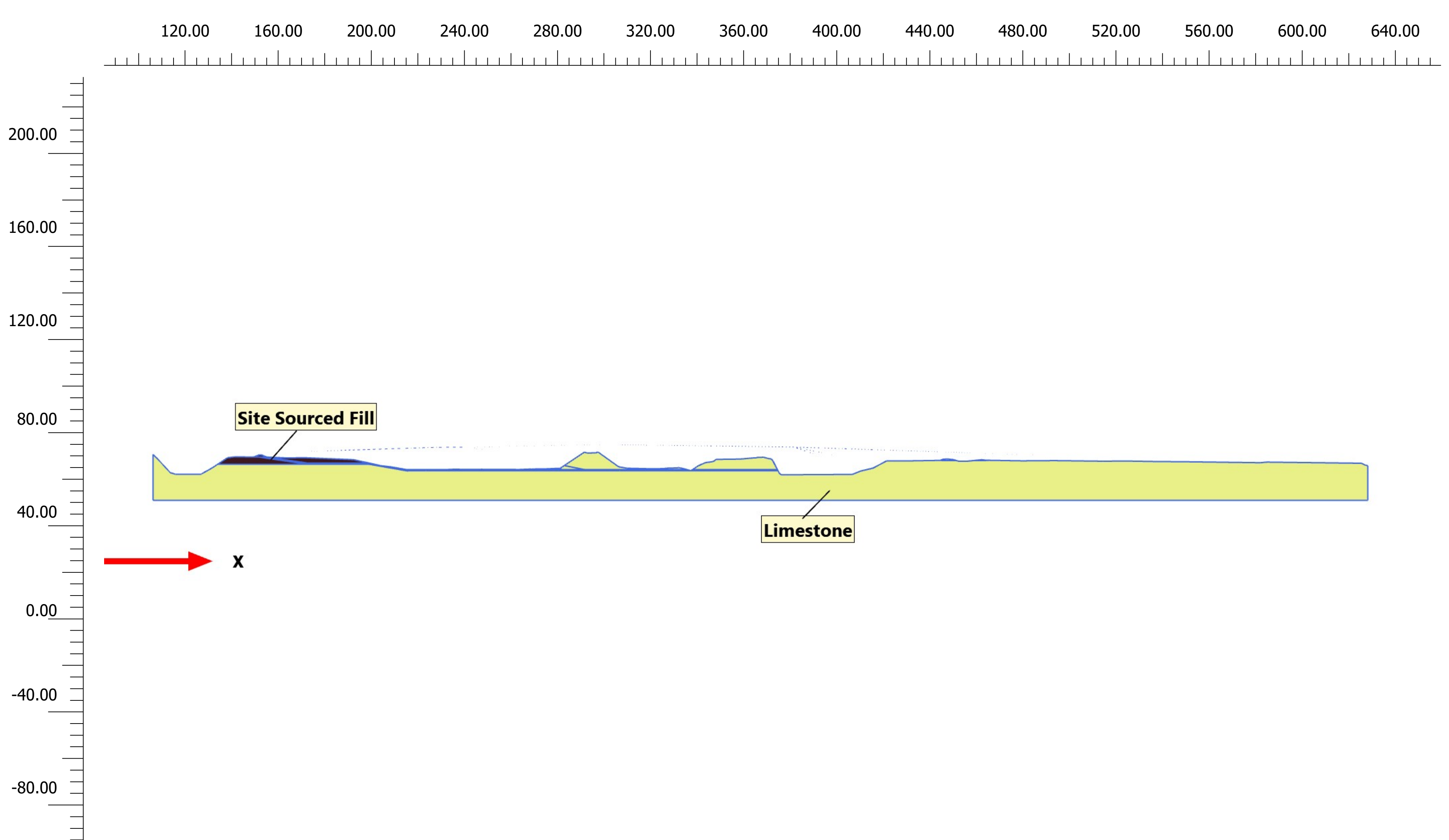
# APPENDICES

# APPENDIX SRA1

# Model Geometry and Material Parameters

Output Version 21.1.0.479



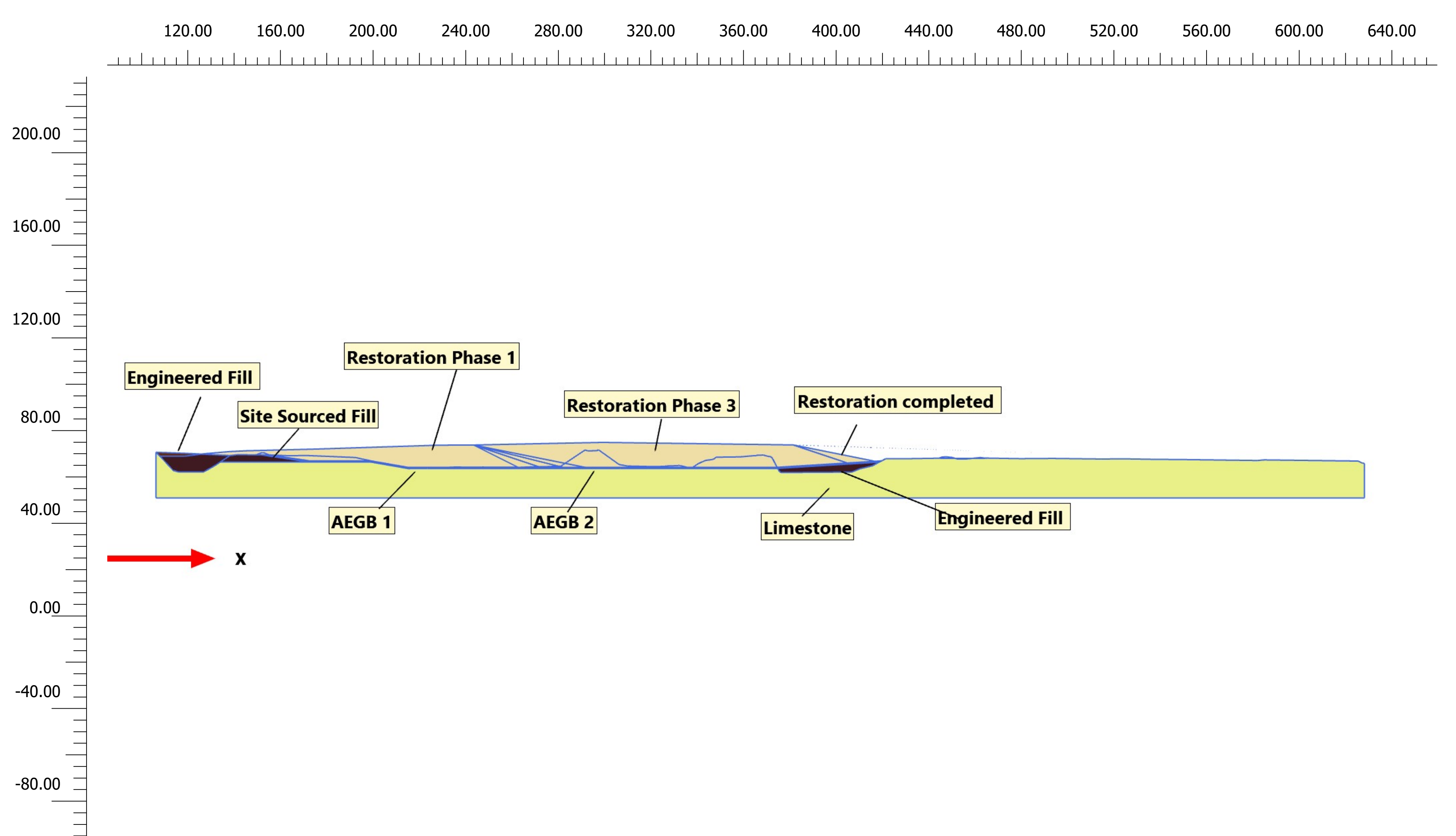

**Connectivity plot**

| Project description | | Date |
|---|---|---|
| Cross Leys Quarry Section A-A | | 06/10/2022 |

| Project filename | Step | Company |
|---|---|---|
| Cross Leys Quarry Sectio ... | 9 | Sirius Environmental Ltd |

PLAXIS® 2D CONNECT Edition

Output Version 21.1.0.479




# Connectivity plot

PLAXIS® 2D CONNECT Edition

| Project description | | | Date |
|---|---|---|---|
| Cross Leys Quarry Section A-A | | | 06/10/2022 |
| Project filename | Step | Company | |
| Cross Leys Quarry Sectio ... | 540 | Sirius Environmental Ltd | |

| **Material set** | | | | |
|---|---|---|---|---|
| Identification number | | 1 | 2 | 3 |
| Identification | | Restoration Soil | Limestone | Engineered Fill |
| Material model | | Hardening soil | Hardening soil | Hardening soil |
| Drainage type | | Drained | Undrained (A) | Undrained (A) |
| Colour | | RGB 232, 215, 161 | RGB 224, 232, 130 | RGB 102, 41, 5 |
| Comments | | | | |
| **General properties** | | | | |
| $\gamma_{unsat}$ | kN/m³ | 18.00 | 20.00 | 18.00 |
| $\gamma_{sat}$ | kN/m³ | 19.00 | 21.00 | 19.00 |
| **Advanced** | | | | |
| **Void ratio** | | | | |
| Dilatancy cut-off | | No | No | No |
| $e_{init}$ | | 0.5000 | 0.5000 | 0.5000 |
| $e_{min}$ | | 0.000 | 0.000 | 0.000 |
| $e_{max}$ | | 999.0 | 999.0 | 999.0 |
| **Stiffness** | | | | |
| $E_{50}^{ref}$ | kN/m² | 4000 | 30.00E3 | 5000 |
| $E_{oed}^{ref}$ | kN/m² | 4000 | 30.00E3 | 5000 |
| $E_{ur}^{ref}$ | kN/m² | 12.00E3 | 90.00E3 | 15.00E3 |
| power (m) | | 0.9000 | 0.7500 | 1.000 |
| **Alternatives** | | | | |
| Use alternatives | | No | No | No |
| $C_c$ | | 0.08625 | 0.01150 | 0.06900 |
| $C_s$ | | 0.02587 | 2.848E-3 | 0.02070 |
| $e_{init}$ | | 0.5000 | 0.5000 | 0.5000 |
| **Strength** | | | | |
| $c_{ref}$ | kN/m² | 5.000 | 5.000 | 5.000 |
| φ (phi) | ° | 25.00 | 35.00 | 30.00 |
| ψ (psi) | ° | 0.000 | 3.000 | 0.000 |

| Identification | | Restoration Soil | Limestone | Engineered Fill |
|---|---|---|---|---|
| **Advanced** | | | | |
| Set to default values | | Yes | No | Yes |
| **Stiffness** | | | | |
| $\nu_{ur}$ | | 0.2000 | 0.3000 | 0.2000 |
| $p_{ref}$ | kN/m² | 100.0 | 100.0 | 100.0 |
| $K_0^{nc}$ | | 0.5774 | 0.6000 | 0.5000 |
| **Strength** | | | | |
| $c_{inc}$ | kN/m²/m | 0.000 | 0.000 | 0.000 |
| $y_{ref}$ | m | 0.000 | 0.000 | 0.000 |
| $R_f$ | | 0.9000 | 0.9000 | 0.9000 |
| Tension cut-off | | Yes | Yes | Yes |
| Tensile strength | kN/m² | 0.000 | 0.000 | 0.000 |
| **Undrained behaviour** | | | | |
| Undrained behaviour | | Standard | Standard | Standard |
| Skempton-B | | 0.9866 | 0.9783 | 0.9866 |
| $\nu_u$ | | 0.4950 | 0.4950 | 0.4950 |
| $K_{w,ref}$ / n | kN/m² | 491.7E3 | 3.375E6 | 614.6E3 |
| **Stiffness** | | | | |
| Stiffness | | Standard | Standard | Standard |
| **Strength** | | | | |
| Strength | | Rigid | Rigid | Rigid |
| $R_{inter}$ | | 1.000 | 1.000 | 1.000 |
| Consider gap closure | | Yes | Yes | Yes |
| **Real interface thickness** | | | | |
| $\delta_{inter}$ | | 0.000 | 0.000 | 0.000 |
| **Groundwater** | | | | |
| Cross permeability | | Impermeable | Impermeable | Impermeable |
| Drainage conductivity, dk | m³/day/m | 0.000 | 0.000 | 0.000 |
| **Thermal** | | | | |
| R | m² K/kW | 0.000 | 0.000 | 0.000 |

| Identification | | Restoration Soil | Limestone | Engineered Fill |
|---|---|---|---|---|
| **K0 settings** | | | | |
| $K_0$ determination | | Automatic | Automatic | Automatic |
| $K_{0,x} = K_{0,z}$ | | Yes | Yes | Yes |
| $K_{0,x}$ | | 0.5774 | 0.6000 | 0.5000 |
| $K_{0,z}$ | | 0.5774 | 0.6000 | 0.5000 |
| **Overconsolidation** | | | | |
| OCR | | 1.000 | 1.000 | 1.000 |
| POP | kN/m² | 0.000 | 0.000 | 0.000 |
| **Model** | | | | |
| Data set | | Standard | Standard | Standard |
| **Soil** | | | | |
| Type | | Coarse | Coarse | Coarse |
| < 2 µm | % | 10.00 | 10.00 | 10.00 |
| 2 µm - 50 µm | % | 13.00 | 13.00 | 13.00 |
| 50 µm - 2 mm | % | 77.00 | 77.00 | 77.00 |
| **Flow parameters** | | | | |
| Use defaults | | None | None | None |
| $k_x$ | m/day | 0.8640E-3 | 0.8640 | 0.08640E-3 |
| $k_y$ | m/day | 0.8640E-3 | 0.8640 | 0.08640E-3 |
| $-\psi_{unsat}$ | m | 10.00E3 | 10.00E3 | 10.00E3 |
| $e_{init}$ | | 0.5000 | 0.5000 | 0.5000 |
| $S_s$ | 1/m | 0.000 | 0.000 | 0.000 |
| **Change of permeability** | | | | |
| $c_k$ | | 1000E12 | 1000E12 | 1000E12 |

| Identification | | Restoration Soil | Limestone | Engineered Fill |
|---|---|---|---|---|
| **Parameters** | | | | |
| $c_s$ | kJ/t/K | 0.000 | 0.000 | 0.000 |
| $\lambda_s$ | kW/m/K | 0.000 | 0.000 | 0.000 |
| $\rho_s$ | t/m³ | 0.000 | 0.000 | 0.000 |
| Solid thermal expansion | | Volumetric | Volumetric | Volumetric |
| $\alpha_s$ | 1/K | 0.000 | 0.000 | 0.000 |
| $D_v$ | m²/day | 0.000 | 0.000 | 0.000 |
| $f_{Tv}$ | | 0.000 | 0.000 | 0.000 |
| Unfrozen water content | | None | None | None |

| **Material set** | | | |
|---|---|---|---|
| Identification number | | 4 | 5 |
| Identification | | AEGB | Site sourced Fill |
| Material model | | Hardening soil | Hardening soil |
| Drainage type | | Undrained (A) | Drained |
| Colour | | RGB 203, 52, 21 | RGB 62, 25, 32 |
| Comments | | | |
| **General properties** | | | |
| $\gamma_{unsat}$ | kN/m³ | 19.00 | 18.00 |
| $\gamma_{sat}$ | kN/m³ | 20.00 | 19.00 |
| **Advanced** | | | |
| **Void ratio** | | | |
| Dilatancy cut-off | | No | No |
| $e_{init}$ | | 0.5000 | 0.5000 |
| $e_{min}$ | | 0.000 | 0.000 |
| $e_{max}$ | | 999.0 | 999.0 |
| **Stiffness** | | | |
| $E_{50}^{ref}$ | kN/m² | 8000 | 5000 |
| $E_{oed}^{ref}$ | kN/m² | 8000 | 5000 |
| $E_{ur}^{ref}$ | kN/m² | 24.00E3 | 15.00E3 |
| power (m) | | 1.000 | 0.7500 |
| **Alternatives** | | | |
| Use alternatives | | No | No |
| $C_c$ | | 0.04312 | 0.06900 |
| $C_s$ | | 0.01294 | 0.02070 |
| $e_{init}$ | | 0.5000 | 0.5000 |
| **Strength** | | | |
| $c_{ref}$ | kN/m² | 5.000 | 5.000 |
| φ (phi) | ° | 25.00 | 25.00 |
| ψ (psi) | ° | 0.000 | 0.000 |

| Identification | | AEGB | Site sourced Fill |
|---|---|---|---|
| **Advanced** | | | |
| Set to default values | | Yes | Yes |
| **Stiffness** | | | |
| $\nu_{ur}$ | | 0.2000 | 0.2000 |
| $p_{ref}$ | kN/m² | 100.0 | 100.0 |
| $K_0^{nc}$ | | 0.5774 | 0.5774 |
| **Strength** | | | |
| $c_{inc}$ | kN/m²/m | 0.000 | 0.000 |
| $y_{ref}$ | m | 0.000 | 0.000 |
| $R_f$ | | 0.9000 | 0.9000 |
| Tension cut-off | | Yes | Yes |
| Tensile strength | kN/m² | 0.000 | 0.000 |
| **Undrained behaviour** | | | |
| Undrained behaviour | | Standard | Standard |
| Skempton-B | | 0.9866 | 0.9866 |
| $\nu_u$ | | 0.4950 | 0.4950 |
| $K_{w,ref}$ / n | kN/m² | 983.3E3 | 614.6E3 |
| **Stiffness** | | | |
| Stiffness | | Standard | Standard |
| **Strength** | | | |
| Strength | | Rigid | Rigid |
| $R_{inter}$ | | 1.000 | 1.000 |
| Consider gap closure | | Yes | Yes |
| **Real interface thickness** | | | |
| $\delta_{inter}$ | | 0.000 | 0.000 |
| **Groundwater** | | | |
| Cross permeability | | Impermeable | Impermeable |
| Drainage conductivity, dk | m³/day/m | 0.000 | 0.000 |
| **Thermal** | | | |
| R | m² K/kW | 0.000 | 0.000 |

| Identification | | AEGB | Site sourced Fill |
|---|---|---|---|
| **K0 settings** | | | |
| $K_0$ determination | | Automatic | Automatic |
| $K_{0,x} = K_{0,z}$ | | Yes | Yes |
| $K_{0,x}$ | | 0.5774 | 0.5774 |
| $K_{0,z}$ | | 0.5774 | 0.5774 |
| **Overconsolidation** | | | |
| OCR | | 1.000 | 1.000 |
| POP | kN/m² | 0.000 | 0.000 |
| **Model** | | | |
| Data set | | Standard | Standard |
| **Soil** | | | |
| Type | | Coarse | Coarse |
| < 2 µm | % | 10.00 | 10.00 |
| 2 µm - 50 µm | % | 13.00 | 13.00 |
| 50 µm - 2 mm | % | 77.00 | 77.00 |
| **Flow parameters** | | | |
| Use defaults | | None | None |
| $k_x$ | m/day | 0.8640E-3 | 0.8640E-3 |
| $k_y$ | m/day | 0.8640E-3 | 0.8640E-3 |
| $-\psi_{unsat}$ | m | 10.00E3 | 10.00E3 |
| $e_{init}$ | | 0.5000 | 0.5000 |
| $S_s$ | 1/m | 0.000 | 0.000 |
| **Change of permeability** | | | |
| $c_k$ | | 1000E12 | 1000E12 |

| Identification | | AEGB | Site sourced Fill |
|---|---|---|---|
| **Parameters** | | | |
| $c_s$ | kJ/t/K | 0.000 | 0.000 |
| $\lambda_s$ | kW/m/K | 0.000 | 0.000 |
| $\rho_s$ | t/m³ | 0.000 | 0.000 |
| Solid thermal expansion | | Volumetric | Volumetric |
| $\alpha_s$ | 1/K | 0.000 | 0.000 |
| $D_v$ | m²/day | 0.000 | 0.000 |
| $f_{Tv}$ | | 0.000 | 0.000 |
| Unfrozen water content | | None | None |




**NOTES**

1. ALL DIMENSIONS IN MILLIMETRES AND ALL LEVELS IN METRES ABOVE ORDNANCE DATUM.

2. DO NOT SCALE FROM THIS DRAWING.

3. ANY ANOMALIES IDENTIFIED WITH THE DETAILS SHOWN ON THIS DRAWING ARE TO BE BROUGHT TO THE ATTENTION OF SIRIUS ENVIRONMENTAL PRIOR TO CONSTRUCTION WORKS COMMENCING.

**KEY**

18.5 SITE SURVEY

| REV | DESCRIPTION | DATE | BY |
|---|---|---|---|

**CLIENT**

MICK GEORGE

sirius Environmental

Office Suite 2, The Beacon Centre for Enterprise, Dafen, Llanelli. SA14 8LQ. 01554 780 544

**JOB TITLE**

CROSS LEYS ENVIRONMENTAL PERMIT VARIATION APPLICATION

**DRAWING TITLE**

Stability Risk Assessment Section Location

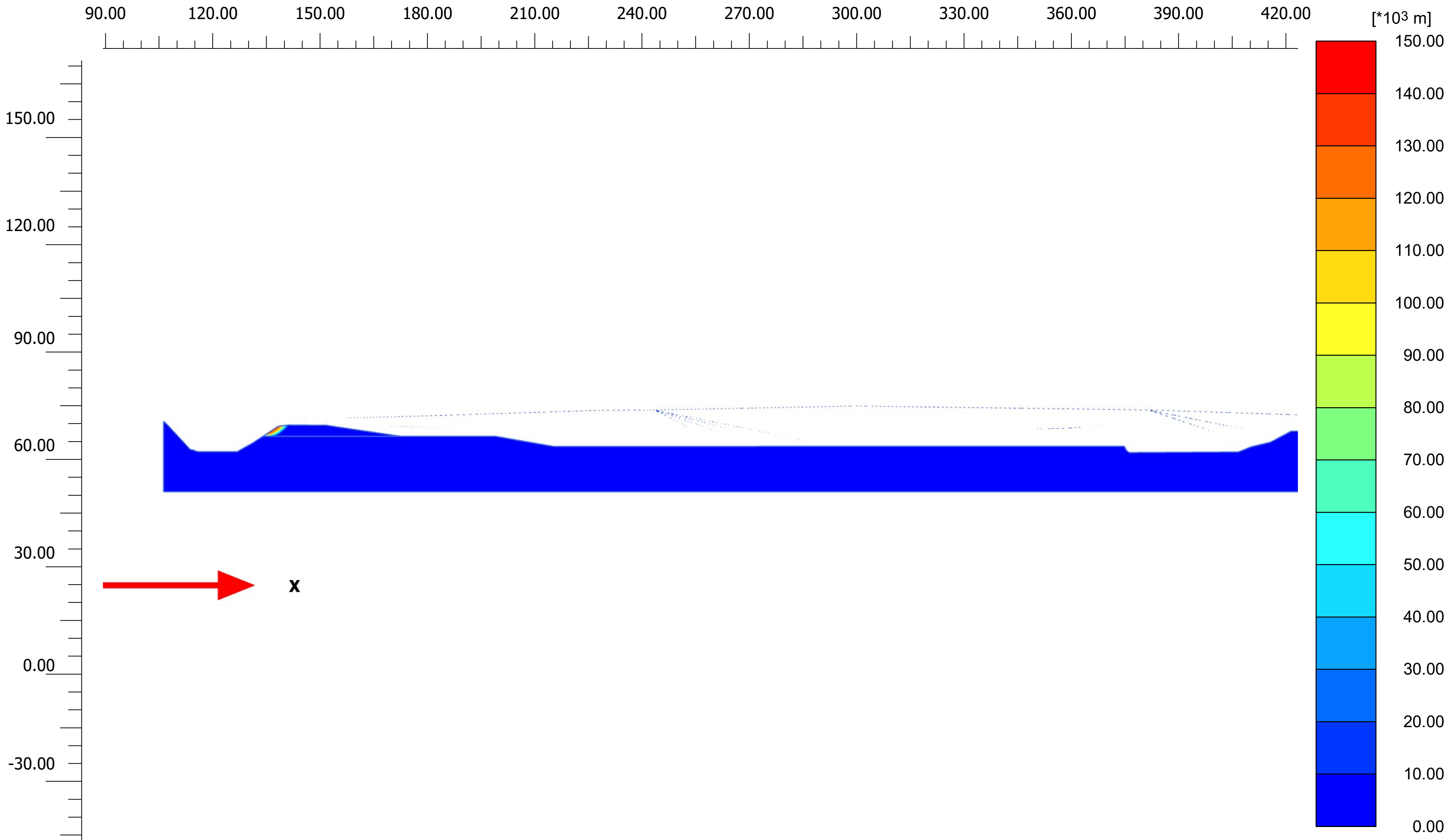
| DRAWN | DATE | APPROVED | DATE |
|---|---|---|---|
| M.C | 20/08/2024 | J.D | 20/08/2024 |

| SCALE | SHEET | DRAWING NUMBER | REVISION |
|---|---|---|---|
| 1:1000 | A1L | MG1002 /SRA/01 | 0 |

# APPENDIX SRA2

# PLAXIS Stability Printouts

Output Version 21.1.0.479




**Incremental displacements |Δu| (scaled up 0.100*10$^{-3}$ times)**

Maximum value = 141.1*10$^{3}$ m (Element 773 at Node 16358)

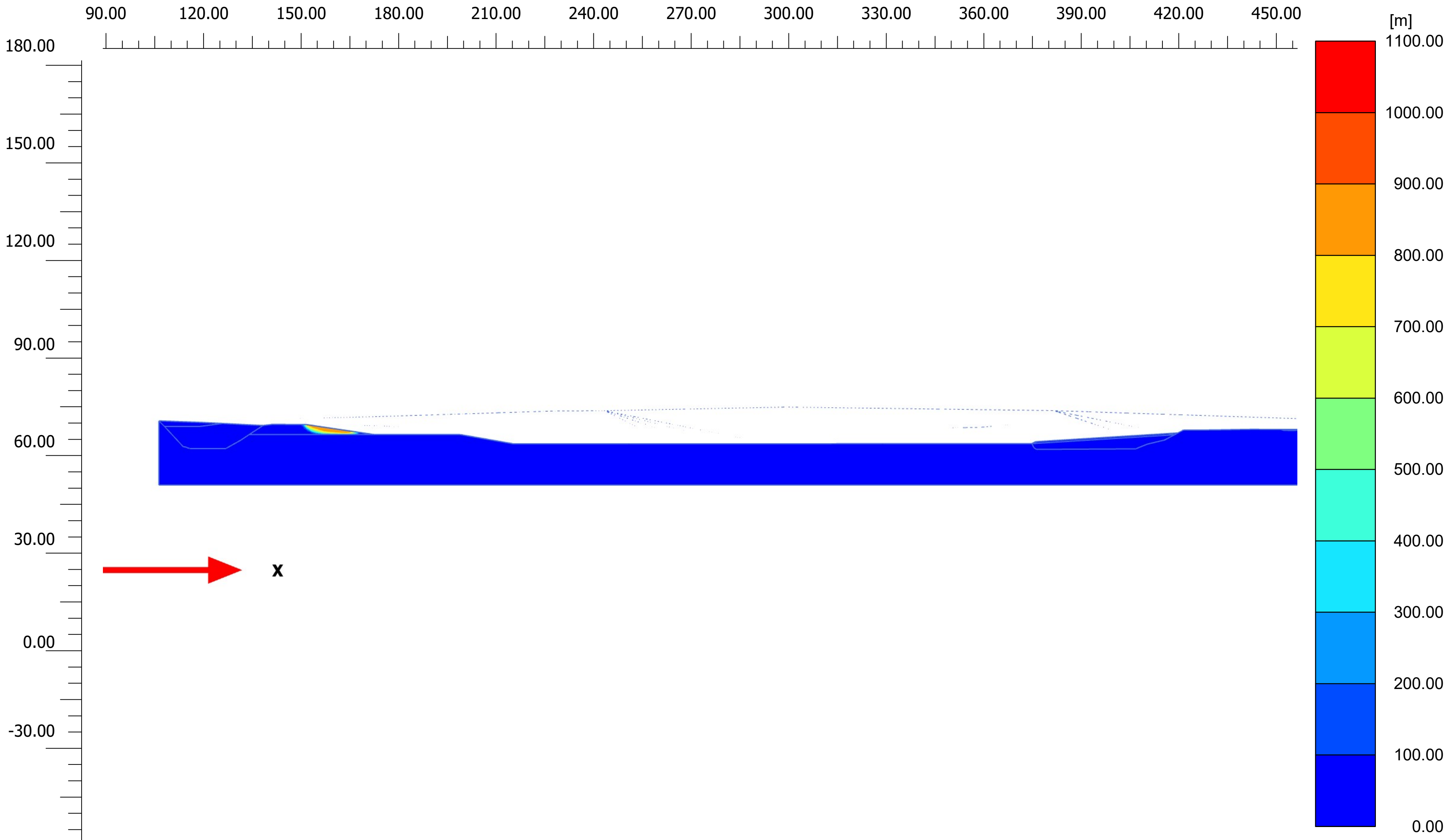
PLAXIS® 2D CONNECT Edition

| *Project description* | | | *Date* |
|---|---|---|---|
| Cross Leys Quarry Section A-A | | | 06/10/2022 |
| *Project filename* | *Step* | *Company* | |
| Cross Leys Quarry Sectio ... | 116 | Sirius Environmental Ltd | |

| | | |
|---|---|---|
| Project description | : Cross Leys Quarry Section BB2 JC 1 in 3 | **Output Version 21.1.0.479** |
| Company | : Sirius Environmental Ltd | |
| Project filename | : Cross Leys Quarry Section BB2 JC 1 in 3 | Date : 06/10/2022 |
| Output | : Calculation information | Page : 1 |

| | | | | |
|---|---|---|---|---|
| **Step info** | | | | |
| Phase | Excavate Safety [Phase_2] | | | |
| Step | Initial | | | |
| Calulation mode | Classical mode | | | |
| Step type | Safety | | | |
| Updated mesh | False | | | |
| Solver type | Picos | | | |
| Kernel type | 64 bit | | | |
| Extrapolation factor | 0.5000 | | | |
| Relative stiffness | 0.02723E-12 | | | |
| **Multipliers** | | | | |
| Soil weight | | | $\Sigma M_{Weight}$ | 1.000 |
| Strength reduction factor | $M_{sf}$ | 0.1268E-3 | $\Sigma M_{sf}$ | 1.845 |
| Time | Increment | 0.000 | End time | 45.00 |
| **Staged construction** | | | | |
| Active proportion total area | $M_{Area}$ | 0.000 | $\Sigma M_{Area}$ | 0.7133 |
| Active proportion of stage | $M_{Stage}$ | 0.000 | $\Sigma M_{Stage}$ | 0.000 |
| **Forces** | | | | |
| $F_X$ | 0.000 kN/m | | | |
| $F_Y$ | 0.000 kN/m | | | |
| **Consolidation** | | | | |
| Realised $P_{Excess,Max}$ | 35.83 kN/m$^2$ | | | |

Output Version 21.1.0.479




**Incremental displacements |Δu| (scaled up 0.0200 times)**

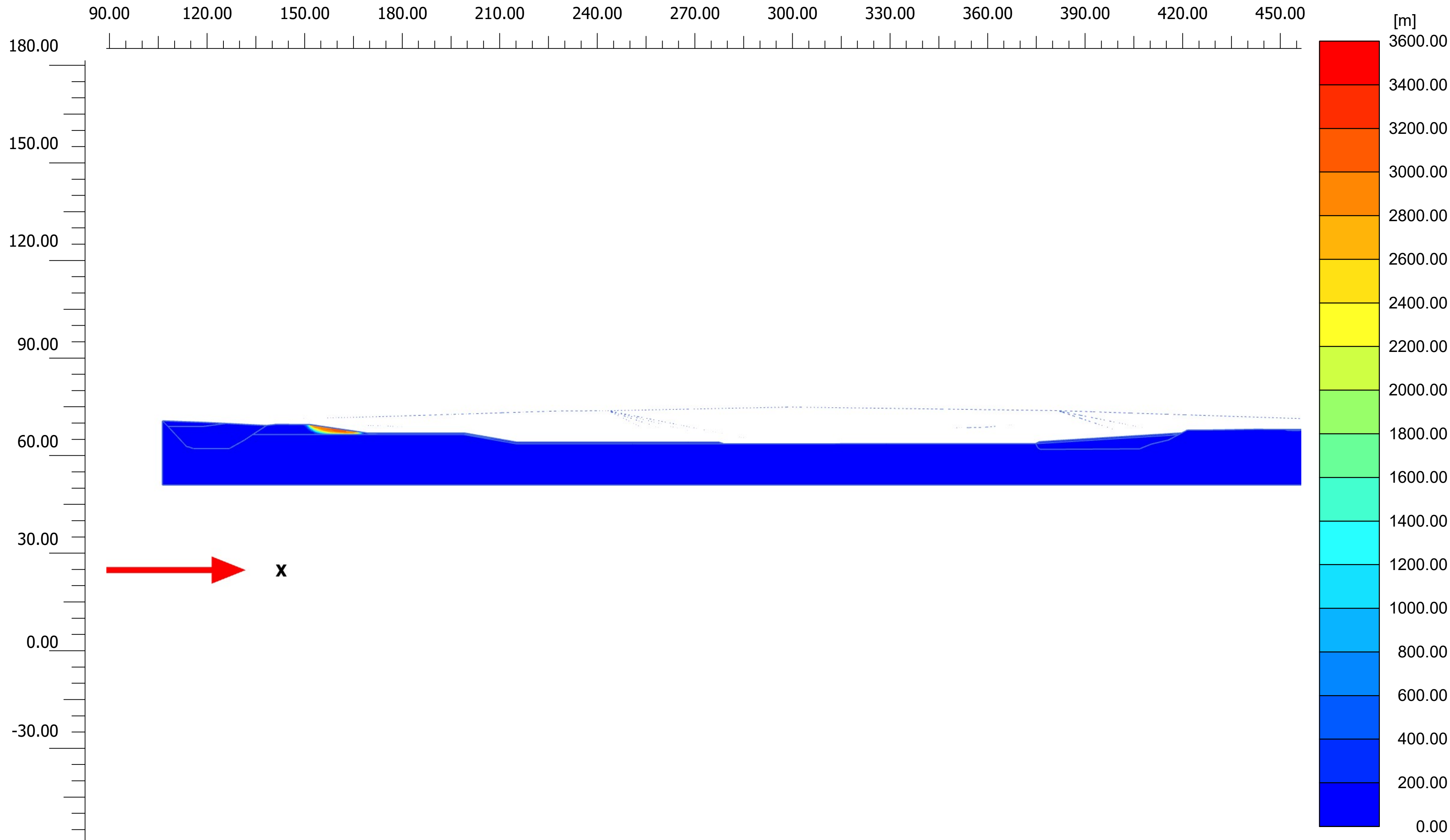
Maximum value = 1000 m (Element 778 at Node 16259)

PLAXIS® 2D CONNECT Edition

| *Project description* | | | *Date* |
|---|---|---|---|
| Cross Leys Quarry Section A-A | | | 06/10/2022 |
| *Project filename* | *Step* | *Company* | |
| Cross Leys Quarry Sectio ... | 224 | Sirius Environmental Ltd | |

| | | | | |
|---|---|---|---|---|
| **Step info** | | | | |
| Phase | Engineered Fill Safety [Phase_4] | | | |
| Step | Initial | | | |
| Calulation mode | Classical mode | | | |
| Step type | Safety | | | |
| Updated mesh | False | | | |
| Solver type | Picos | | | |
| Kernel type | 64 bit | | | |
| Extrapolation factor | 0.5000 | | | |
| Relative stiffness | 0.1906E-12 | | | |
| **Multipliers** | | | | |
| Soil weight | | | $\Sigma M_{Weight}$ | 1.000 |
| Strength reduction factor | $M_{sf}$ | -0.06284E-3 | $\Sigma M_{sf}$ | 5.122 |
| Time | Increment | 0.000 | End time | 105.0 |
| **Staged construction** | | | | |
| Active proportion total area | $M_{Area}$ | 0.000 | $\Sigma M_{Area}$ | 0.7419 |
| Active proportion of stage | $M_{Stage}$ | 0.000 | $\Sigma M_{Stage}$ | 0.000 |
| **Forces** | | | | |
| $F_X$ | 0.000 kN/m | | | |
| $F_Y$ | 0.000 kN/m | | | |
| **Consolidation** | | | | |
| Realised $P_{Excess,Max}$ | 53.75 kN/m$^2$ | | | |

Output Version 21.1.0.479




**Incremental displacements |Δu| (scaled up $5.00*10^{-3}$ times)**

Maximum value = 3501 m (Element 778 at Node 16259)

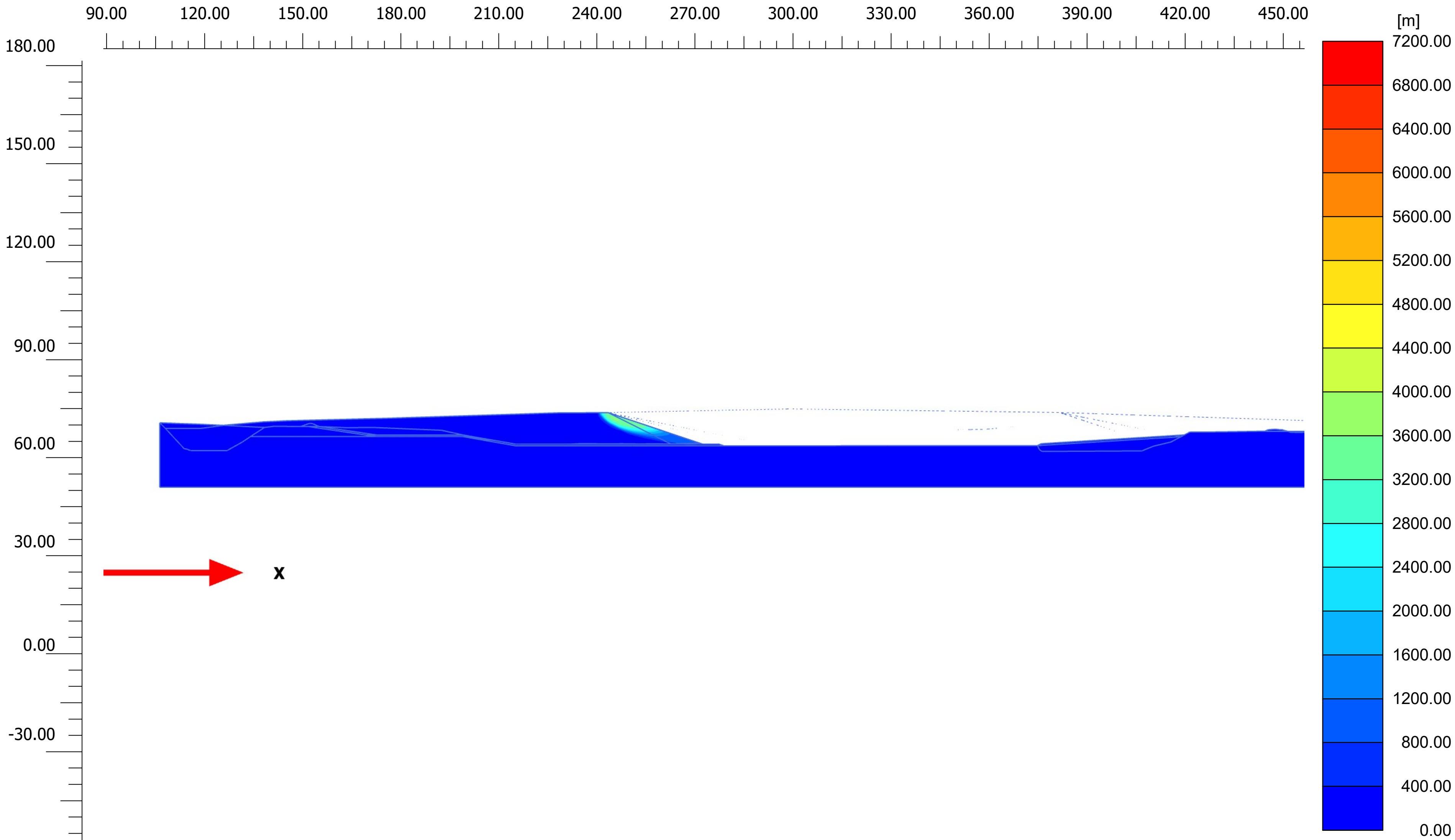
PLAXIS® 2D CONNECT Edition

| Project description | | Date |
|---|---|---|
| Cross Leys Quarry Section A-A | | 06/10/2022 |

| Project filename | Step | Company |
|---|---|---|
| Cross Leys Quarry Sectio ... | 328 | Sirius Environmental Ltd |

| **Step info** | | | | |
|---|---|---|---|---|
| Phase | AEGB Safety [Phase_6] | | | |
| Step | Initial | | | |
| Calulation mode | Classical mode | | | |
| Step type | Safety | | | |
| Updated mesh | False | | | |
| Solver type | Picos | | | |
| Kernel type | 64 bit | | | |
| Extrapolation factor | 0.5000 | | | |
| Relative stiffness | 0.06723E-12 | | | |
| **Multipliers** | | | | |
| Soil weight | | | $\Sigma M_{Weight}$ | 1.000 |
| Strength reduction factor | $M_{sf}$ | 0.1101E-3 | $\Sigma M_{sf}$ | 5.072 |
| Time | Increment | 0.000 | End time | 120.0 |
| **Staged construction** | | | | |
| Active proportion total area | $M_{Area}$ | 0.000 | $\Sigma M_{Area}$ | 0.7469 |
| Active proportion of stage | $M_{Stage}$ | 0.000 | $\Sigma M_{Stage}$ | 0.000 |
| **Forces** | | | | |
| $F_X$ | 0.000 kN/m | | | |
| $F_Y$ | 0.000 kN/m | | | |
| **Consolidation** | | | | |
| Realised $P_{Excess,Max}$ | 48.98 kN/m$^2$ | | | |

Output Version 21.1.0.479




**Incremental displacements |Δu| (scaled up 2.00*10⁻³ times)**

Maximum value = 6919 m (Element 836 at Node 9921)

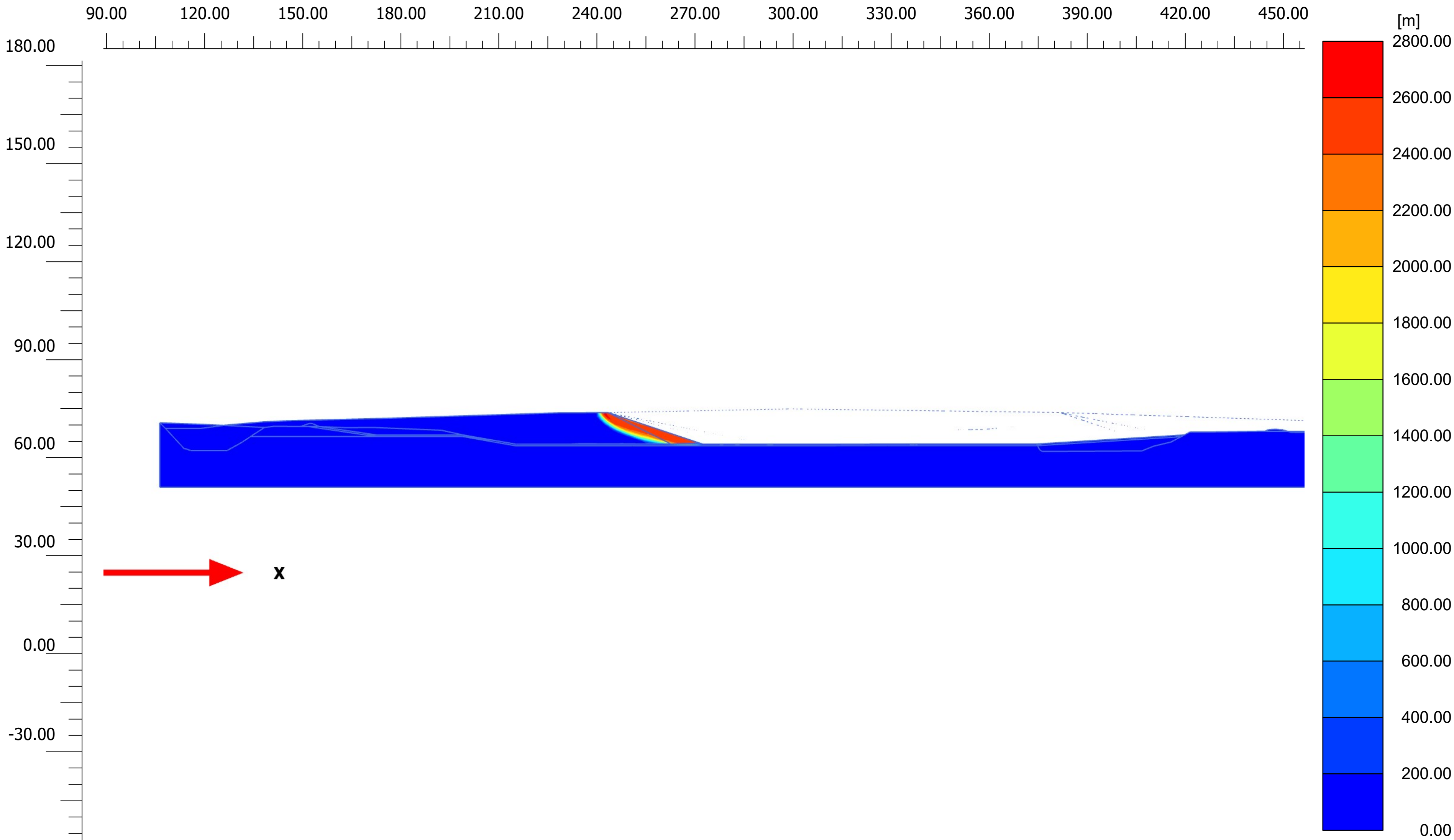
PLAXIS® 2D CONNECT Edition

| Project description | | Date |
|---|---|---|
| Cross Leys Quarry Section A-A | | 06/10/2022 |

| Project filename | Step | Company |
|---|---|---|
| Cross Leys Quarry Sectio ... | 428 | Sirius Environmental Ltd |

| | | | | |
|---|---|---|---|---|
| **Step info** | | | | |
| Phase | Import Restoration Phase 1 Safety [Phase_8] | | | |
| Step | Initial | | | |
| Calulation mode | Classical mode | | | |
| Step type | Safety | | | |
| Updated mesh | False | | | |
| Solver type | Picos | | | |
| Kernel type | 64 bit | | | |
| Extrapolation factor | 2.000 | | | |
| Relative stiffness | 0.1261E-9 | | | |
| **Multipliers** | | | | |
| Soil weight | | | $\Sigma M_{Weight}$ | 1.000 |
| Strength reduction factor | $M_{sf}$ | 0.1649E-3 | $\Sigma M_{sf}$ | 1.561 |
| Time | Increment | 0.000 | End time | 360.0 |
| **Staged construction** | | | | |
| Active proportion total area | $M_{Area}$ | 0.000 | $\Sigma M_{Area}$ | 0.8199 |
| Active proportion of stage | $M_{Stage}$ | 0.000 | $\Sigma M_{Stage}$ | 0.000 |
| **Forces** | | | | |
| $F_X$ | 0.000 kN/m | | | |
| $F_Y$ | 0.000 kN/m | | | |
| **Consolidation** | | | | |
| Realised $P_{Excess,Max}$ | 138.8 kN/m$^2$ | | | |

Output Version 21.1.0.479




**Incremental displacements |Δu| (scaled up $5.00*10^{-3}$ times)**

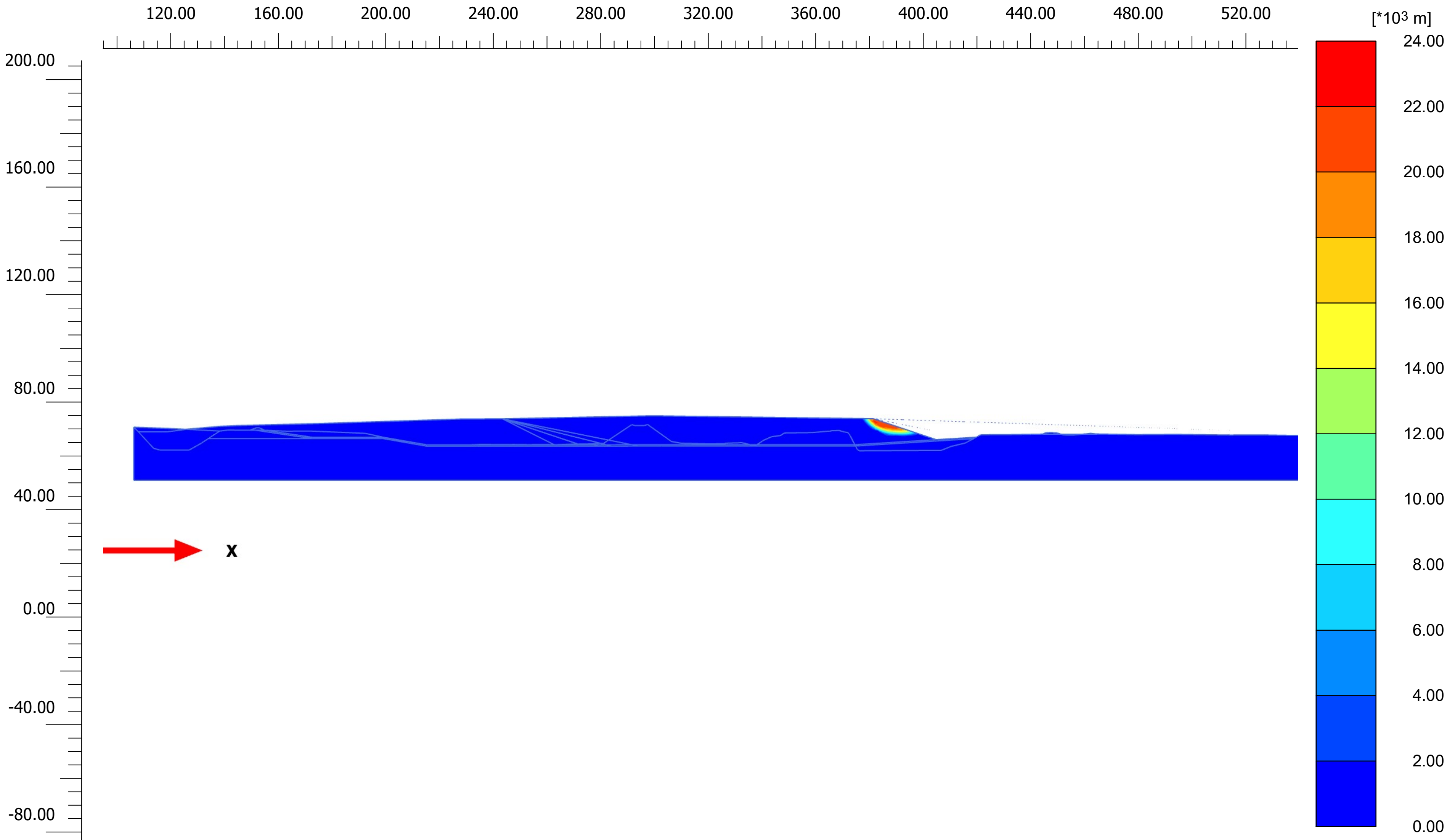
Maximum value = 2675 m (Element 482 at Node 10624)

PLAXIS® 2D CONNECT Edition

| *Project description* | | | *Date* |
|---|---|---|---|
| Cross Leys Quarry Section A-A | | | 06/10/2022 |
| *Project filename* | *Step* | *Company* | |
| Cross Leys Quarry Sectio ... | 864 | Sirius Environmental Ltd | |

| **Step info** | | | | |
|---|---|---|---|---|
| Phase | AEGB 2 Safety [Phase_16] | | | |
| Step | Initial | | | |
| Calulation mode | Classical mode | | | |
| Step type | Safety | | | |
| Updated mesh | False | | | |
| Solver type | Picos | | | |
| Kernel type | 64 bit | | | |
| Extrapolation factor | 2.000 | | | |
| Relative stiffness | 0.04652E-9 | | | |
| **Multipliers** | | | | |
| Soil weight | | | $\Sigma M_{Weight}$ | 1.000 |
| Strength reduction factor | $M_{sf}$ | 0.09346E-3 | $\Sigma M_{sf}$ | 1.681 |
| Time | Increment | 0.000 | End time | 380.0 |
| **Staged construction** | | | | |
| Active proportion total area | $M_{Area}$ | 0.000 | $\Sigma M_{Area}$ | 0.8244 |
| Active proportion of stage | $M_{Stage}$ | 0.000 | $\Sigma M_{Stage}$ | 0.000 |
| **Forces** | | | | |
| $F_X$ | 0.000 kN/m | | | |
| $F_Y$ | 0.000 kN/m | | | |
| **Consolidation** | | | | |
| Realised $P_{Excess,Max}$ | 142.9 kN/m$^2$ | | | |

Output Version 21.1.0.479



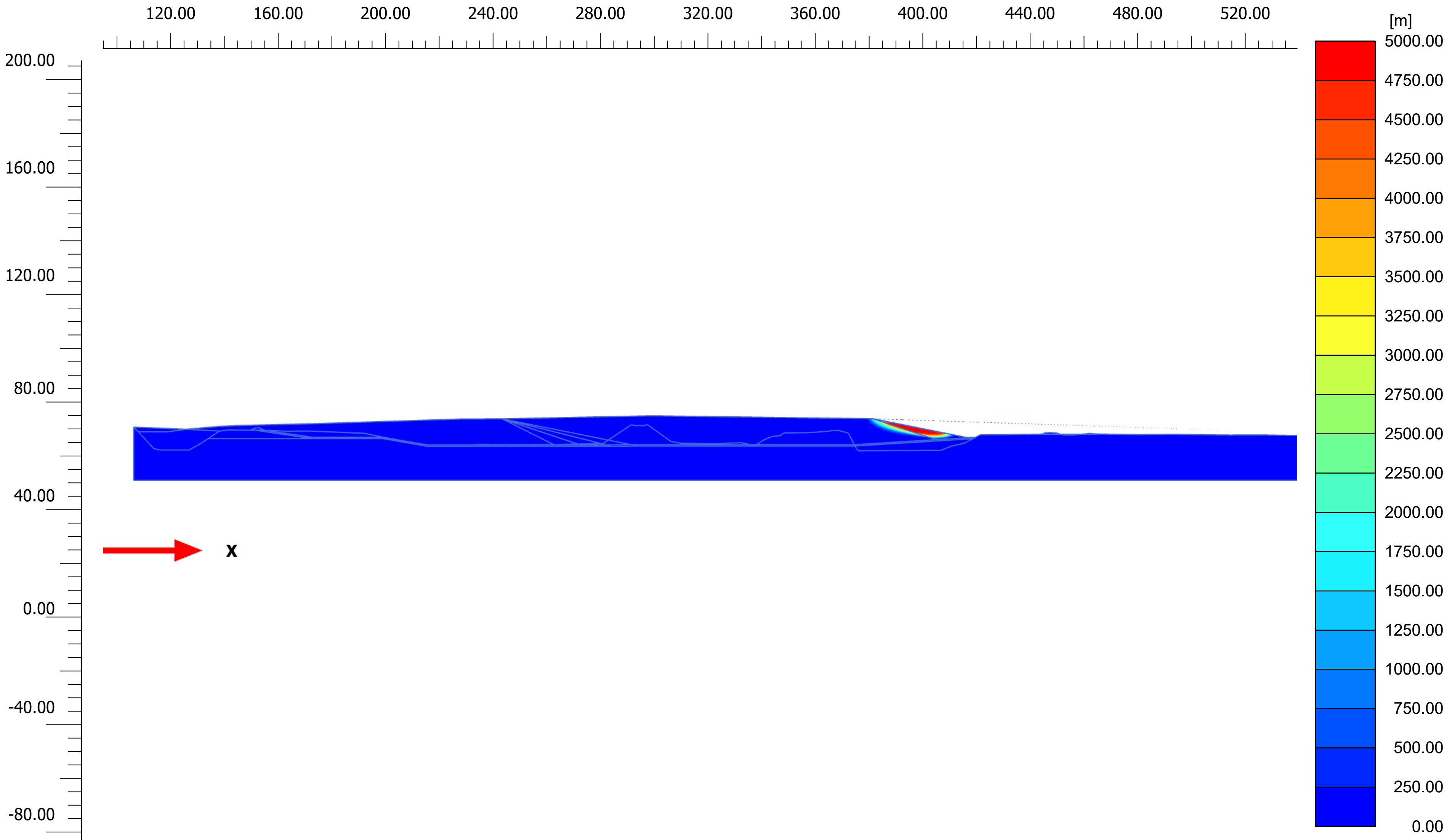

**Incremental displacements |Δu| (scaled up $0.500*10^{-3}$ times)**

Maximum value = $22.48*10^{3}$ m (Element 2 at Node 3063)

| PLAXIS® 2D CONNECT Edition | *Project description* Cross Leys Quarry Section A-A | | *Date* 06/10/2022 |
|---|---|---|---|
| | *Project filename* Cross Leys Quarry Sectio ... | *Step* 537 | *Company* Sirius Environmental Ltd |

| **Step info** | | | | |
|---|---|---|---|---|
| Phase | Import Restoration Phase 2 Safety [Phase_10] | | | |
| Step | Initial | | | |
| Calulation mode | Classical mode | | | |
| Step type | Safety | | | |
| Updated mesh | False | | | |
| Solver type | Picos | | | |
| Kernel type | 64 bit | | | |
| Extrapolation factor | 0.5000 | | | |
| Relative stiffness | -0.1507E-9 | | | |
| **Multipliers** | | | | |
| Soil weight | | | $\Sigma M_{Weight}$ | 1.000 |
| Strength reduction factor | $M_{sf}$ | -0.3453E-3 | $\Sigma M_{sf}$ | 1.380 |
| Time | Increment | 0.000 | End time | 620.0 |
| **Staged construction** | | | | |
| Active proportion total area | $M_{Area}$ | 0.000 | $\Sigma M_{Area}$ | 0.9519 |
| Active proportion of stage | $M_{Stage}$ | 0.000 | $\Sigma M_{Stage}$ | 0.000 |
| **Forces** | | | | |
| $F_X$ | 0.000 kN/m | | | |
| $F_Y$ | 0.000 kN/m | | | |
| **Consolidation** | | | | |
| Realised $P_{Excess,Max}$ | 41.69 kN/m$^2$ | | | |

Output Version 21.1.0.479




**Incremental displacements |Δu| (scaled up 5.00*10$^{-3}$ times)**

Maximum value = 4917 m (Element 640 at Node 3159)

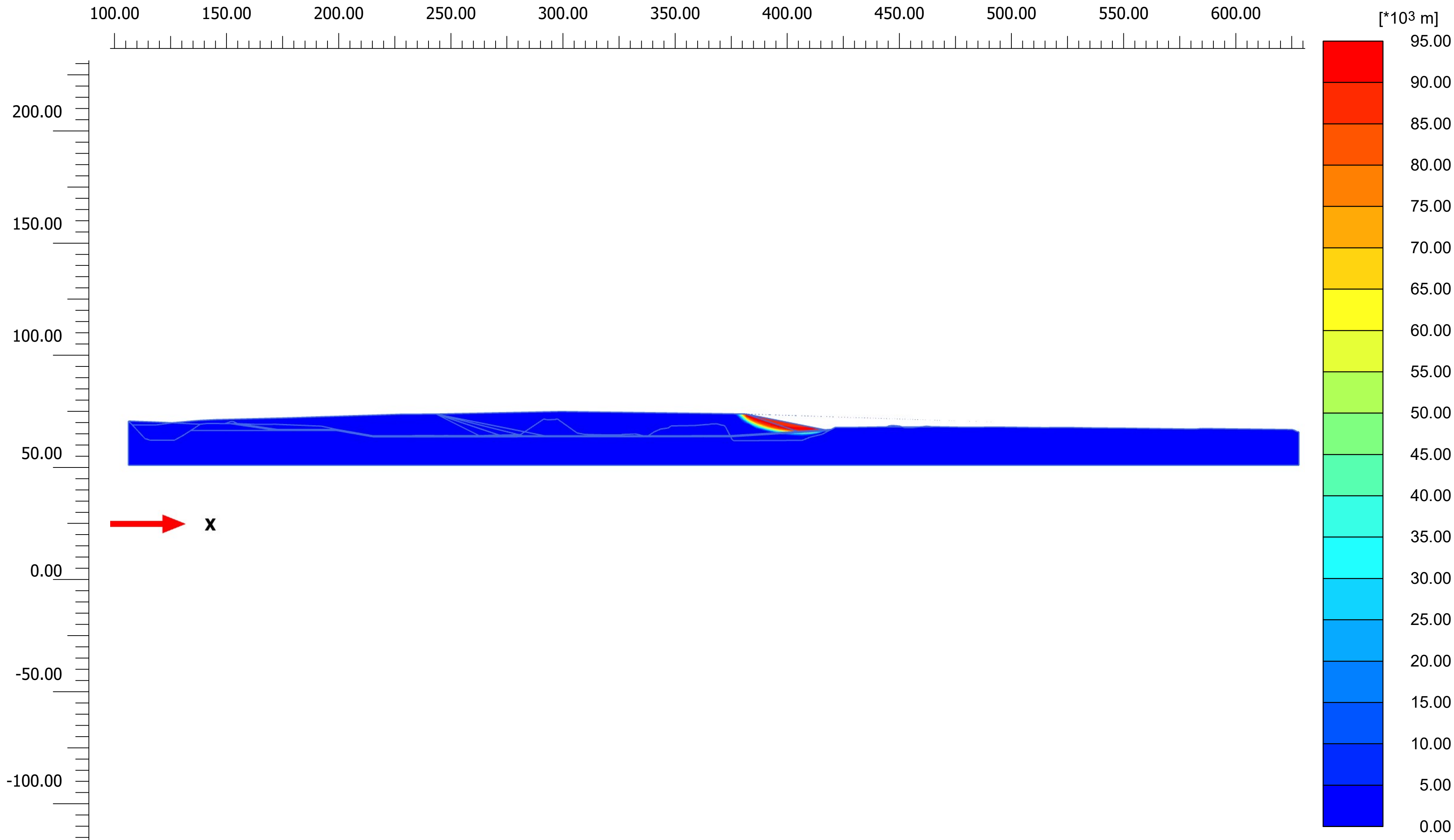
PLAXIS® 2D CONNECT Edition

| Project description | Date |
|---|---|
| Cross Leys Quarry Section A-A | 06/10/2022 |

| Project filename | Step | Company |
|---|---|---|
| Cross Leys Quarry Sectio ... | 754 | Sirius Environmental Ltd |

| **Step info** | | | | |
|---|---|---|---|---|
| Phase | Import Restoration Phase 3 Safety [Phase_12] | | | |
| Step | Initial | | | |
| Calulation mode | Classical mode | | | |
| Step type | Safety | | | |
| Updated mesh | False | | | |
| Solver type | Picos | | | |
| Kernel type | 64 bit | | | |
| Extrapolation factor | 1.000 | | | |
| Relative stiffness | -0.02410E-9 | | | |
| **Multipliers** | | | | |
| Soil weight | | | $\Sigma M_{Weight}$ | 1.000 |
| Strength reduction factor | $M_{sf}$ | 0.3044E-3 | $\Sigma M_{sf}$ | 2.124 |
| Time | Increment | 0.000 | End time | 665.0 |
| **Staged construction** | | | | |
| Active proportion total area | $M_{Area}$ | 0.000 | $\Sigma M_{Area}$ | 0.9569 |
| Active proportion of stage | $M_{Stage}$ | 0.000 | $\Sigma M_{Stage}$ | 0.000 |
| **Forces** | | | | |
| $F_X$ | 0.000 kN/m | | | |
| $F_Y$ | 0.000 kN/m | | | |
| **Consolidation** | | | | |
| Realised $P_{Excess,Max}$ | 47.96 kN/m$^2$ | | | |

Output Version 21.1.0.479




**Incremental displacements |Δu| (scaled up $0.200*10^{-3}$ times)**

Maximum value = $93.87*10^{3}$ m (Element 1 at Node 3069)

PLAXIS® 2D
CONNECT Edition

*Project description*
Cross Leys Quarry Section A-A

*Date*
06/10/2022

*Project filename*
Cross Leys Quarry Sectio ...

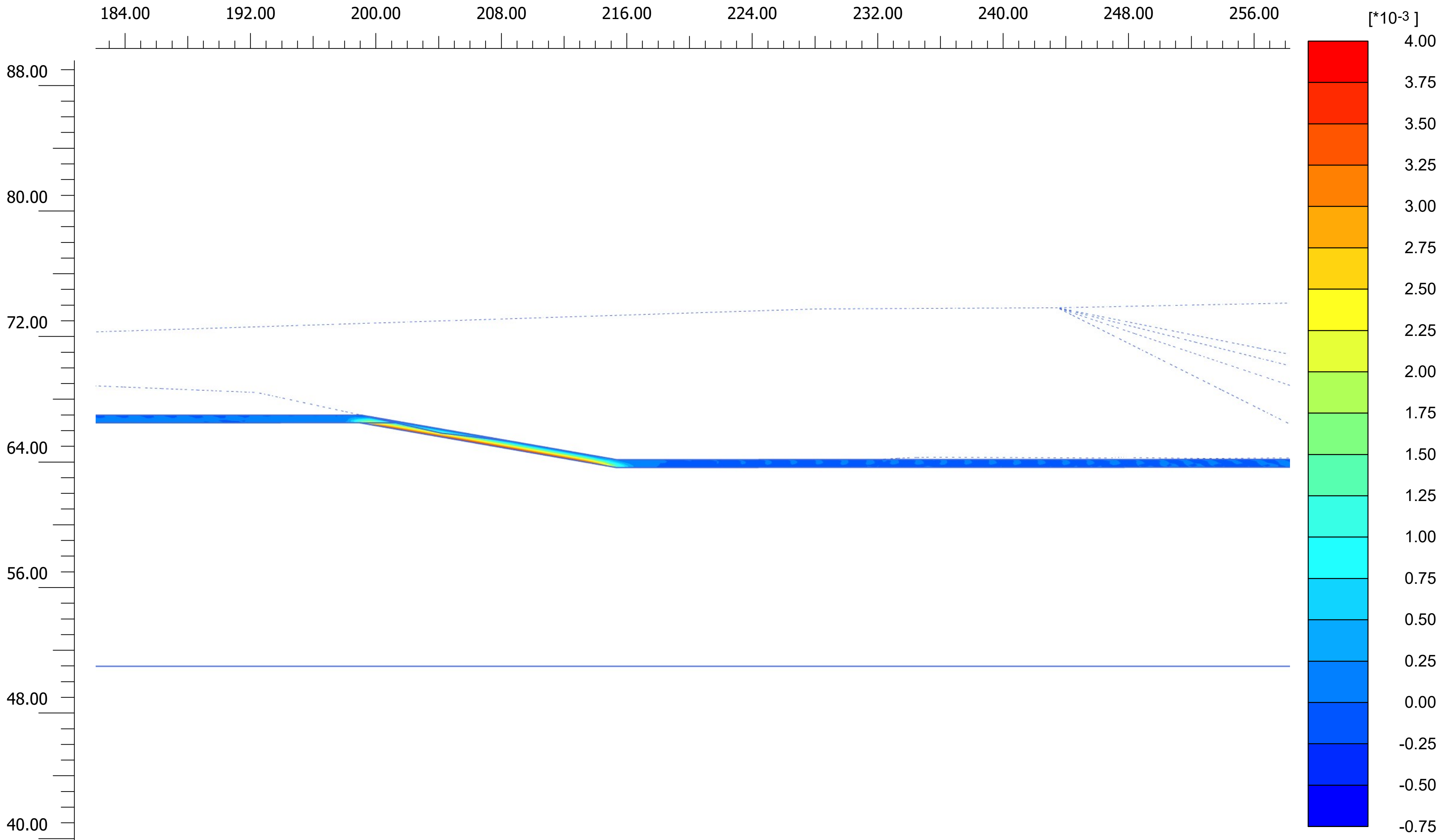
*Company*
Sirius Environmental Ltd

| **Step info** | | | | |
|---|---|---|---|---|
| Phase | Wait 2 Years Safety [Phase_14] | | | |
| Step | Initial | | | |
| Calulation mode | Classical mode | | | |
| Step type | Safety | | | |
| Updated mesh | False | | | |
| Solver type | Picos | | | |
| Kernel type | 64 bit | | | |
| Extrapolation factor | 2.000 | | | |
| Relative stiffness | 0.4116E-12 | | | |
| **Multipliers** | | | | |
| Soil weight | | | $\Sigma M_{Weight}$ | 1.000 |
| Strength reduction factor | $M_{sf}$ | -0.6144E-3 | $\Sigma M_{sf}$ | 3.075 |
| Time | Increment | 0.000 | End time | 1395 |
| **Staged construction** | | | | |
| Active proportion total area | $M_{Area}$ | 0.000 | $\Sigma M_{Area}$ | 0.9569 |
| Active proportion of stage | $M_{Stage}$ | 0.000 | $\Sigma M_{Stage}$ | 0.000 |
| **Forces** | | | | |
| $F_X$ | 0.000 kN/m | | | |
| $F_Y$ | 0.000 kN/m | | | |
| **Consolidation** | | | | |
| Realised $P_{Excess,Max}$ | 71.82 kN/m$^2$ | | | |

# APPENDIX SRA3

# PLAXIS Integrity Printouts

Output Version 21.1.0.479




**Total cartesian strain $\gamma_{xy}$ (scaled up $5.00 \times 10^3$ times) (Time 120.0 day)**

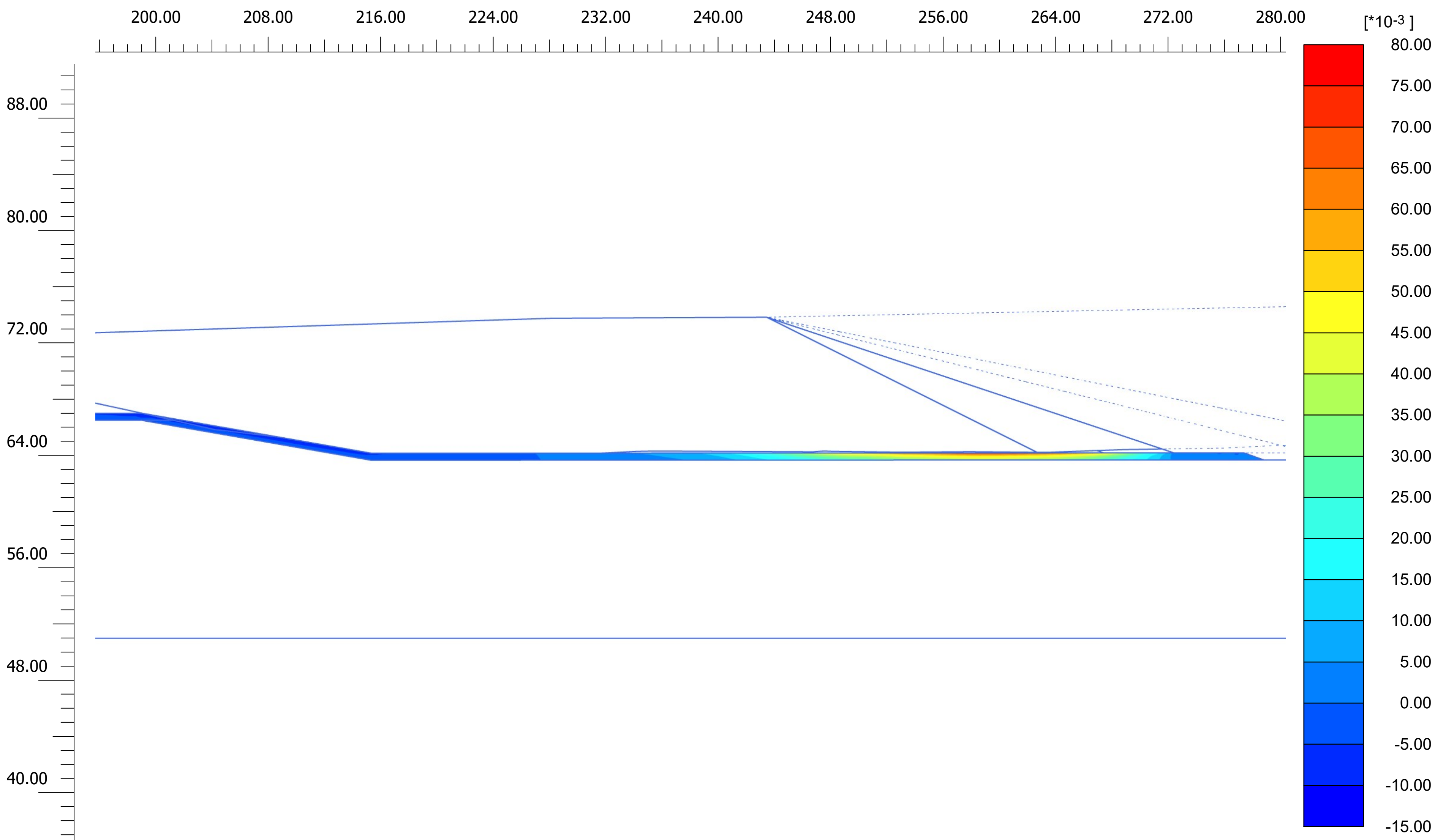
Maximum value = $3.960 \times 10^{-3}$ (Element 1431 at Node 14655)

Minimum value = $-0.5603 \times 10^{-3}$ (Element 980 at Node 15352)

PLAXIS® 2D CONNECT Edition

| *Project description* | | *Date* |
|---|---|---|
| Cross Leys Quarry Section A-A | | 06/10/2022 |
| *Project filename* | *Step* | *Company* |
| Cross Leys Quarry Sectio ... | 228 | Sirius Environmental Ltd |

Output Version 21.1.0.479




**Total cartesian strain $\gamma_{xy}$ (scaled up 200 times) (Time 360.0 day)**

Maximum value = 0.07522 (Element 1420 at Node 12004)

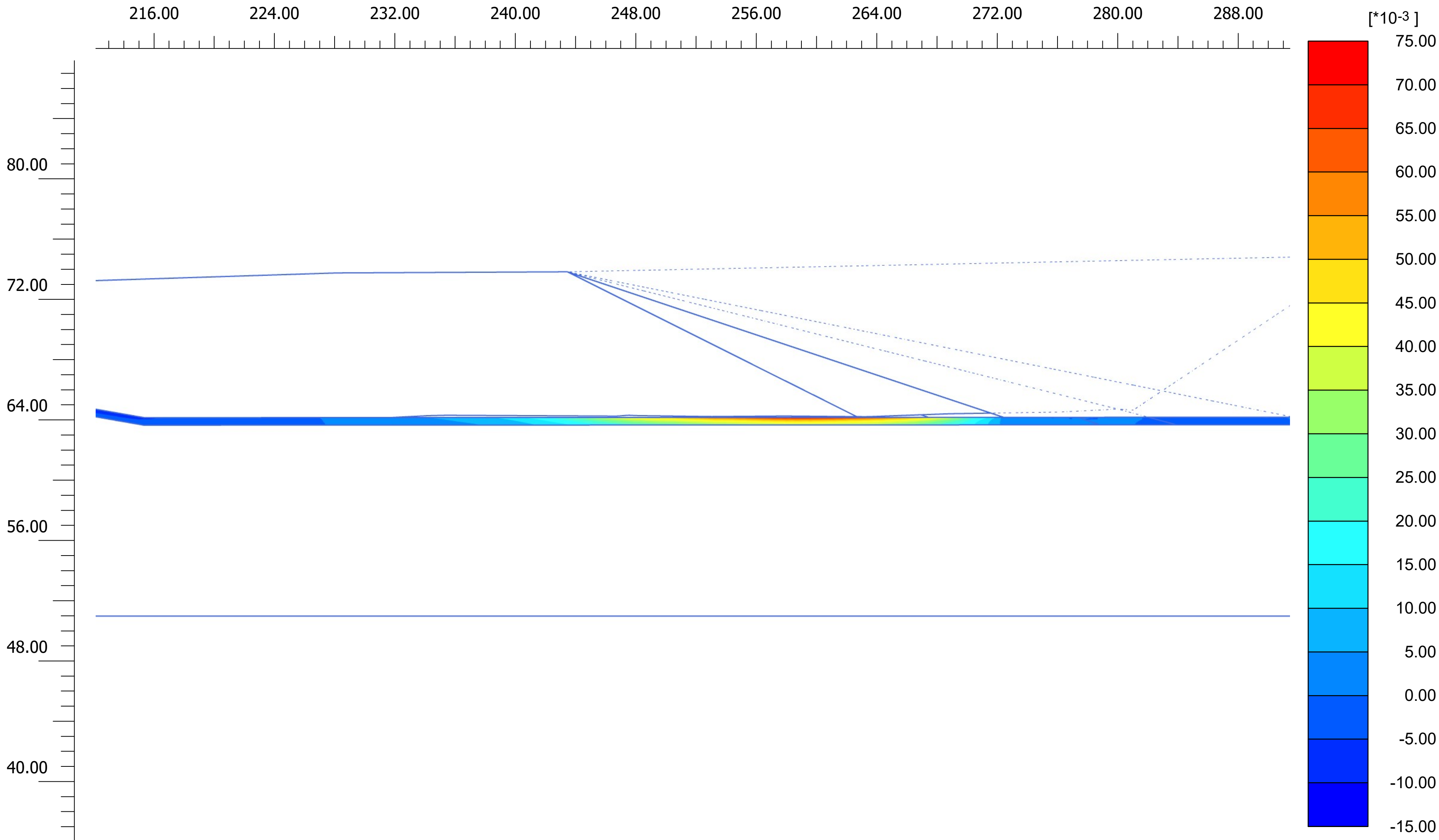
Minimum value = -0.01072 (Element 1205 at Node 13644)

PLAXIS® 2D CONNECT Edition

| Project description | Date |
|---|---|
| Cross Leys Quarry Section BB | 06/10/2022 |

| Project filename | Step | Company |
|---|---|---|
| Cross Leys Quarry Sectio ... | 764 | Sirius Environmental Ltd |

Output Version 21.1.0.479




**Total cartesian strain $\gamma_{xy}$ (scaled up 200 times) (Time 380.0 day)**

Maximum value = 0.07484 (Element 1420 at Node 12004)

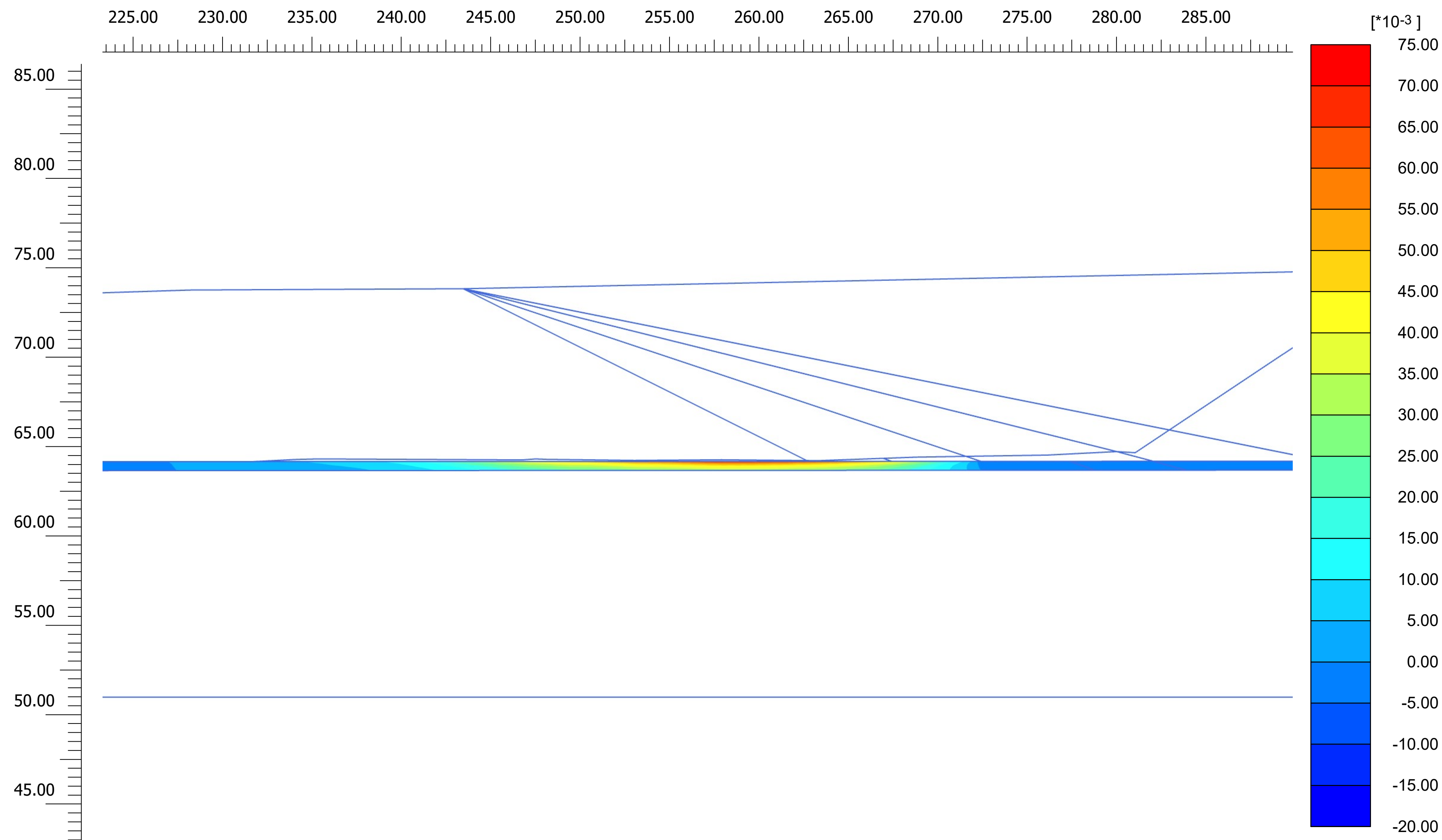
Minimum value = -0.01065 (Element 1205 at Node 13644)

PLAXIS® 2D CONNECT Edition

| *Project description* | *Date* |
|---|---|
| Cross Leys Quarry Section A-A | 06/10/2022 |

| *Project filename* | *Step* | *Company* |
|---|---|---|
| Cross Leys Quarry Sectio ... | 430 | Sirius Environmental Ltd |

Output Version 21.1.0.479




**Total cartesian strain $\gamma_{xy}$ (scaled up 200 times) (Time 665.0 day)**

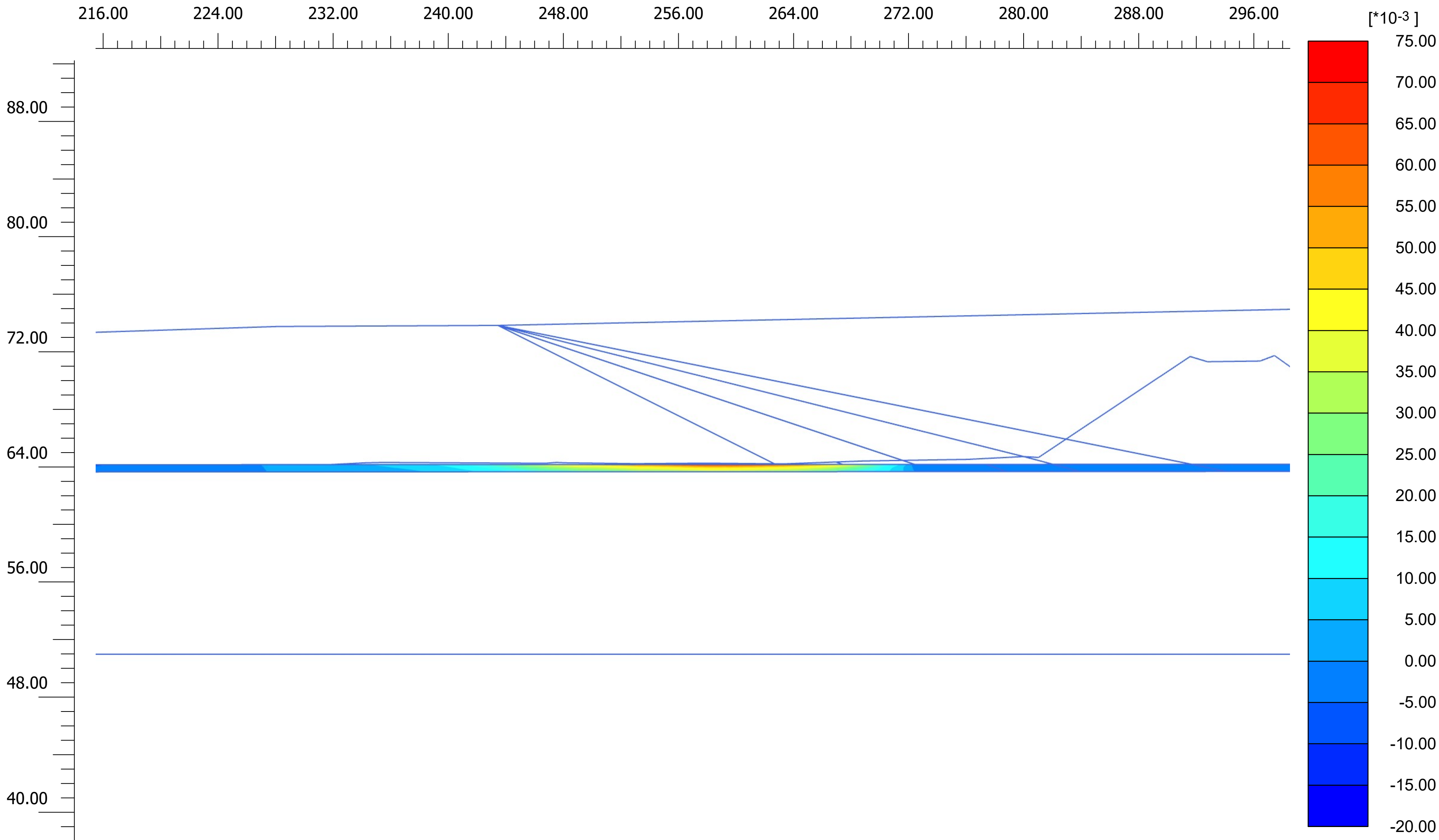
Maximum value = 0.07043 (Element 1420 at Node 12004)

Minimum value = -0.01750 (Element 1541 at Node 6033)

PLAXIS® 2D CONNECT Edition

| Project description | | Date |
|---|---|---|
| Cross Leys Quarry Section A-A | | 06/10/2022 |
| Project filename | Step | Company |
| Cross Leys Quarry Sectio ... | 540 | Sirius Environmental Ltd |

Output Version 21.1.0.479




**Total cartesian strain $\gamma_{xy}$ (scaled up 200 times) (Time 1395 day)**

Maximum value = 0.07055 (Element 1420 at Node 12004)

Minimum value = -0.01759 (Element 1541 at Node 6033)

PLAXIS® 2D
CONNECT Edition

| | | | |
|---|---|---|---|
| *Project description* Cross Leys Quarry Section A-A | | | *Date* 06/10/2022 |
| *Project filename* Cross Leys Quarry Sectio ... | *Step* 546 | *Company* Sirius Environmental Ltd | |