
Technical Note

Project:	Innova Legacy Site Wrexham	
Project No:	60727919	
Subject:	A483 Slope Stability Review [Rev 02]	
Prepared by:	Bruce Shearer, Principal Geotechnical Engineer	Date: 30 October 2024
Checked by:	Koh Ong, Principal Geotechnical Engineer	Date: 31 October 2024
Approved by:	David Raeside, Associate	Date: 31 October 2024

1. INTRODUCTION

1.1. General Background

AECOM have been commissioned by Innova Renewables Developments Limited (Innova) to review comments made in response to a planning application for an Energy Storage System (ESS). The assessment is particularly aimed at assessing concerns relating to stability of an existing slope on the A483 (Wrexham bypass) and if construction of a SuDS basin in the vicinity of the crest of this existing slope will have a detrimental impact on both global stability and groundwater flows.

The site is located 1km southwest of the town of Wrexham, directly west of the A483 Trunk Road and north of Bronwylfa Road, Rhostyllen. The site is centred on National Grid Reference (NGR) SJ 30836 48701. A Site Location Plan is presented in Appendix A.

1.2. Purpose of Technical Note

The purpose of this Technical Note is to summarise the assumptions, calculations and results from the ground investigation and present a preliminary assessment of any impact from proposed drainage regime of the proposed development on the existing A483 cutting.

Some ground investigation works have been undertaken for the ESS site but not the assessment of the A483 cutting specifically. A drawing showing the location of the Ground Investigation is presented in Appendix A. In line with standard practices, further onsite verification of ground conditions may be required prior to construction. This will be determined during the detailed design phase.

The main outcome of this technical note is to determine if the A483 will be negatively impacted by the development of the ESS site, and in particular the proposed construction of a SuDS basin and its relative proximity from the existing slope crest.

2. REVIEW OF HISTORICAL INFORMATION

2.1. Topography

A topographic survey is available for the site but not the A483 corridor. LIDAR was available for this area and this source has been used to create representative cross section of the existing ground level.

The land profile was then amended to add in the currently proposed SuDS basin to undertake a slope stability assessment of the existing and proposed situations to determine if the proposed works will have a negative impact on global slope stability. Further discussion can be found in Section 4.2 below.

2.2. British Geological Society (BGS)

The following general assessment of the geology of the site has been derived from available information from the British Geological Survey (BGS) online viewer (Ref. 1). No assurance is given to its accuracy.

Superficial Geology

The BGS online viewer indicates the A483 cutting slope is underlain with superficial deposits of Till Devensian – Diamicton, this is described by the BGS as *“Till is unsorted and unstratified drift, generally overconsolidated, deposited directly by and underneath a glacier without subsequent reworking by water from the glacier. It consists of a heterogenous mixture of clay, sand, gravel, and boulders varying widely in size and shape.”*

No made ground is recorded in the area of the cutting slope, however it is recorded to the north where there is an abandoned railway embankment and to the south for the B5097 which is on an embankment leading to a bridge crossing over the A483. Made ground would be anticipated to be below the A483.

Bedrock Geology

The cutting is shown to be underlain on the northern half by the *Pennine Lower Coal Measures Formation and Pennine Middle Coal Measures Formation*, which is described as *“Interbedded grey mudstone, siltstone and pale grey sandstone, commonly with mudstones containing marine fossils in the lower part, and more numerous and thicker coal seams in the upper part.”*

And on the southern half underlain by Etruria Formation which is described as *“Red, purple, brown, ochreous, green, grey and commonly mottled mudstone, with lenticular sandstones and conglomerates referred to as ‘espleys’.* Common pedogenic horizons, but coal seams are rare. Subordinate, lenticular sandstones and conglomerates commonly consist mostly of volcanic and lithic clasts. Intrusions of dolerite sills and dykes and extrusion of a small volume of volcanoclastic rocks are present in south Staffordshire and south Nottinghamshire.”

A fault is recorded to be approximately 150m west of the existing cutting, no information was available on the fault.

2.3. Coal Authority

The Client (Innova) instructed South West Geotechnical to undertake a coal mining risk assessment, which can be found in Appendix B. This included the Coal Authority’s Mining Report.

For the purposes of this assessment the influence of any possible coal mining has not been considered as there is no changes proposed to the existing A483 cutting and the creation of the SuDS basin is considered as part of the wider site.

3. GROUND INVESTIGATION

3.1. Summary

Between 22 and 26 April 2024 South West Geotechnical undertook geotechnical a ground investigation on behalf of the Client. Refer to Appendix A for a location plan and Appendix B for copies of the factual report. Additionally, Archaeology Wales undertook a geophysical survey in May 2023. A review of the report indicated no anomalies presented in the vicinity of the A483 cutting.

The Southwest Geotechnical ground investigation was undertaken to cover the full ESS site although the eastern extents were not explicitly part of that scope.

3.2. Ground Model

Based on the available geotechnical investigation data (specifically TP09), an indicative ground model was developed. This ground model will require verification prior to construction which will in turn will also allow the assumptions made in the design development to be verified. The preliminary ground model is summarised below in Table 1.

Table 1. Preliminary Ground Model

Strata	Depth		Comment
	Top (mbgl)	Base (mbgl)	
Sand and Gravel	0.0	2.10	Loose brown clayey silty very sandy GRAVEL and Loose orange brown slightly gravelly fine to coarse SAND
Firm Silt	2.10	2.80*	Firm light brown thickly laminated sandy clayey SILT
Groundwater	1.00		Assumed based on site wide GI, as none encountered close to cutting

*base not encountered, for purposes of this technical note and to undertake assessment, base assumed to be 4.6m (2.5m thick layer).

3.3. Material Parameters

Based on the available geotechnical investigation and testing, a set of conservative parameters were selected adopting standard correlations and previous experience for similar material.

It will be expected that when works commence on site a geotechnical engineer will inspect to verify the design assumptions. It is anticipated some further sensitivity assessment and refinement of the design might need to be undertaken, if ground conditions vary significantly from the assumptions made. All parameters used for ground stability analysis, hard standings and access road design are summarised in Table 2.

Unit Weight

The unit weight of the made ground and new engineering fill was taken from BS 8002 (Ref. 3), the value adopted are appropriate based on experience with similar materials.

Undrained Shear Strength

For the firm clay, values were determined based on the site wide GI and reference was made to guide in BS 5930 Table 9 (Ref. 4) which gives indicative strength ranges for undrained materials. On the basis that the firm clay made ground identified on site correlates to firm medium strength clay, a c_u values of 50 kPa was adopted. This is comparable with c_u values for firm/medium strength clays based on experience with similar material, however given the inherent risk of variability in made ground parameters on site verification should be undertaken during construction works.

Drained Shear Strength

For the ϕ' of the firm clay a value of 28° was adopted based on experience with similar materials and correlation of plasticity index (PI) results obtained from laboratory testing. The 3 No. PI results for the made ground ranged from 6% to 13%, taking a value of 13% would equate to a $\phi' = 28^\circ$ using equation 8 from BS 8004 (Ref. 5).

For the new loose sand and gravel a value of ϕ' was based on experience with similar material and no SPT N values were recorded in similar material. In this instance a conservative ϕ' of 30° was adopted, this correlates with typical ϕ' values for granular materials described as loose.

Drained Cohesion

A value of 0 kPa was conservatively selected for the made ground.

The characteristic values presented in Table 2 are considered to be 'cautious estimates', in accordance with Eurocode 7.

Table 2. Material Parameters

Parameter	Loose Sand and Gravel	Firm Clay
Unit Weight (kN/m ³)	18	18
Undrained Shear Strength [c_u] (kPa)	N/A	50
Drained Shear Strength [ϕ'] (°)	30	28
Drained Cohesion [c'] (kPa)	0	0
Permeability [k] (m/s)	1.2×10^{-4}	1.0×10^{-9}

4. Design

4.1. Assumptions and Limitations

- The assessment has been undertaken based on the available topographical information.
- The design parameters have been taken from several published sources and limited site-specific ground investigation data.
- An assessment of the existing slope was undertaken to establish a base line slope stability Factor of Safety.
- When considering the impact of the SuDS basin it was modelled full and empty, with the worst case results presented.
- A steady state seepage assessment only was undertaken, this included all materials being assumed as saturated.

4.2. Slope Stability

An indicative cross section was developed based on limited topographical information and was then input to Slope/W slope stability software (Version 2024.2.0), with material parameters, groundwater conditions and surcharge added and analysed. The surcharge of 10 kPa was based on the recommendation presented in BS:6031 for maintenance vehicles.

Both undrained (short term) and drained (long term) assessments were undertaken, with the drained presenting the lower factors of safety. All stability assessments were undertaken in accordance with BS EN 1997-1 Design Approach 1 combination 1 and 2 (Ref. 7 and 8), where material and some load factors are applied. The material parameters and surcharges were factored within the Slope/W software.

The calculation methodology adopted for the Slope/W assessment was the Morgenstern Price method, which considers both interslice forces and moments, making it one of the more rigorous slope stability assessment techniques. The failure surface locating options used was the grid and radius technique which searches for the lowest factor of safety to ensure the proposed design is likely to be stable within a user defined area.

4.3. Seepage Assessment

A seepage analysis was undertaken to assess the volume of water that would flow through the existing soil cutting, the analysis was undertaken in the computer software Seep/W produced by Geostudio. Seep/W works using finite element analyses.

There are two type of finite element seepage analyses, steady-state and transient, however in this instance only a steady-state assessment was undertaken. Steady-state works by modelling the water pressures and flow rates without change, in this case this method can be considered a worst case situation as the time for a soil to become fully saturated is often longer than the time that a flood event will occur over. Steady-state method can be used to model the long-term flows, however, it cannot be used to calculate flow rate over a period of time.

Seep/W models have been used to calculate & assess the volume of water flowing through the existing cutting for:-

- A base case, taken as groundwater being at existing ground level during a rainfall event.
- Water being retained in the SuDS basin post construction during a flood event.
- The addition of design interventions to provide mitigation such as impermeable lining to the sides of SuDS basins to help avoid erosion of the soil below the surface, commonly referred to as piping. Piping can eventually lead to failure of the soil cutting.

The values of water flow and porewater pressure calculated by the seepage assessment are then used to reassess the slope stability of the existing cutting to represent the potential instability caused during a flood event.

4.4. Results

Table 3 below summarises the slope stability results. The location of the section can be seen on drawing 60727919-ACM-XX-00-SK-CE-0105 in Appendix A and a visual representation of the slope stability assessment outputs can be found in Appendix C.

Table 3. Summary of Slope Stability Assessment Results

Model	Slope Stability Factor of Safety*	
	DA1 – C1	DA1 – C2
Existing Slope – Drained	1.562	1.263
Existing Slope – Undrained	1.562	1.263
Existing Slope with SUDS pond added – Drained	1.562	1.263
Existing Slope with SUDS pond added – Undrained	1.562	1.263

* minimum target value to comply with BS EN 1997 design standard = 1.0

It is noted that the drained and undrained factor of safety are the same due to the predicted slope failures being within the sand layer which doesn't have any undrained strength properties.

Table 4 on the following page sets out the comparative seepage assessment results of a series of design scenarios and establishes a baseline value. The change between the results in Table 3 is the addition of pore water pressures and groundwater flow rates/volumes to replicate flooding conditions. If the calculated values are ...

(a) less than the "Baseline" seepage value in Table 4 and

(b) show a Factor of Safety >1

...the slope is regarded as stable during a flood event.

The area practicably available for siting the SuDS basin is constrained by site boundaries and the route of a Public Right of Way. As such, the three comparative designs along with the baseline scenario that have been considered and presented work within those plan parameters. In the context of proximity and depth of the SUDS basin to the crest of the cutting along the A483, the assessed options are as follows:

- Baseline scenario to establish the predicted flow rates and slope stability during flood events
- 1 – 5m offset from the crest, and no liner installed. The basin drains via infiltration.

- 2 – 5m offset from the crest, with impermeable liner installed at the sides of the basin. Infiltration of stored water is through the base of the basin.
- 4 – 10m offset from the crest with impermeable liner installed at the sides of the basin. Infiltration of stored water is through the base of the basin which is 200mm deeper than (3) above. The overall footprint of the basin is reduced to work within other layout constraints, hence the increased depth.

Table 4. Summary of Seepage Assessment Results

Case	Seepage Result* (m³/day)	Slope Stability Factor of Safety**				Comments
		Drained		Undrained		
		DA1-C1	DA1-C2	DA1-C1	DA1-C2	
Base line	5.88	1.015	0.626	1.015	0.626	Non-compliant design during a flood event
5m offset	4.84	1.141	0.795	1.141	0.795	Non-compliant design during a flood event
5m offset with partial liner	2.59	1.410	1.099	1.410	1.099	Compliant design during flood event
10m offset and 0.2m deeper with partial liner	1.99	1.495	1.202	1.495	1.202	Compliant design during flood event

*value calculated at toe of cutting

** minimum target value to comply with BS EN 1997 design standard = 1.0

It is noted that the drained and undrained factor of safety against slope failure are the same due to the predicted slope failures being within the sand layer which doesn't have any undrained strength properties.

4.5. Discussion

Based on the assessed cross sections and assumptions made, the limited available information and engineering judgement, the proposed addition of the SuDS basins offset approximately 5m from the existing A483 slope crest and lined along its sides would not have a detrimental impact on the slope stability during normal groundwater conditions. These results were refined by the seepage assessment to consider the impact on groundwater flows and porewater pressures during a flood event.

The results of the seepage assessment for the baseline condition (that is the cutting and adjacent field with the current geometry) generate results that suggest there is low resistance to slope instability during a flood event where groundwater would be at existing surface level and fully saturate the existing cutting slope.

There are increased flow rates and reduced factor of safety for slope stability when installing the proposed SuDS basin with a 5m offset and no allowance for a liner, however, if a liner on the side slope and 5m along the base are included then the results show an improvement on the base case. An improvement is also shown in one further case explored by AECOM. The results presented in Table 4 show the improvement in slope stability and reducing the predicted flow rates.

As such it can be concluded that installing the SuDS basin with a partial liner would provide a reduction in flow rates and a betterment on the slope stability during a flood event and have no predicted impact during normal groundwater conditions.

This preliminary slope stability assessment should not be considered as a detailed design assessment and is based on the information available at the time of writing.

5. RECOMMENDATIONS

5.1. Recommendations

Based on the assumptions from the current ground investigation, the existing A483 slope would be at no additional risk from slope instability, and the proposed works may improve slope stability in a full flood event.

It is reasonable to expect that during detailed design stages there may be amendment to the ESS site layout in the course of design development, in which case the slope stability assessment should be revisited.

Further Ground Investigation is understood to be planned commensurate with the next stages of design. Again, the results of which can be utilised to update the currently assumed ground model and/or parameters and affirm the conclusions in section 4 above.

The assessment is considered appropriate for the current status of the development proposals.

6. Reference

Ref 1 – British Geological Survey, Interactive Online Viewer, available at:
<http://mapapps2.bgs.ac.uk/geoindex/home.html> [Accessed 23/07/2024].

Ref 2 – The Coal Authority, Interactive Online Viewer, available at:
<http://mapapps2.bgs.ac.uk/coalauthority/home.html> [Accessed 23/07/2024].

Ref. 3 – BSI, (2015), BS 8002:2015 Code of practice for earth retaining structures.

Ref. 4 – BSI, (2020), BS 8004:2015+A1:2020 Code of practice for foundations.

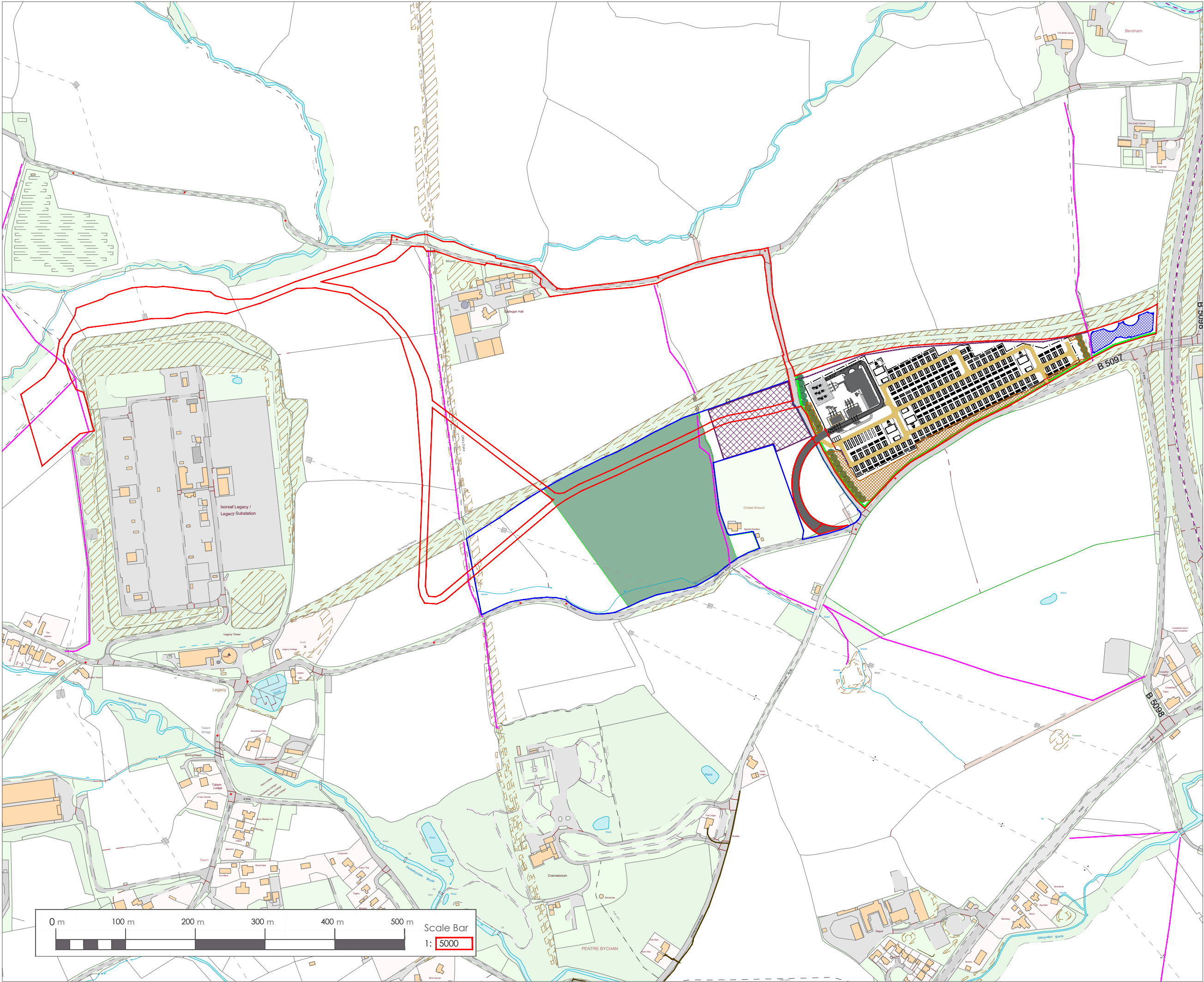
Ref. 5 – BSI, (2020), BS 5930:2015+A1:2020 Code of practice for ground investigations

Ref. 6 – BSI (2003), NA to BS EN 1991-2:2003, UK National Annex to Eurocode 1: Actions on structures
– Part 2: Traffic loads on bridge

Ref. 7 – BSI, (2014), BS EN 1997-1:2004+A1:2013 Eurocode 7: Geotechnical design – Part 1: General rules

Ref. 8 – BSI, (2014), NA+A1:2014 to BS EN 1997-1:2004+A1:2013 UK National Annex to Eurocode 7: Geotechnical design – Part 1: General rules

Appendix A – Drawings



- KEY:
- Development Boundary
 - Additional Land Within Applicants Control
 - ESS Unit
 - 400kV Substation
 - 33kV Bay
 - Access Track
 - Access Road
 - Permissive Footpath
 - Bund
 - Attenuation Basin
 - Construction Compound
 - Ecological Enhancement Area
 - Woodland Planting
 - Hedgerow Enhancement
 - Fenceline
 - Access Gate
 - Water Container
 - Storage Container
 - Office Container
 - Parking Spaces
 - PRoW



DATE: 28/06/2024

PROJECT TITLE:

Legacy

DRAWING TITLE:

Layout Plan

DRAWING VERSION NUMBER:

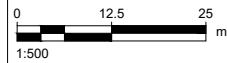
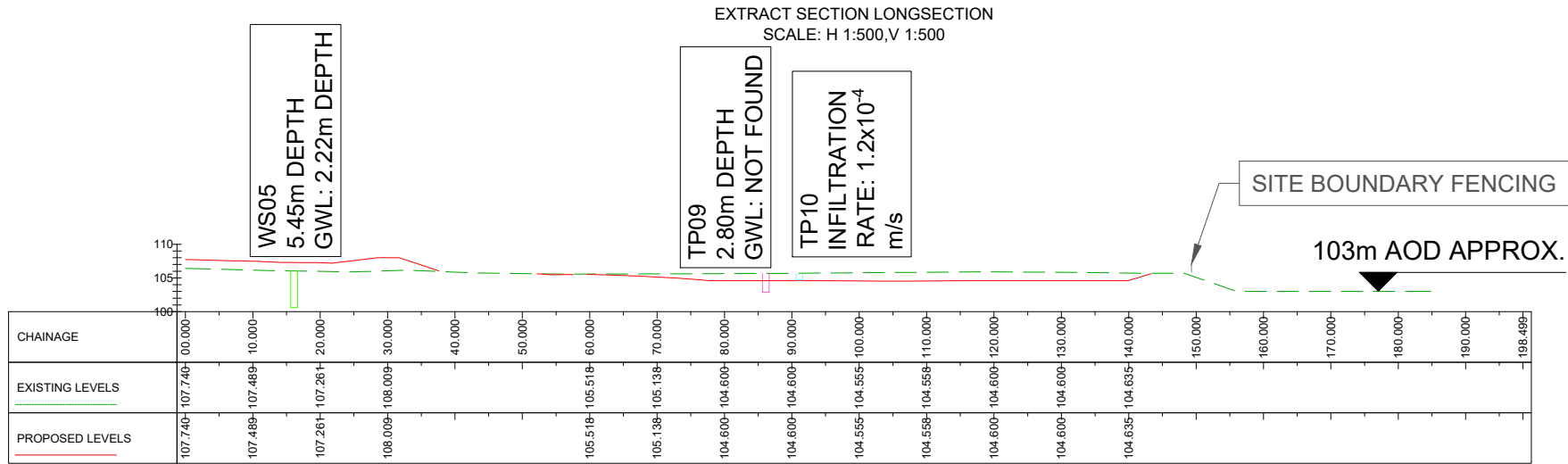
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APPROVED BY: WG



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OS Base Mapping	INNOVA	V12 REV	02.2024
Topographical Survey	RPS GROUP	UAT3172_A	03.2023
Planning Layout	INNOVA	V12 REV	02.2024
Proposed Development Levels	INNOVA	332610070-STN-HGT -XX-DR-CE-0601-P03	09.2023
Trial Pit and Borehole Information	SOUTH WEST GEOTECHNICAL LTD	-	05.2024
Infiltration Trial Pit Testing	GIBBS GEOTECHNICAL	-	05.2023

1. ALL DIMENSIONS SHOWN IN METERS UNLESS OTHERWISE STATED.

KEY

- MAY 2024 GROUND INVESTIGATION
- STANDARD TRIAL PIT (ON SECTION LINE, OFF SECTION LINE)
 - EXTENDED TRENCH (ON SECTION LINE, OFF SECTION LINE)
 - WINDOW SAMPLE BOREHOLE (ON SECTION LINE, OFF SECTION LINE)

MAY 2023 INFILTRATION TESTING

- TRIAL PIT (ON SECTION LINE, OFF SECTION LINE)

ISSUE/REVISION

Rev	Date	Description	Drn/Chk/Appr
-	06.09.2024	FIRST ISSUE	TGR/RQ

Key Plan

Purpose Of Issue

FOR INFORMATION

Project Number

60727919

Sheet Title

LEGACY SITE LEVELS STRATEGY -
SITE SECTION WITH GI RESULTS
NATURAL SCALE EXTRACT

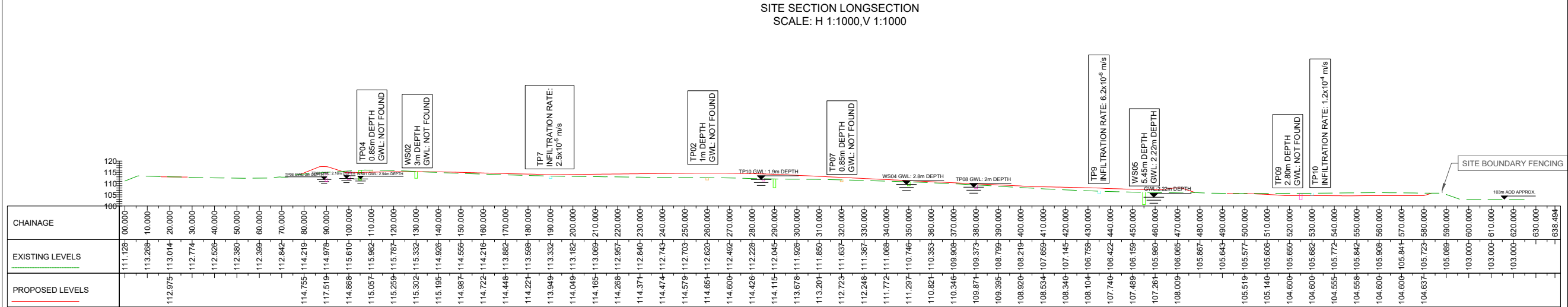
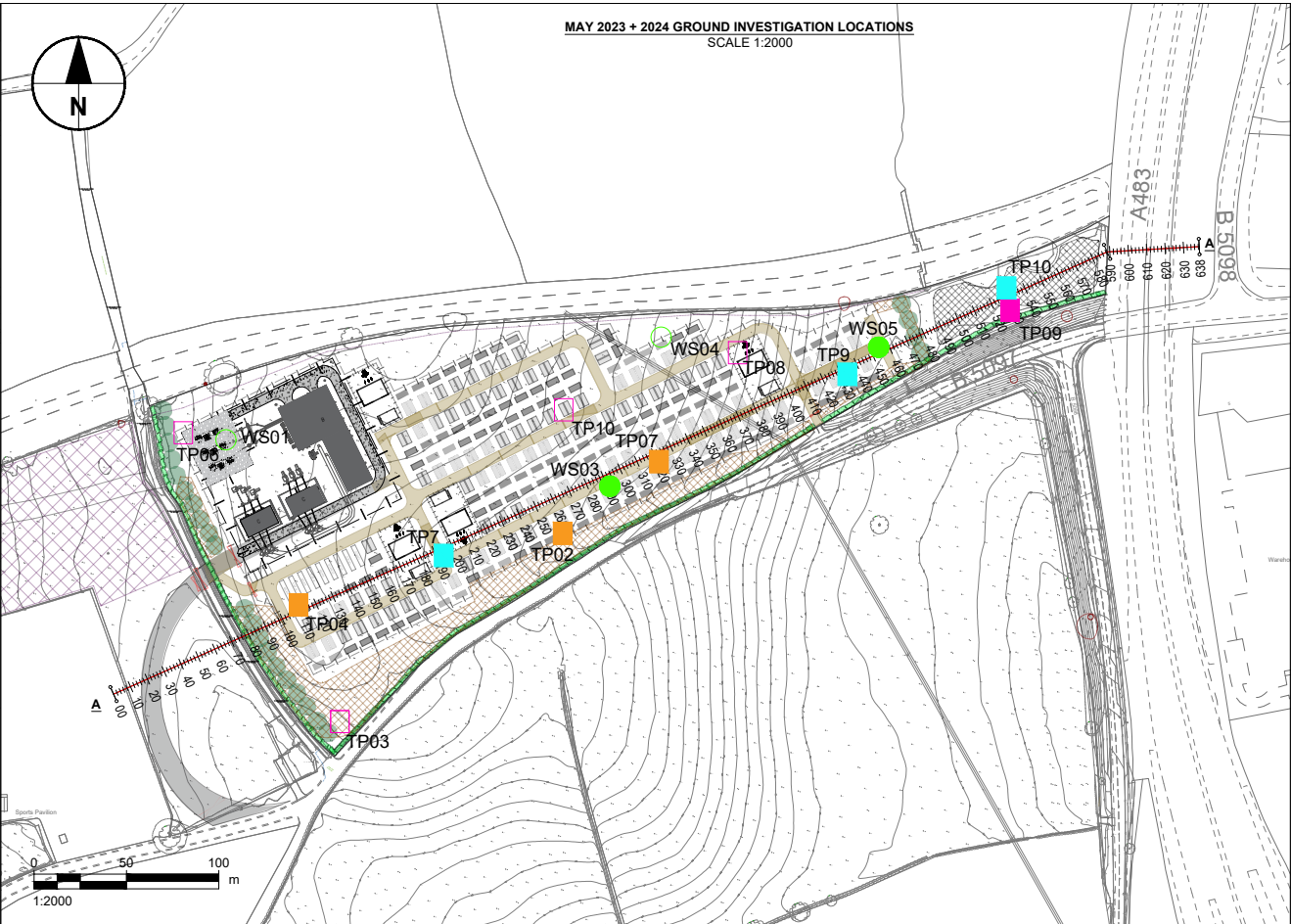
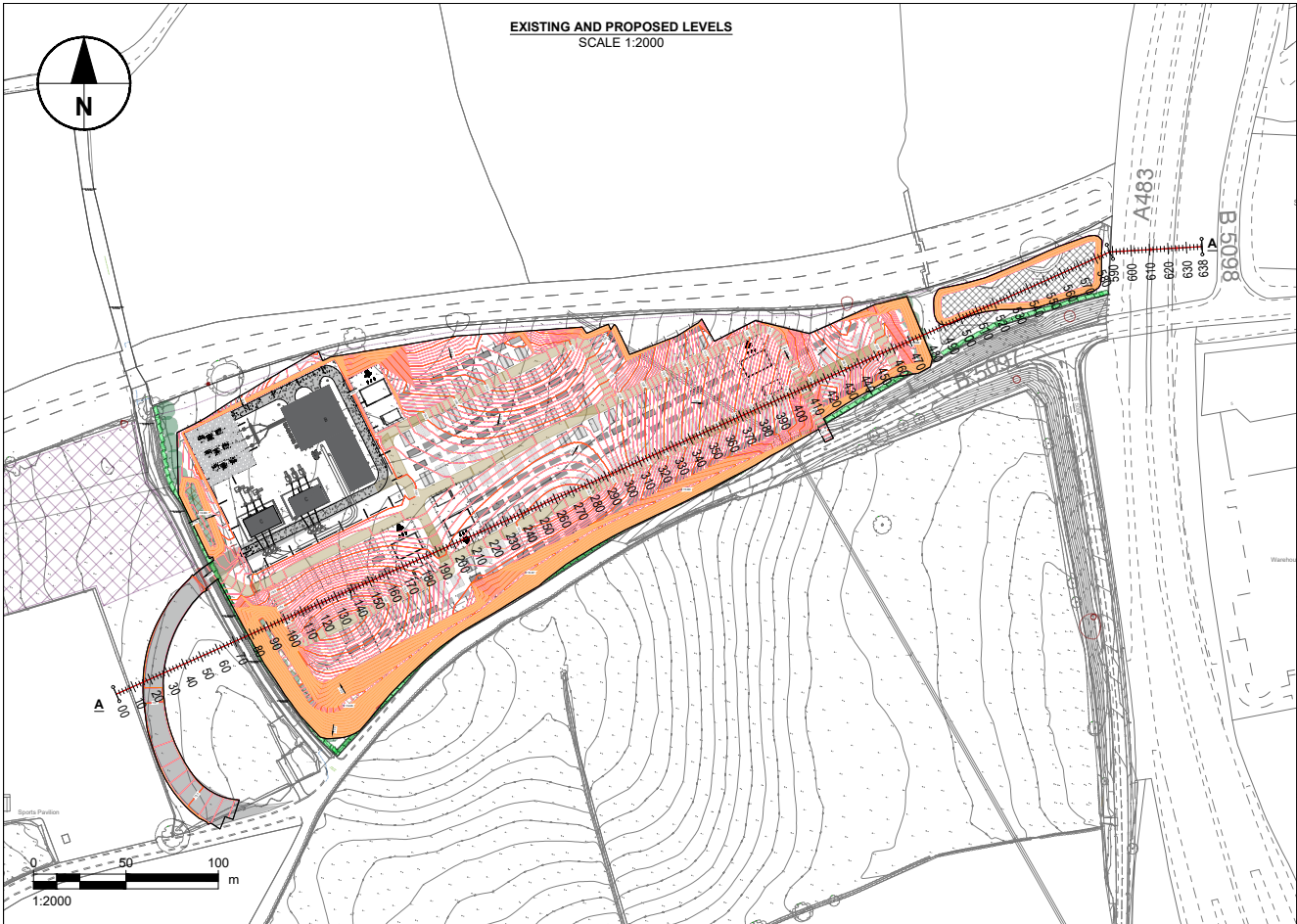
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Third Party Information	Issued By:	DWG Ref:	Date:
OS Base Mapping	INNOVA	V12 REV	02.2024
Topographical Survey	RPS GROUP	UAT3172_A	03.2023
Planning Layout	INNOVA	V12 REV	02.2024
Proposed Development Levels	INNOVA	332610070-STN-HGT -XX-DR-CE-0601-P03	09.2023
Trial Pit and Borehole Information	SOUTH WEST GEOTECHNICAL LTD	-	05.2024
Infiltration Trial Pit Testing	GIBBS GEOTECHNICAL	-	05.2023

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Notes

1. ALL DIMENSIONS SHOWN IN METERS UNLESS OTHERWISE STATED.

KEY
MAY 2024 GROUND INVESTIGATION
STANDARD TRIAL PIT (ON SECTION LINE, OFF SECTION LINE)
EXTENDED TRENCH (ON SECTION LINE, OFF SECTION LINE)
WINDOW SAMPLE BOREHOLE (ON SECTION LINE, OFF SECTION LINE)

MAY 2023 INFILTRATION TESTING
TRIAL PIT (ON SECTION LINE, OFF SECTION LINE)

ISSUE/REVISION

Rev	Date	Description	TG/RQR
-	06.09.2024	FIRST ISSUE	TG/RQR

Key Plan

Purpose Of Issue

FOR INFORMATION

Project Number

60727919

Sheet Title

LEGACY SITE LEVELS STRATEGY -
SITE SECTION WITH GI RESULTS
NATURAL SCALE

Sheet Number

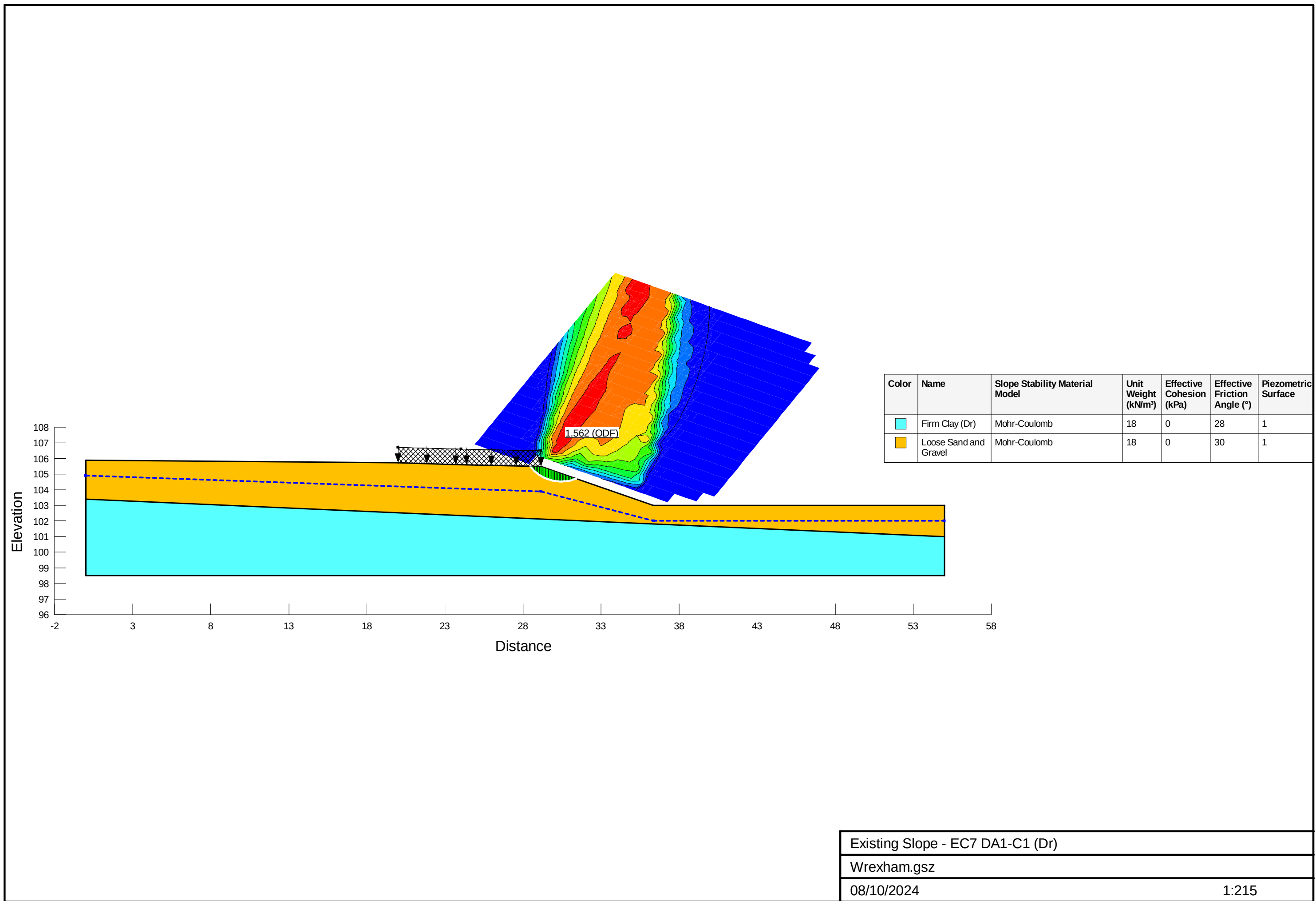
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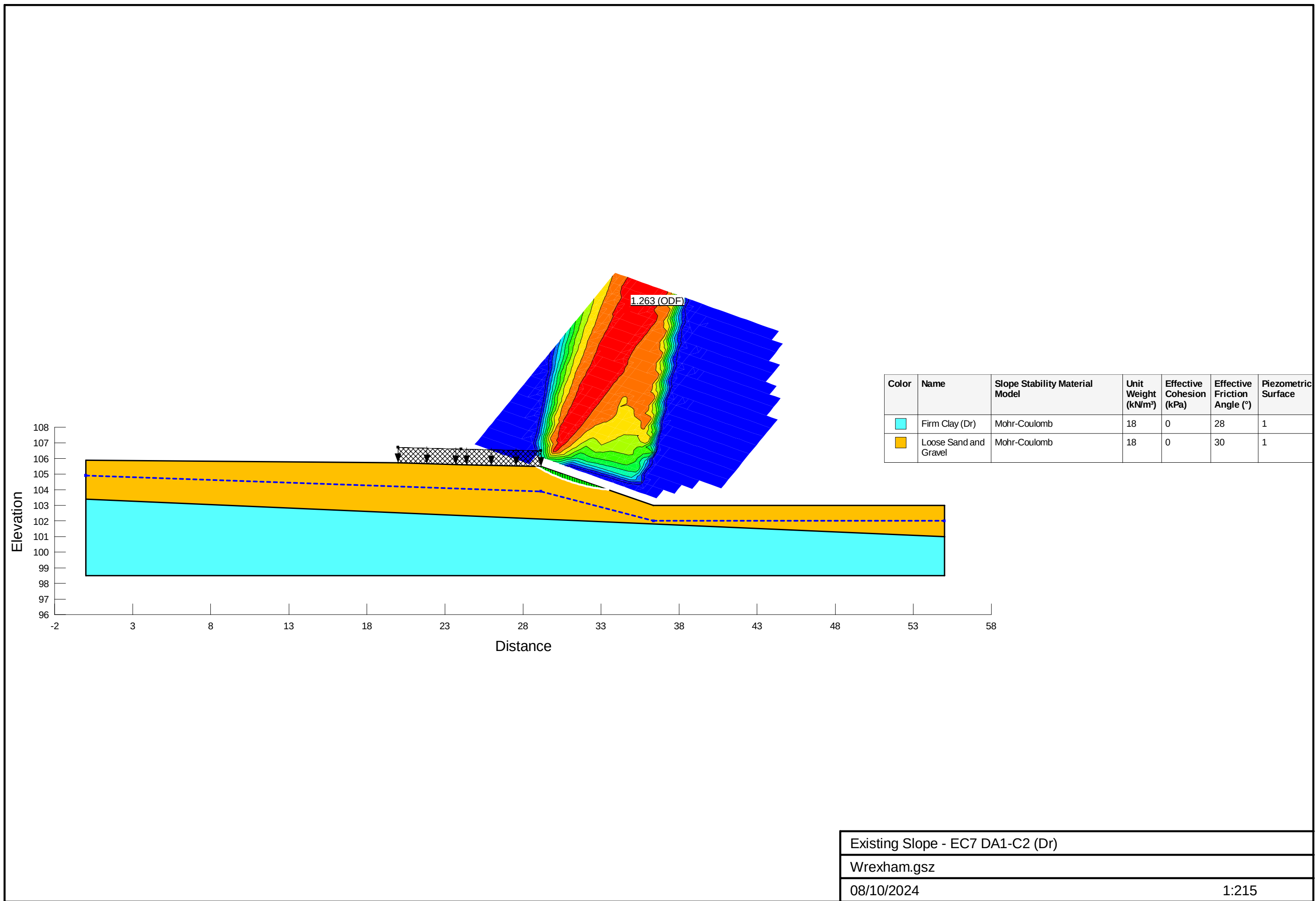
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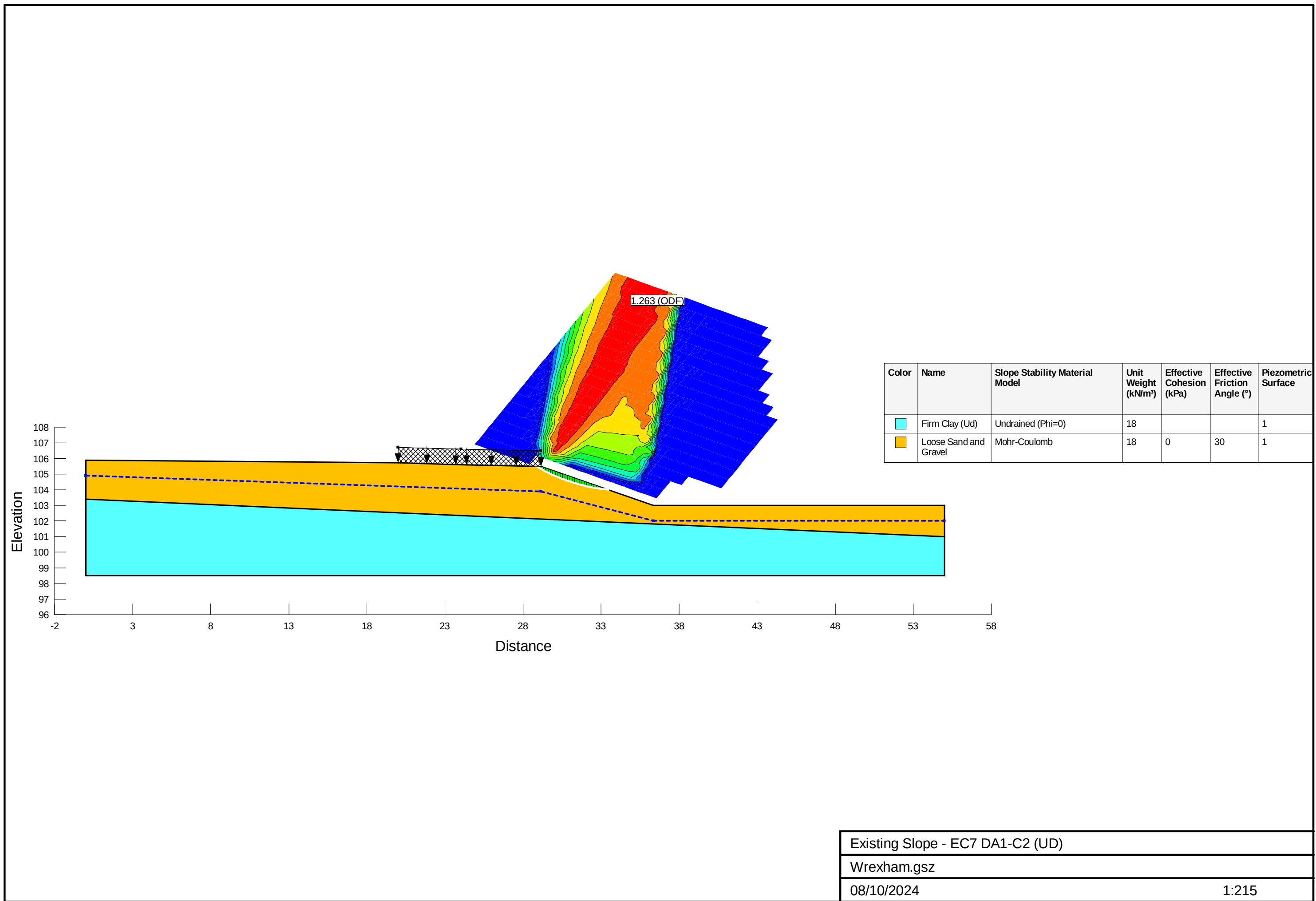
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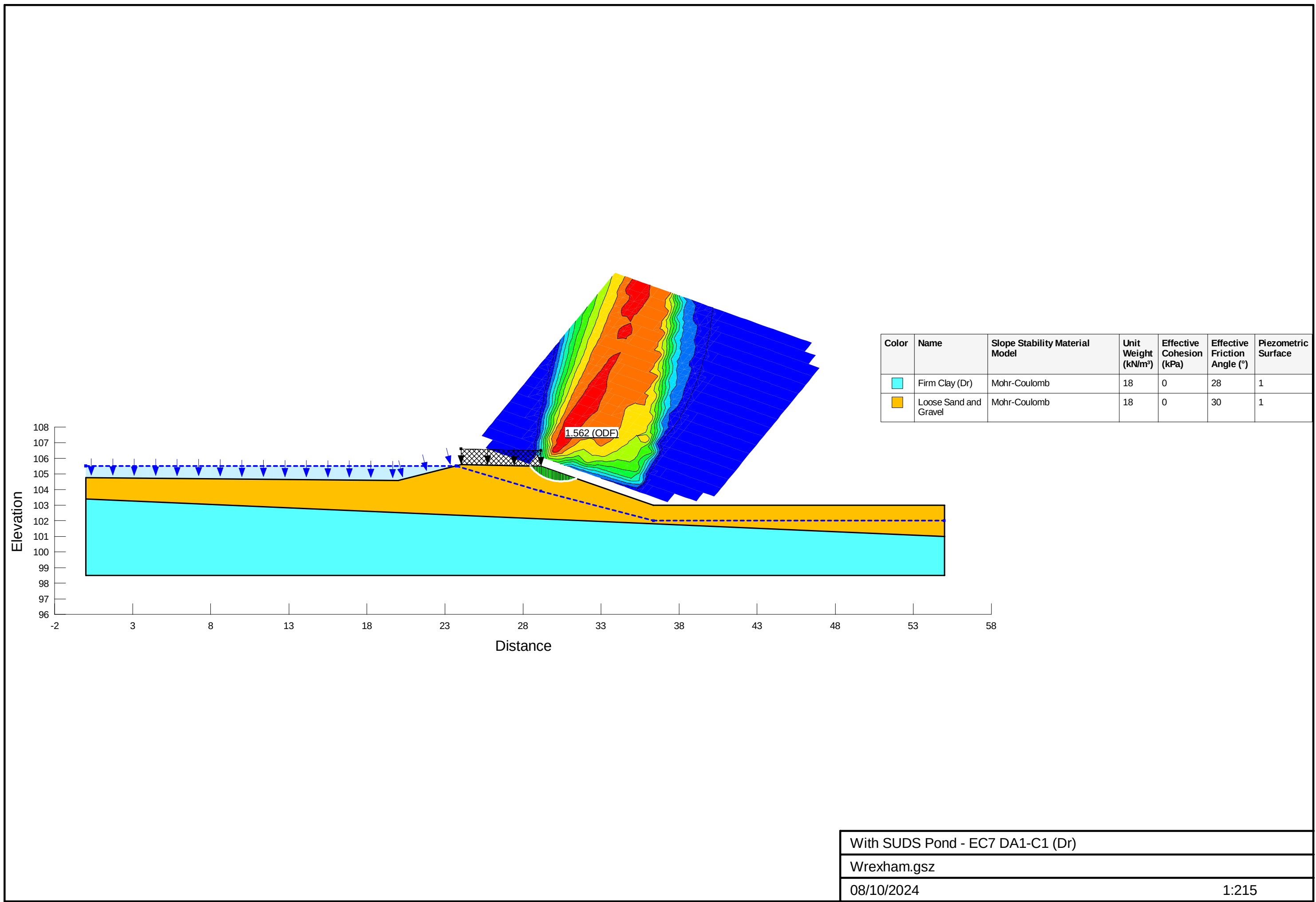
Appendix B – GI Report

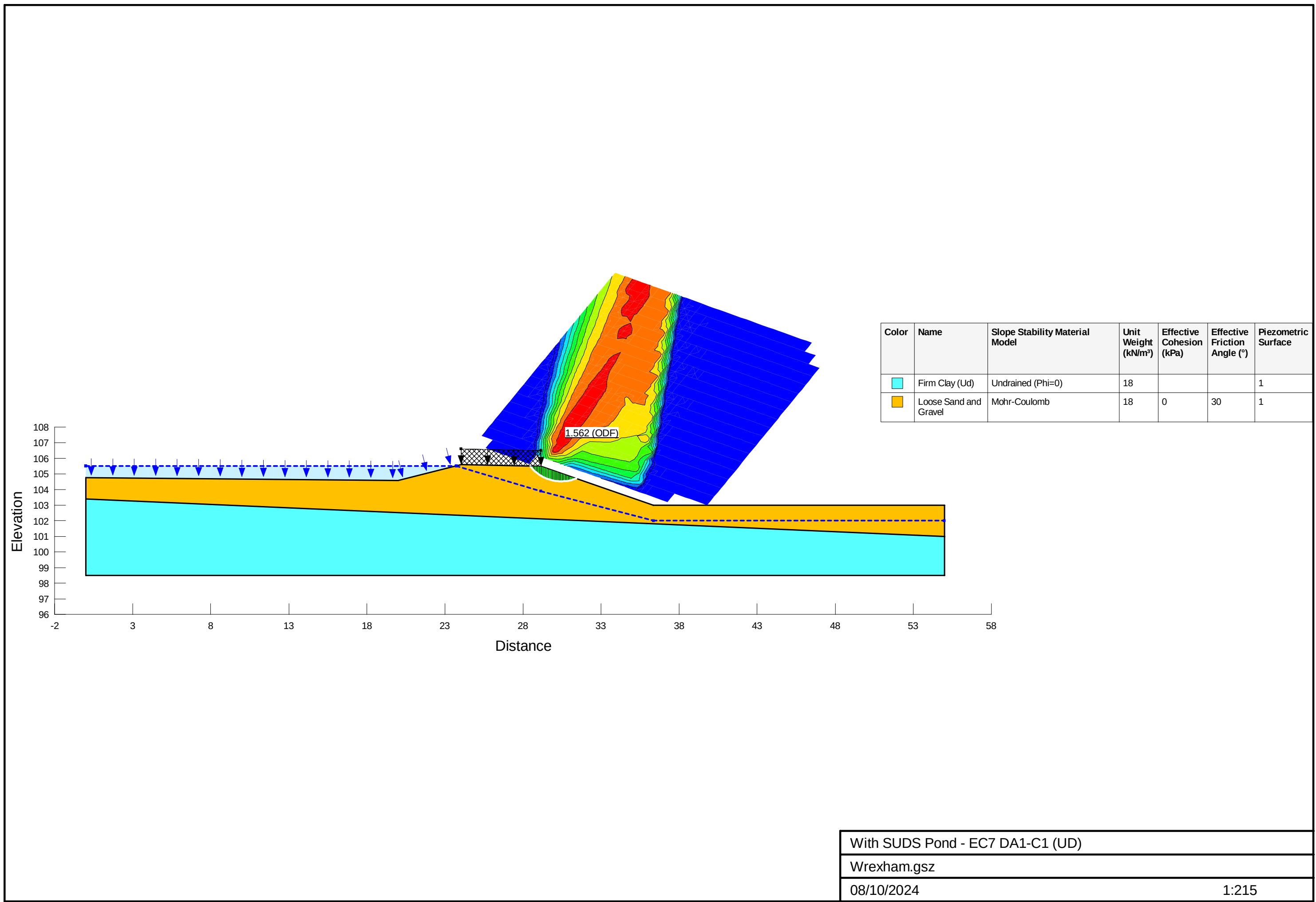
Appendix C – Slope/W Outputs

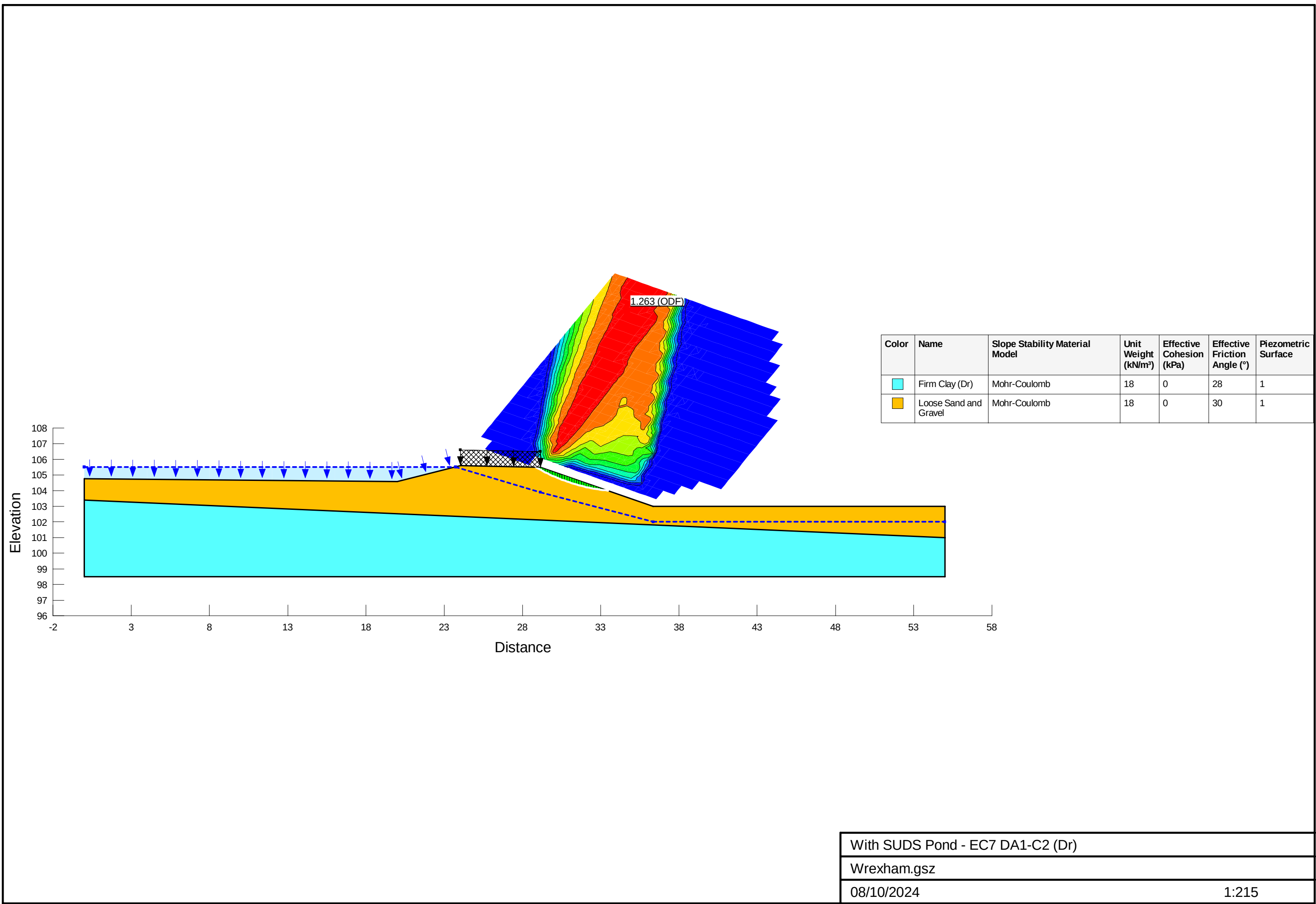


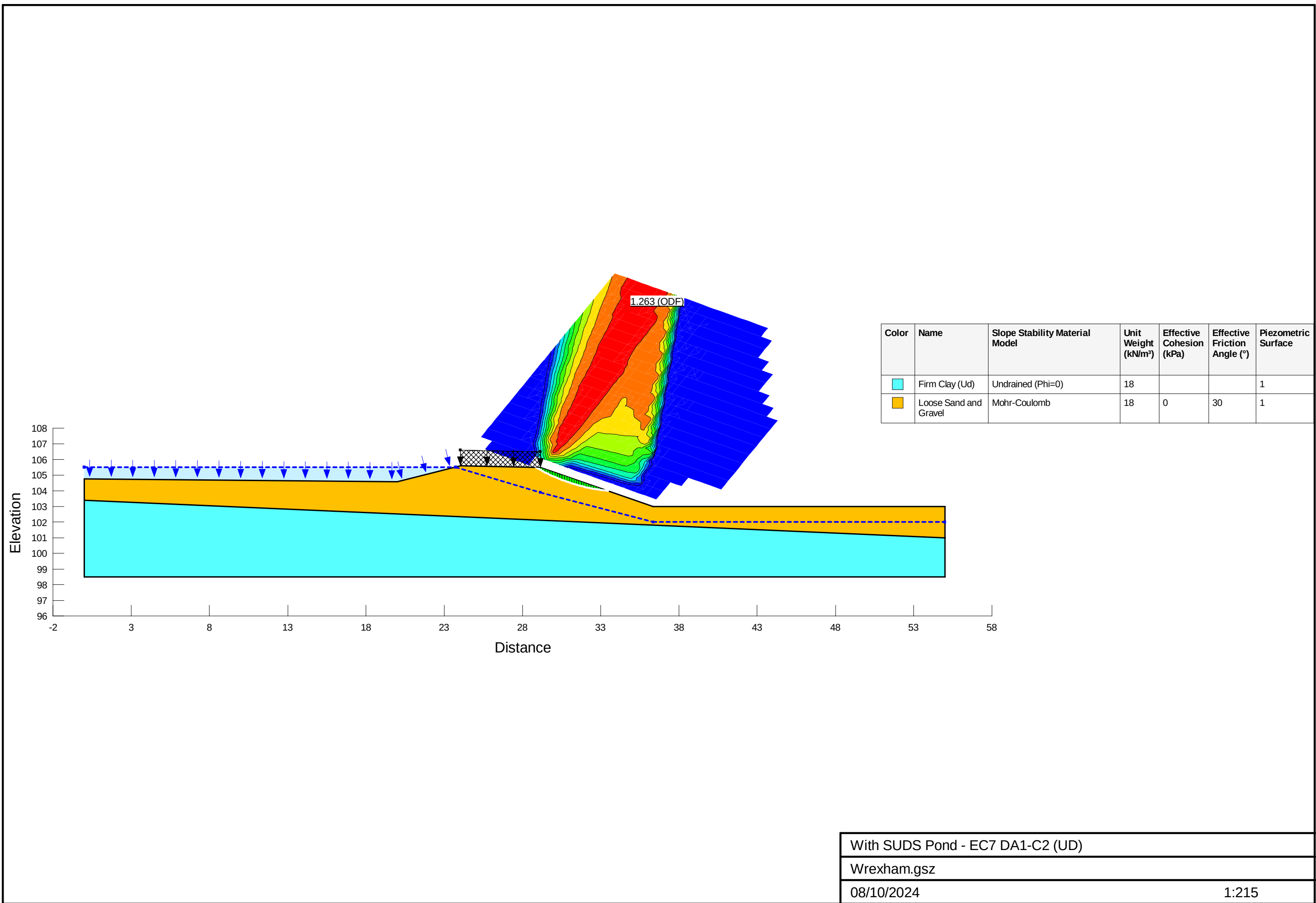






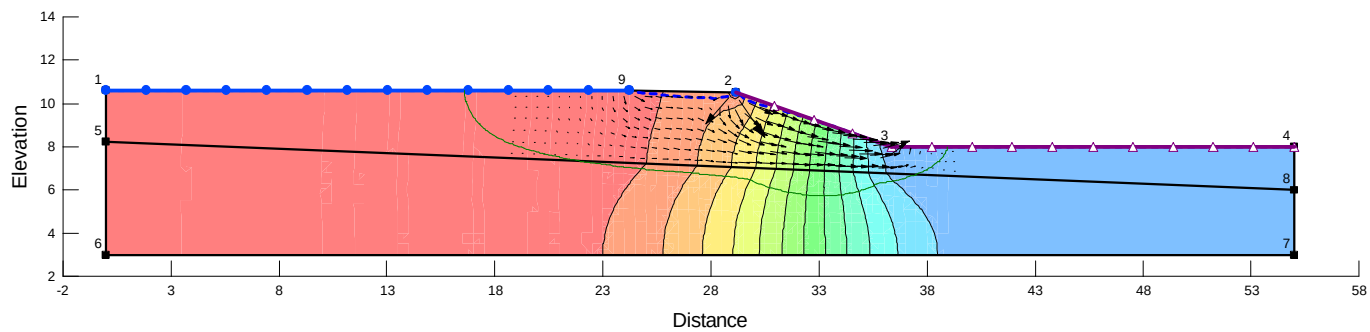






Appendix D – Seep/W Outputs

Color	Name	Hydraulic Material Model	Vol. WC. Function	K-Function	Ky/Kx' Ratio	Kz/Kx' Ratio	Dip Direction (°)	Dip (°)
■	Firm Clay (UD)	Saturated / Unsaturated		Clay	1	1	90	0
■	Loose Sand & Gravel	Saturated / Unsaturated	S+G	S+G	1	1	90	0



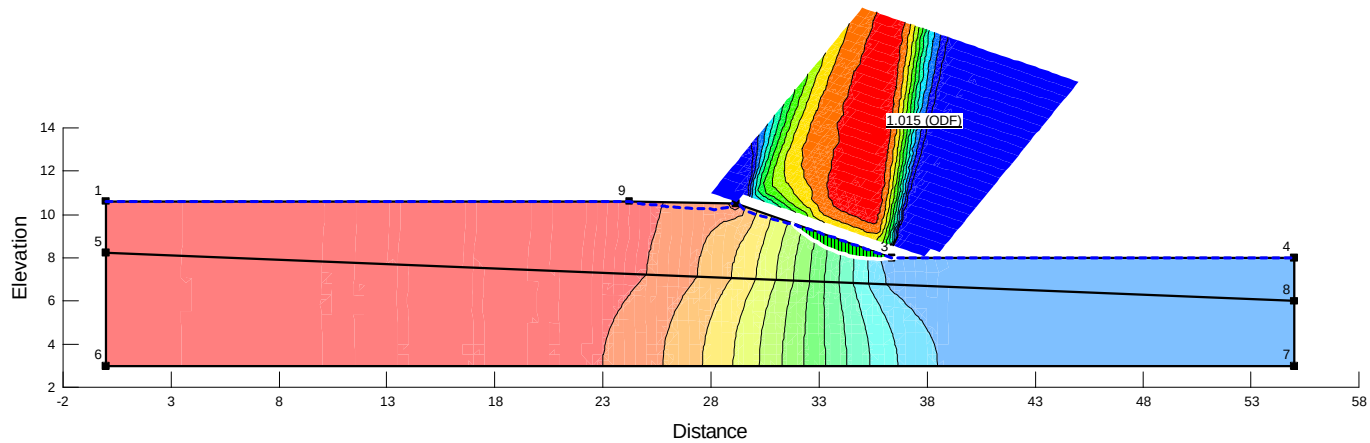
SEEP/W (Baseline)

Wrexham SS Seepage Analysis (Liner).gsz

08/10/2024

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Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)
	Firm Clay (DR)	Mohr-Coulomb	18	0	28	0
	Loose Sand & Gravel	Mohr-Coulomb	18	0	30	0



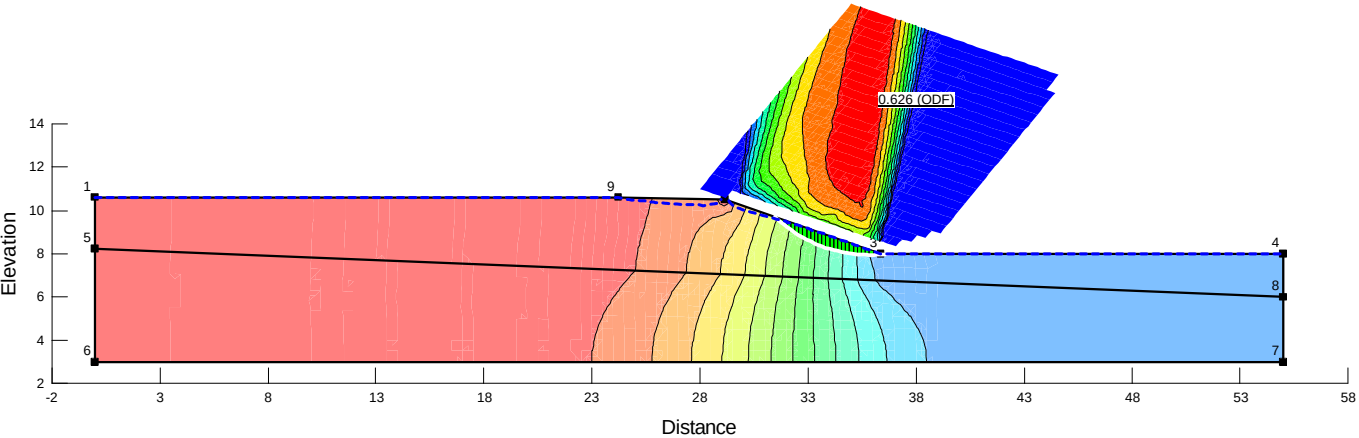
EC7 DA1-C1 DR (Baseline)

Wrexham SS Seepage Analysis (Liner).gsz

08/10/2024

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Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)
Green	Firm Clay (DR)	Mohr-Coulomb	18	0	28	0
Yellow	Loose Sand & Gravel	Mohr-Coulomb	18	0	30	0



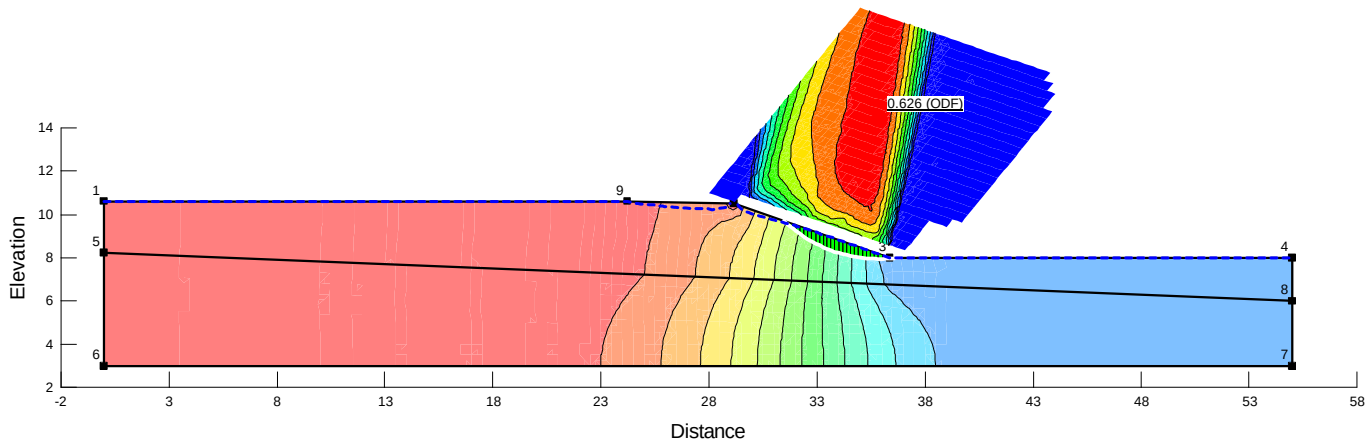
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Wrexham SS Seepage Analysis (Liner).gsz

08/10/2024

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Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Undrained Shear Strength (kPa)
■	Firm Clay (UD)	Undrained (Phi=0)	18				50
■	Loose Sand & Gravel	Mohr-Coulomb	18	0	30	0	



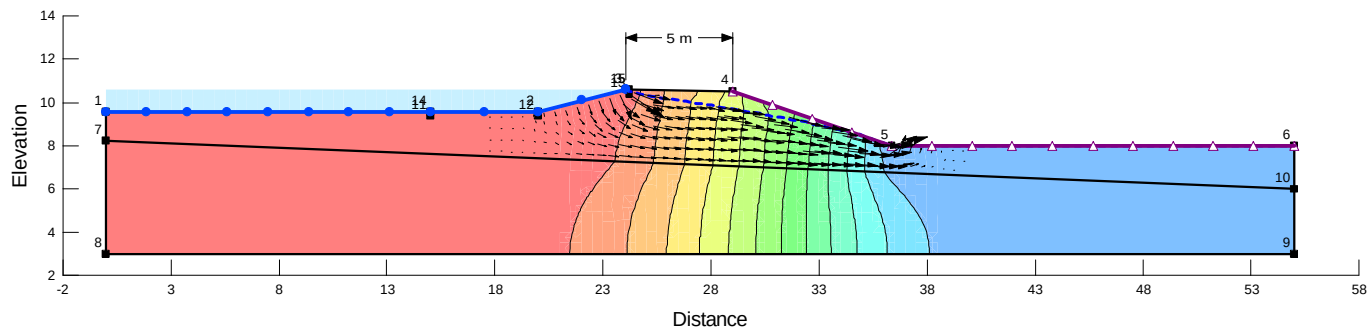
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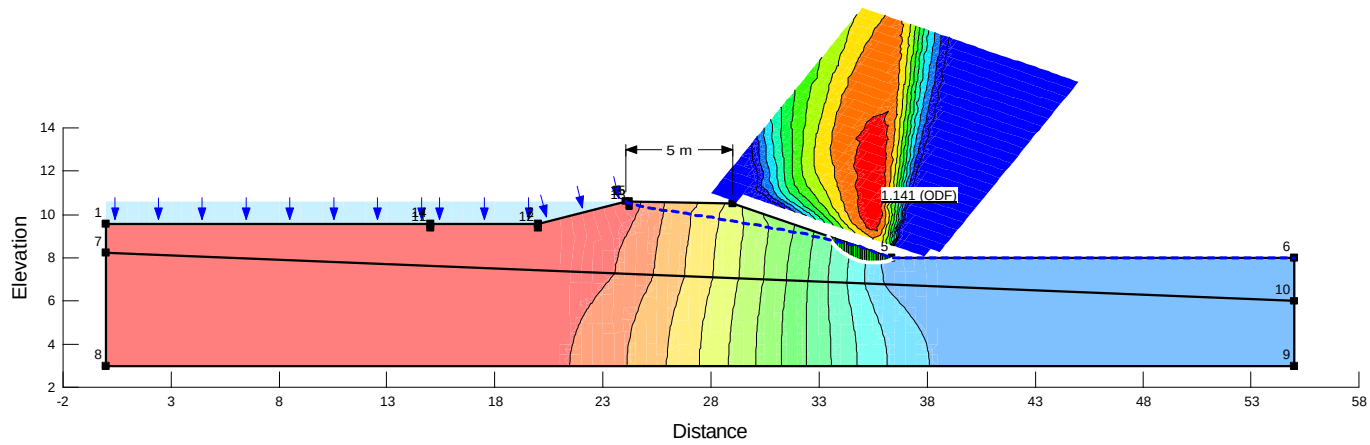
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Color	Name	Hydraulic Material Model	Vol. WC. Function	K-Function	Ky/Kx' Ratio	Kz/Kx' Ratio	Dip Direction (°)	Dip (°)
■	Firm Clay (UD)	Saturated / Unsaturated		Clay	1	1	90	0
■	Loose Sand & Gravel	Saturated / Unsaturated	S+G	S+G	1	1	90	0



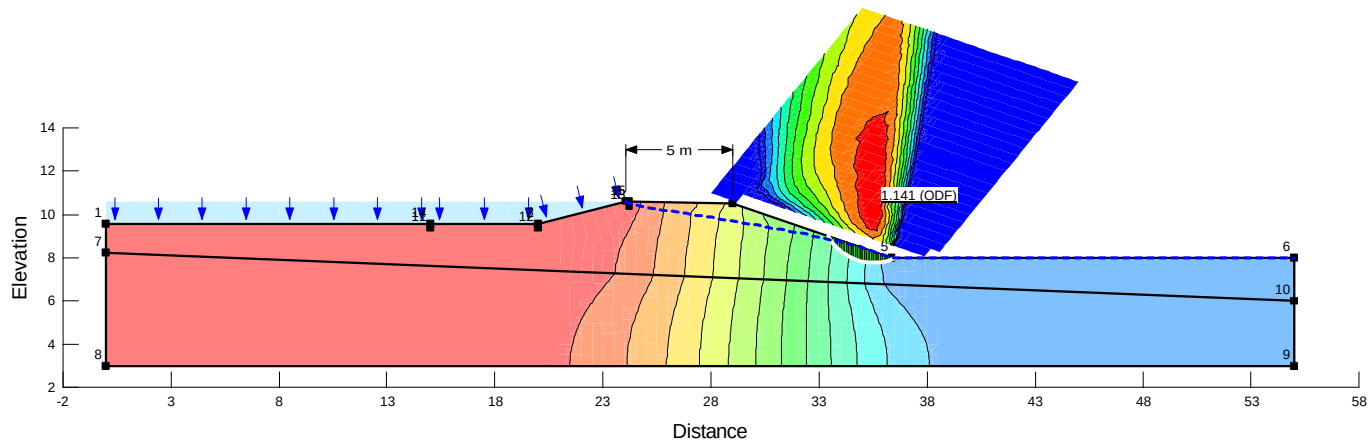
SEEP/W (5m Offset)
Wrexham SS Seepage Analysis (Liner).gsz
08/10/2024
1:350

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)
Green	Firm Clay (DR)	Mohr-Coulomb	18	0	28	0
Yellow	Loose Sand & Gravel	Mohr-Coulomb	18	0	30	0



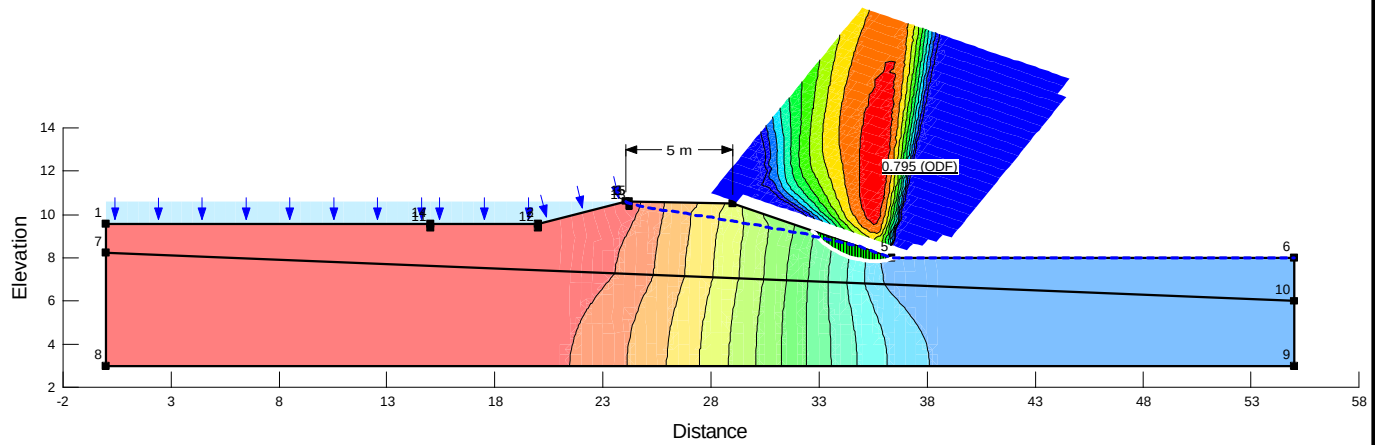
EC7 DA1-C1 DR (5m Offset)
Wrexham SS Seepage Analysis (Liner).gsz
08/10/2024
1:350

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Undrained Shear Strength (kPa)
■	Firm Clay (UD)	Undrained (Phi=0)	18				50
■	Loose Sand & Gravel	Mohr-Coulomb	18	0	30	0	



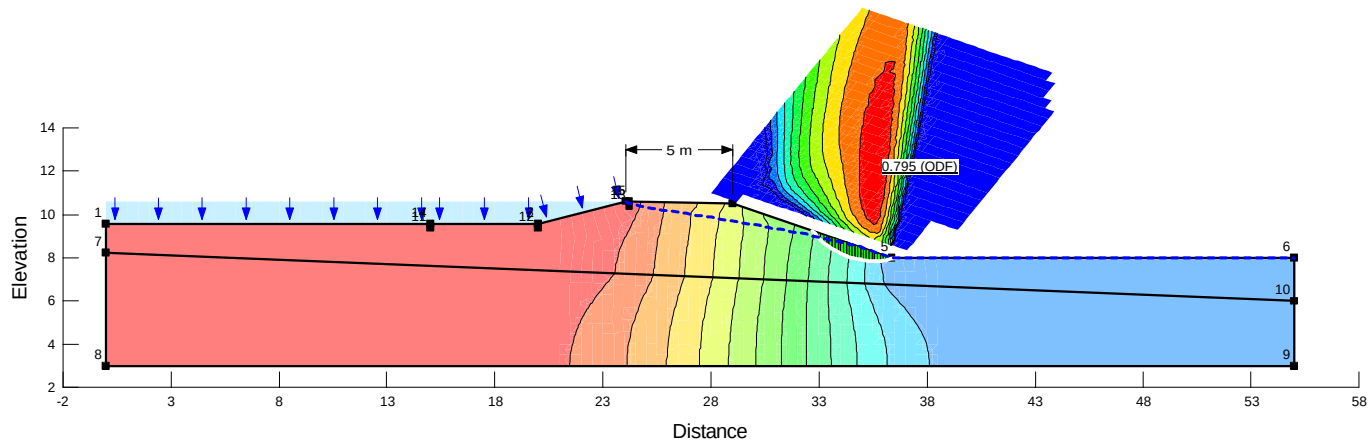
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Wrexham SS Seepage Analysis (Liner).gsz
08/10/2024
1:350

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)
Green	Firm Clay (DR)	Mohr-Coulomb	18	0	28	0
Yellow	Loose Sand & Gravel	Mohr-Coulomb	18	0	30	0



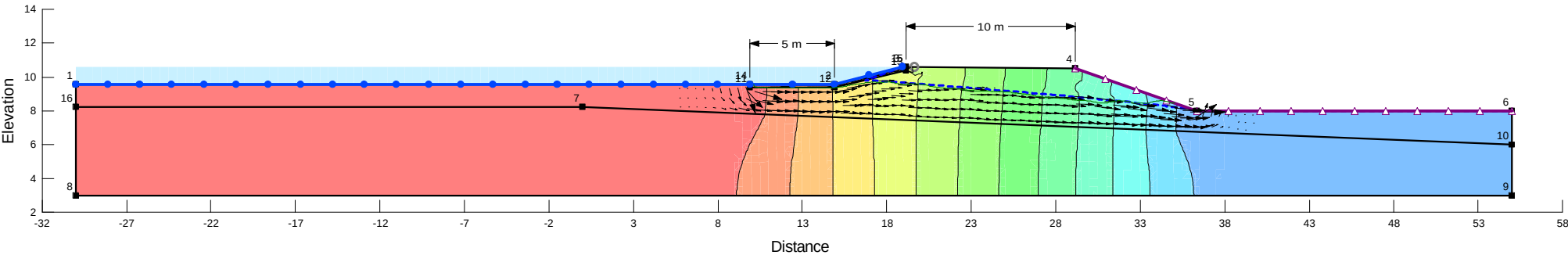
EC7 DA1-C2 DR (5m Offset)
Wrexham SS Seepage Analysis (Liner).gsz
08/10/2024
1:350

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Undrained Shear Strength (kPa)
Green	Firm Clay (UD)	Undrained (Phi=0)	18				50
Yellow	Loose Sand & Gravel	Mohr-Coulomb	18	0	30	0	



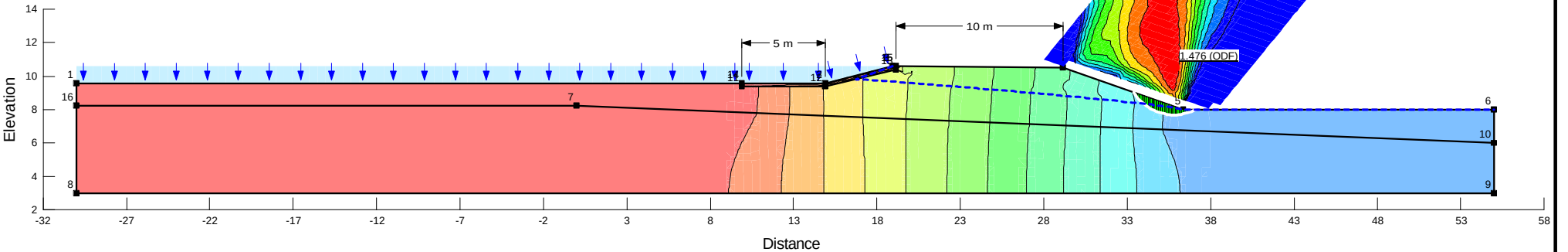
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Wrexham SS Seepage Analysis (Liner).gsz
08/10/2024
1:350

Color	Name	Hydraulic Material Model	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Kz'/Kx' Ratio	Dip Direction (°)	Dip (°)	Sat Kx (m/sec)	Volumetric Water Content	Compressibility (/kPa)
■	Clay Liner (UD)	Saturated Only			1	1	90	0	1e-09	5	0
■	Firm Clay (UD)	Saturated / Unsaturated		Clay	1	1	90	0			
■	Loose Sand & Gravel	Saturated / Unsaturated	S+G	S+G	1	1	90	0			



SEEP/W (10m Offset)
Wrexham SS Seepage Analysis (Liner).gsz
08/10/2024
1:350

Color	Name	Slope Stability Material Model	Unit Weight (kN/m ³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)
	Clay Liner (DR)	Mohr-Coulomb	18	0	28	0
	Firm Clay (DR)	Mohr-Coulomb	18	0	28	0
	Loose Sand & Gravel	Mohr-Coulomb	18	0	30	0



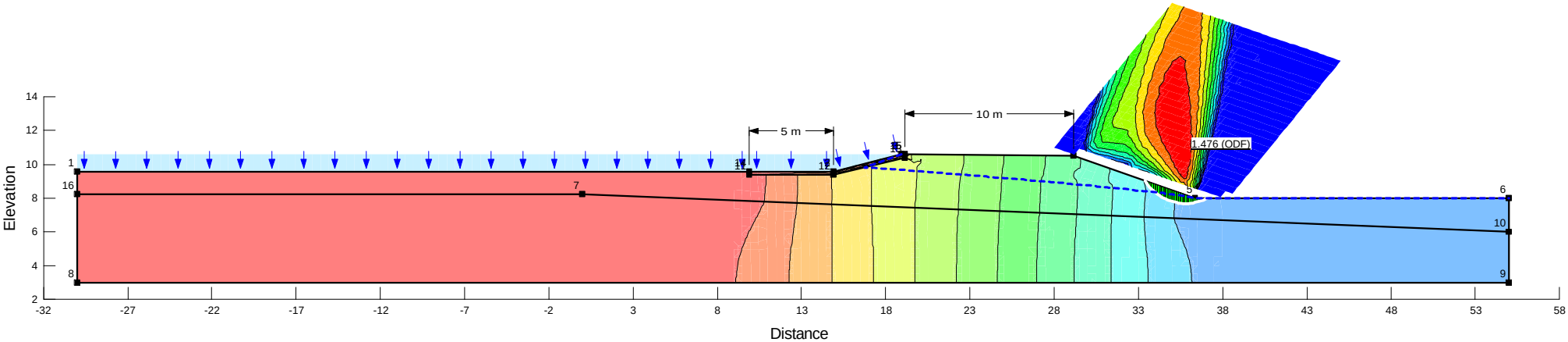
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Wrexham SS Seepage Analysis (Liner).gsz

08/10/2024

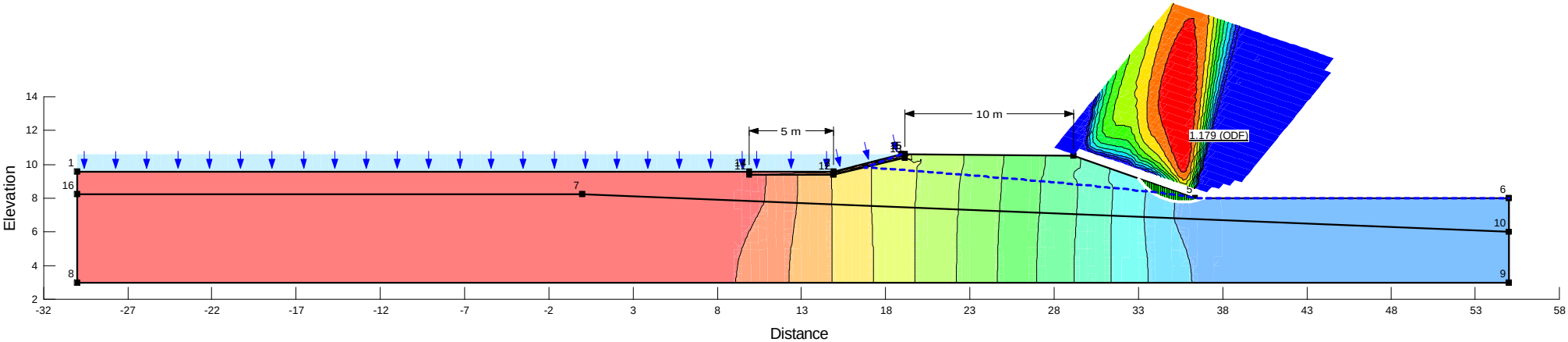
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Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Undrained Shear Strength (kPa)
Green	Clay Liner (UD)	Undrained (Phi=0)	18				50
Light Green	Firm Clay (UD)	Undrained (Phi=0)	18				50
Yellow	Loose Sand & Gravel	Mohr-Coulomb	18	0	30	0	



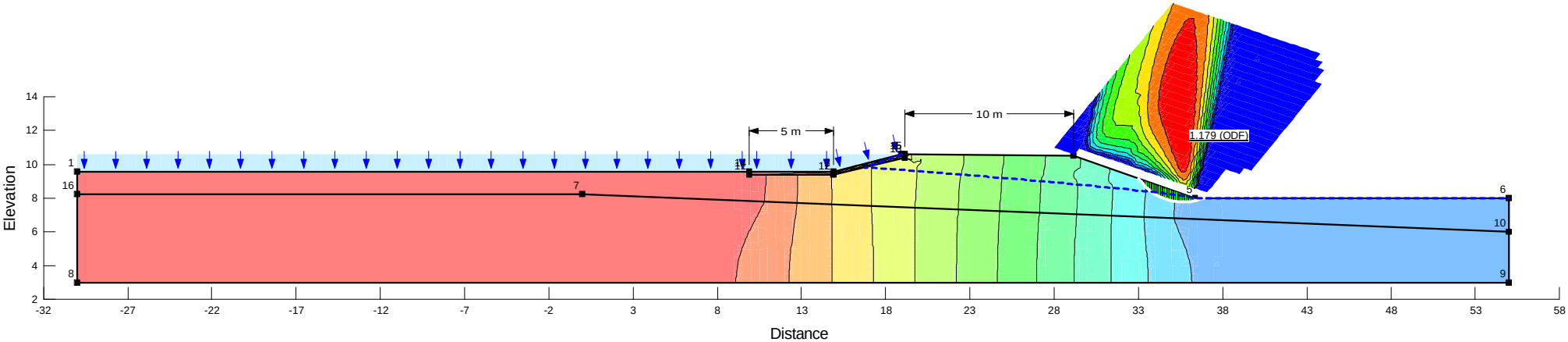
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Wrexham SS Seepage Analysis (Liner).gsz
08/10/2024
1:350

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)
Light Blue	Clay Liner (DR)	Mohr-Coulomb	18	0	28	0
Light Green	Firm Clay (DR)	Mohr-Coulomb	18	0	28	0
Yellow	Loose Sand & Gravel	Mohr-Coulomb	18	0	30	0



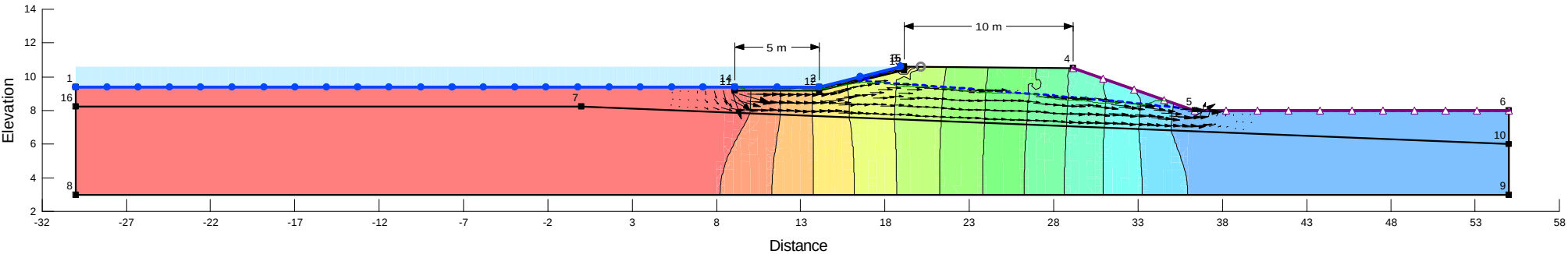
EC7 DA1-C2 DR (10m Offset)
Wrexham SS Seepage Analysis (Liner).gsz
08/10/2024
1:350

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Undrained Shear Strength (kPa)
█	Clay Liner (UD)	Undrained (Phi=0)	18				50
█	Firm Clay (UD)	Undrained (Phi=0)	18				50
█	Loose Sand & Gravel	Mohr-Coulomb	18	0	30	0	



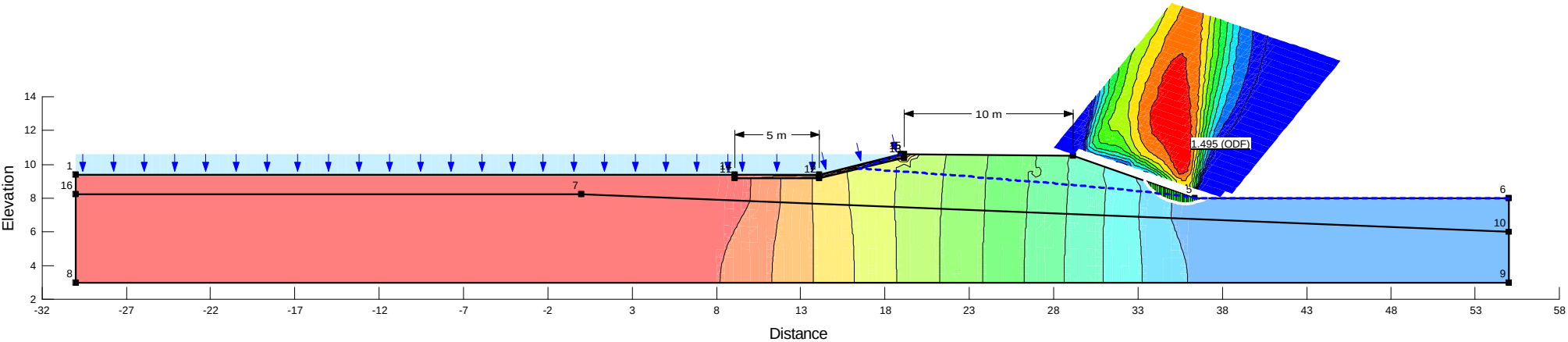
EC7 DA1-C2 UD (10m Offset)
Wrexham SS Seepage Analysis (Liner).gsz
08/10/2024
1:350

Color	Name	Hydraulic Material Model	Vol. WC. Function	K-Function	Ky/Kx' Ratio	Kz/Kx' Ratio	Dip Direction (°)	Dip (°)	Sat Kx (m/sec)	Volumetric Water Content	Compressibility (kPa)
■	Clay Liner (UD)	Saturated Only			1	1	90	0	1e-09	5	0
■	Firm Clay (UD)	Saturated / Unsaturated		Clay	1	1	90	0			
■	Loose Sand & Gravel	Saturated / Unsaturated	S+G	S+G	1	1	90	0			



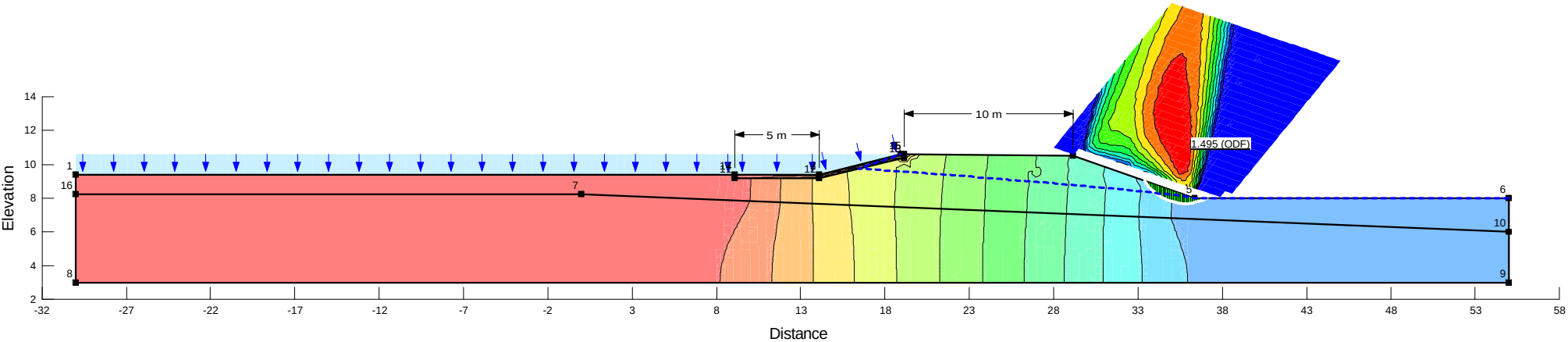
SEEP/W (10m Offset - 0.2m deeper)
Wrexham SS Seepage Analysis (Liner).gsz
08/10/2024
1:350

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)
Light Blue	Clay Liner (DR)	Mohr-Coulomb	18	0	28	0
Light Green	Firm Clay (DR)	Mohr-Coulomb	18	0	28	0
Yellow	Loose Sand & Gravel	Mohr-Coulomb	18	0	30	0



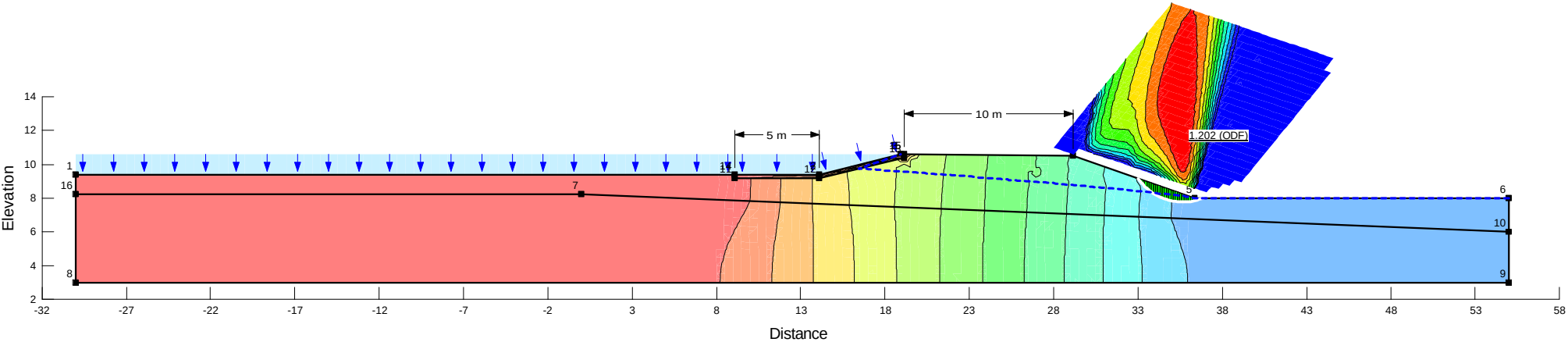
EC7 DA1-C1 DR (10m Offset - 0.2m deeper)
Wrexham SS Seepage Analysis (Liner).gsz
08/10/2024
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Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Undrained Shear Strength (kPa)
Green	Clay Liner (UD)	Undrained (Phi=0)	18				50
Light Green	Firm Clay (UD)	Undrained (Phi=0)	18				50
Yellow	Loose Sand & Gravel	Mohr-Coulomb	18	0	30	0	



EC7 DA1-C1 UD (10m Offset - 0.2m deeper)
Wrexham SS Seepage Analysis (Liner).gsz
08/10/2024
1:350

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)
Light Blue	Clay Liner (DR)	Mohr-Coulomb	18	0	28	0
Light Green	Firm Clay (DR)	Mohr-Coulomb	18	0	28	0
Yellow	Loose Sand & Gravel	Mohr-Coulomb	18	0	30	0



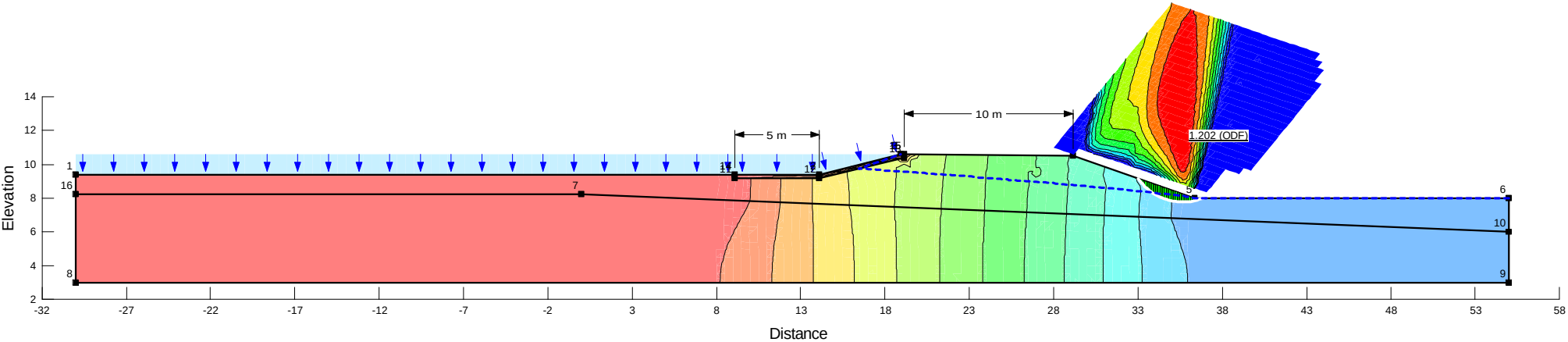
EC7 DA1-C2 DR (10m Offset - 0.2m deeper)

Wrexham SS Seepage Analysis (Liner).gsz

08/10/2024

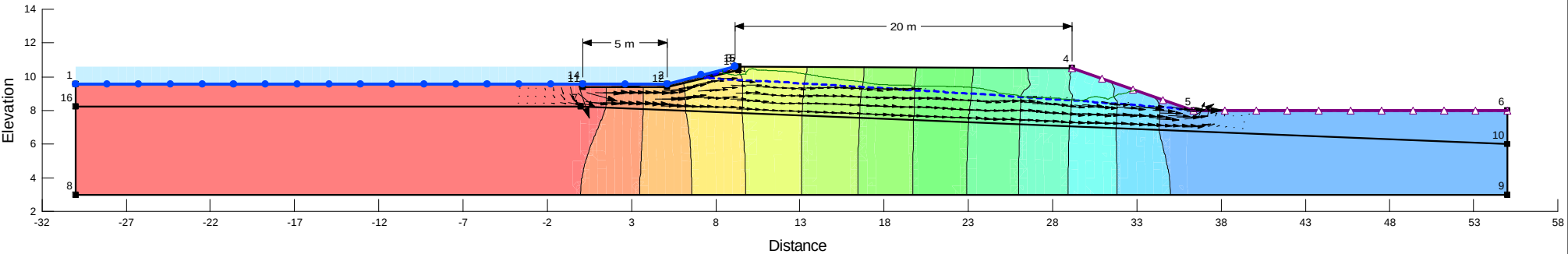
1:350

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Undrained Shear Strength (kPa)
Green	Clay Liner (UD)	Undrained (Phi=0)	18				50
Light Green	Firm Clay (UD)	Undrained (Phi=0)	18				50
Yellow	Loose Sand & Gravel	Mohr-Coulomb	18	0	30	0	



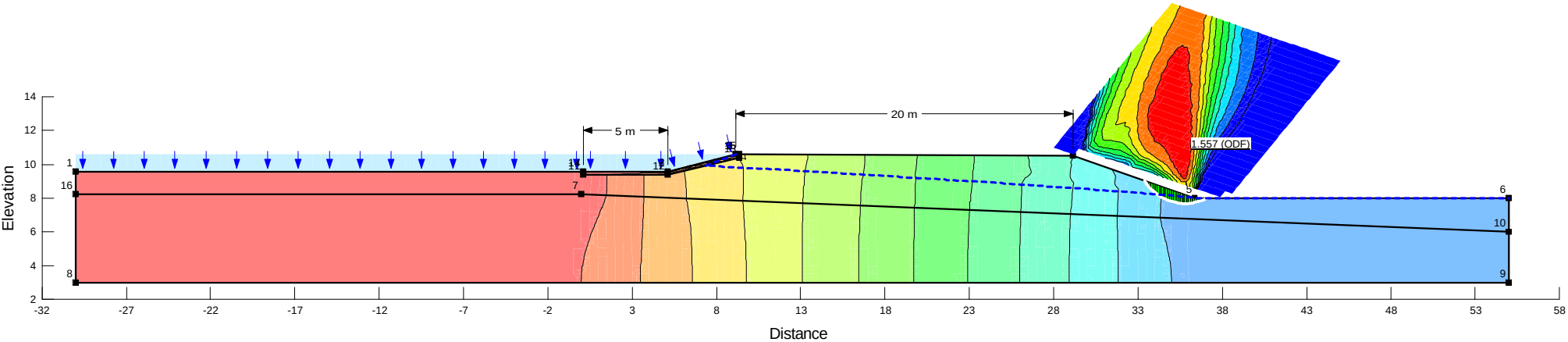
EC7 DA1-C2 UD (10m Offset - 0.2m deeper)
Wrexham SS Seepage Analysis (Liner).gsz
08/10/2024
1:350

Color	Name	Hydraulic Material Model	Vol. WC. Function	K-Function	Ky/Kx' Ratio	Kz/Kx' Ratio	Dip Direction (°)	Dip (°)	Sat Kx (m/sec)	Volumetric Water Content	Compressib (kPa)
	Clay Liner (UD)	Saturated Only			1	1	90	0	1e-09	5	0
	Firm Clay (UD)	Saturated / Unsaturated		Clay	1	1	90	0			
	Loose Sand & Gravel	Saturated / Unsaturated	S+G	S+G	1	1	90	0			



SEEP/W (20m Offset)
Wrexham SS Seepage Analysis (Liner).gsz
08/10/2024
1:350

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)
■	Clay Liner (DR)	Mohr-Coulomb	18	0	28	0
■	Firm Clay (DR)	Mohr-Coulomb	18	0	28	0
■	Loose Sand & Gravel	Mohr-Coulomb	18	0	30	0



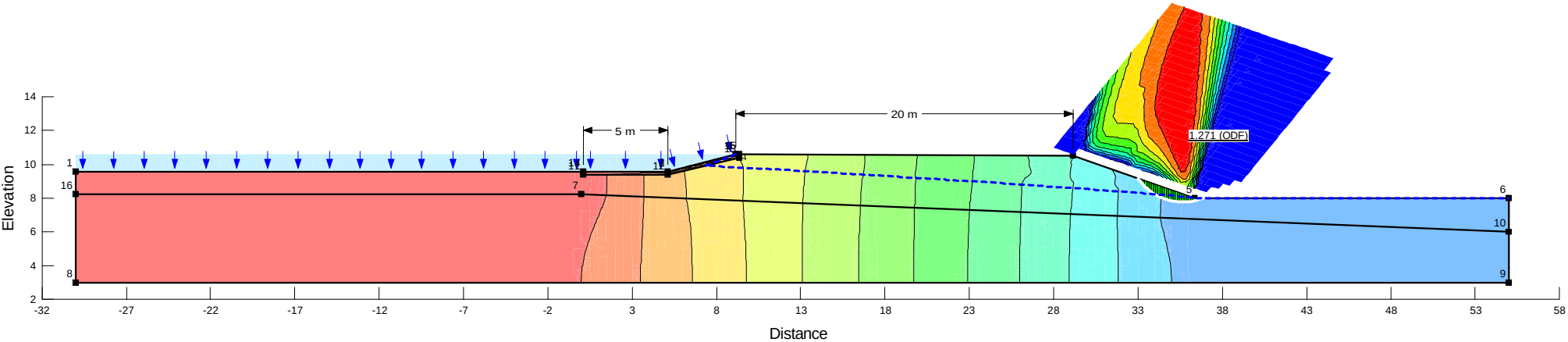
EC7 DA1-C1 DR (20m Offset)

Wrexham SS Seepage Analysis (Liner).gsz

08/10/2024

1:350

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)
■	Clay Liner (DR)	Mohr-Coulomb	18	0	28	0
■	Firm Clay (DR)	Mohr-Coulomb	18	0	28	0
■	Loose Sand & Gravel	Mohr-Coulomb	18	0	30	0



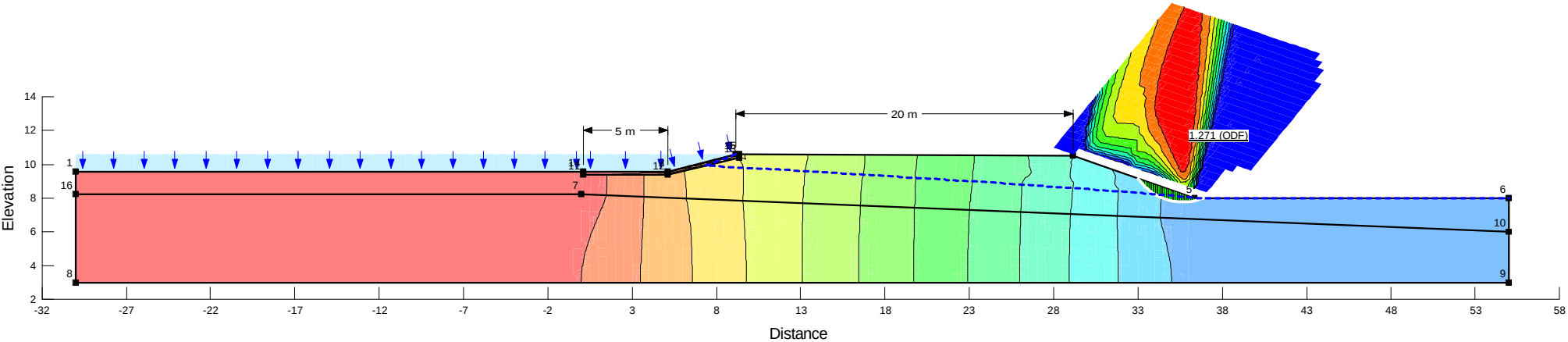
EC7 DA1-C2 DR (20m Offset)

Wrexham SS Seepage Analysis (Liner).gsz

08/10/2024

1:350

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Undrained Shear Strength (kPa)
	Clay Liner (UD)	Undrained (Phi=0)	18				50
	Firm Clay (UD)	Undrained (Phi=0)	18				50
	Loose Sand & Gravel	Mohr-Coulomb	18	0	30	0	



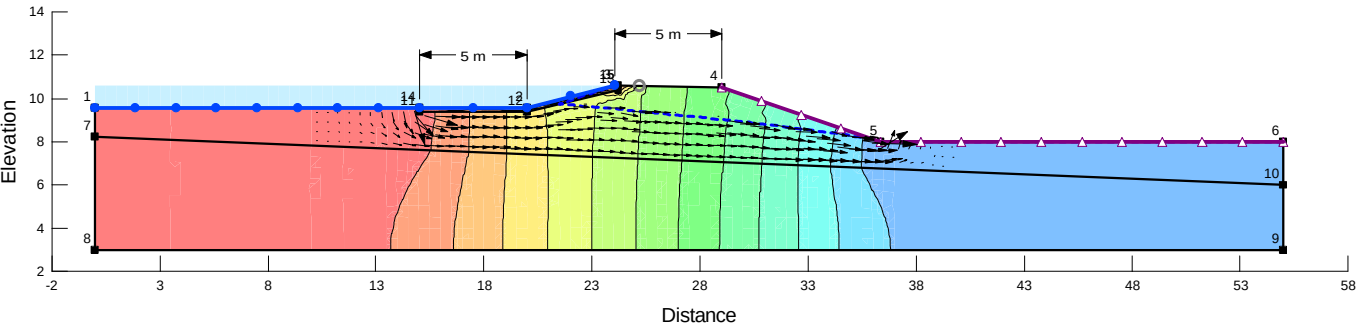
EC7 DA1-C2 UD (20m Offset)

Wrexham SS Seepage Analysis (Liner).gsz

08/10/2024

1:350

Color	Name	Hydraulic Material Model	Vol. WC. Function	K-Function	Ky/Kx' Ratio	Kz/Kx' Ratio	Dip Direction (°)	Dip (°)	Sat Kx (m/sec)	Volumetric Water Content	Comp (kPa)
■	Clay Liner (UD)	Saturated Only			1	1	90	0	1e-09	5	0
■	Firm Clay (UD)	Saturated / Unsaturated		Clay	1	1	90	0			
■	Loose Sand & Gravel	Saturated / Unsaturated	S+G	S+G	1	1	90	0			



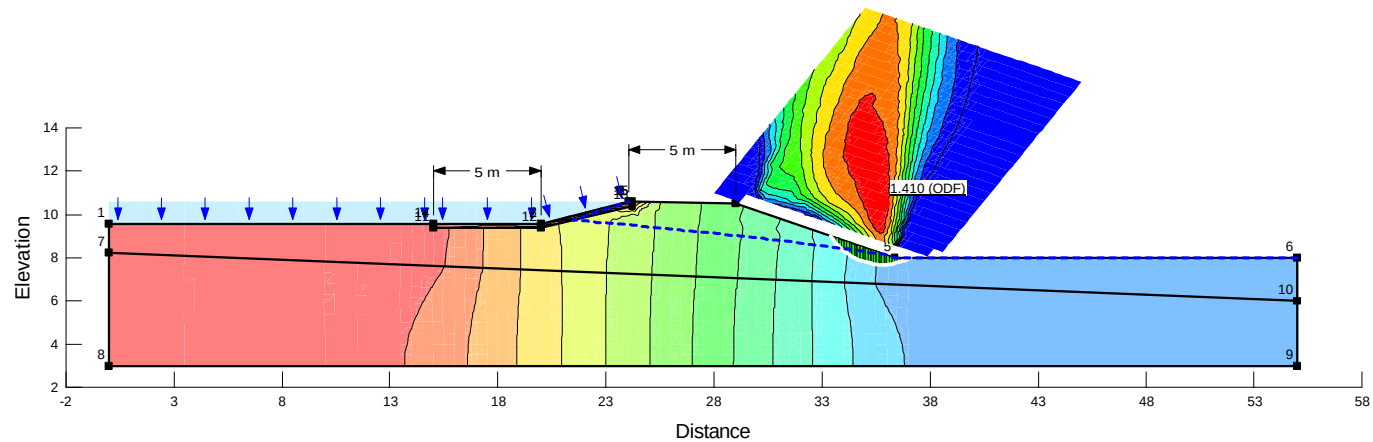
SEEP/W (5m Offset Lined)

Wrexham SS Seepage Analysis (Liner).gsz

08/10/2024

1:350

Color	Name	Slope Stability Material Model	Unit Weight (kN/m ³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)
■	Clay Liner (DR)	Mohr-Coulomb	18	0	28	0
■	Firm Clay (DR)	Mohr-Coulomb	18	0	28	0
■	Loose Sand & Gravel	Mohr-Coulomb	18	0	30	0



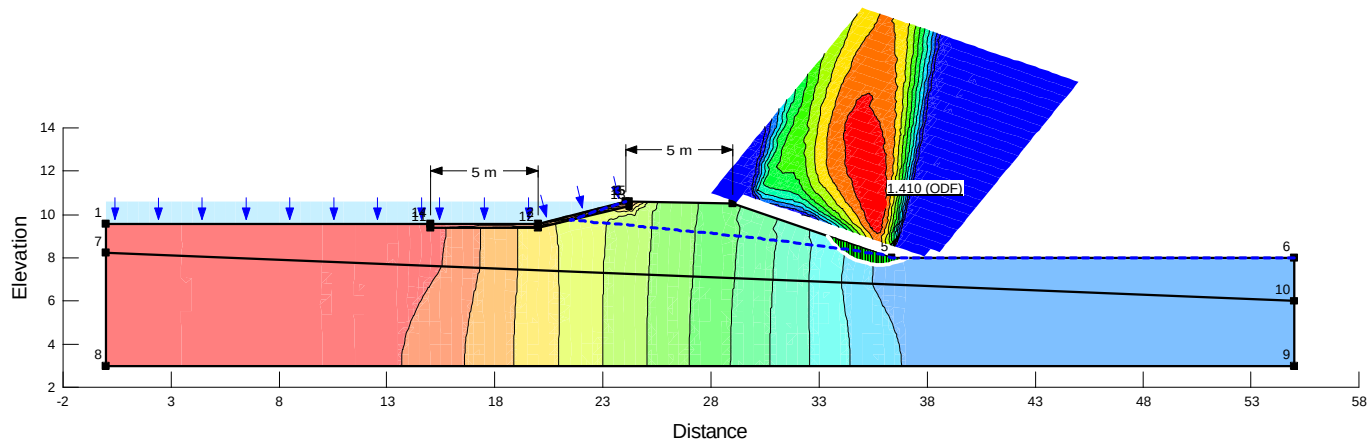
EC7 DA1-C1 DR (5m Offset Lined)

Wrexham SS Seepage Analysis (Liner).gsz

08/10/2024

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Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Undrained Shear Strength (kPa)
■	Clay Liner (UD)	Undrained (Phi=0)	18				50
■	Firm Clay (UD)	Undrained (Phi=0)	18				50
■	Loose Sand & Gravel	Mohr-Coulomb	18	0	30	0	



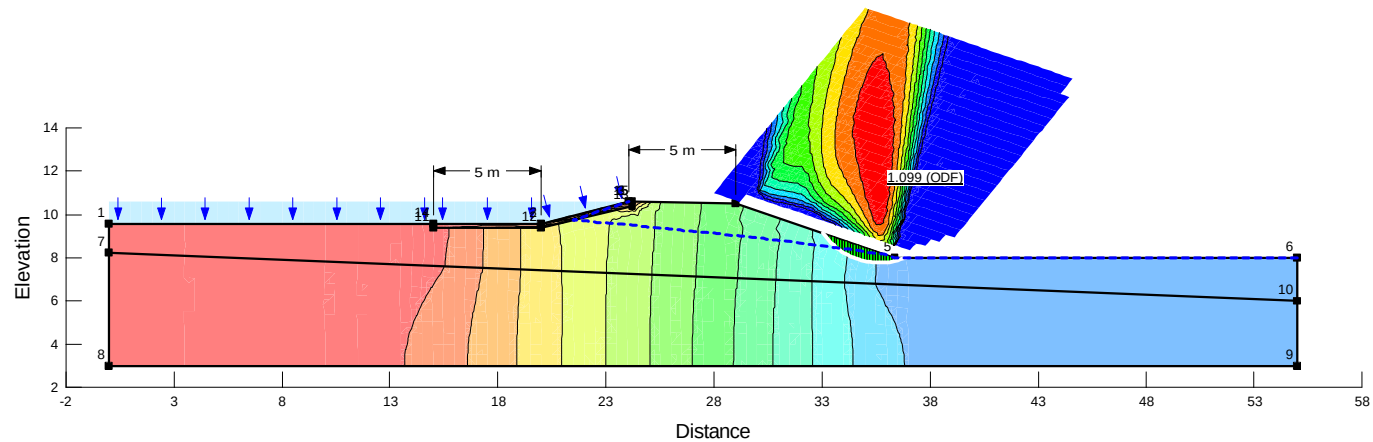
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Wrexham SS Seepage Analysis (Liner).gsz

08/10/2024

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Color	Name	Slope Stability Material Model	Unit Weight (kN/m ³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)
■	Clay Liner (DR)	Mohr-Coulomb	18	0	28	0
■	Firm Clay (DR)	Mohr-Coulomb	18	0	28	0
■	Loose Sand & Gravel	Mohr-Coulomb	18	0	30	0



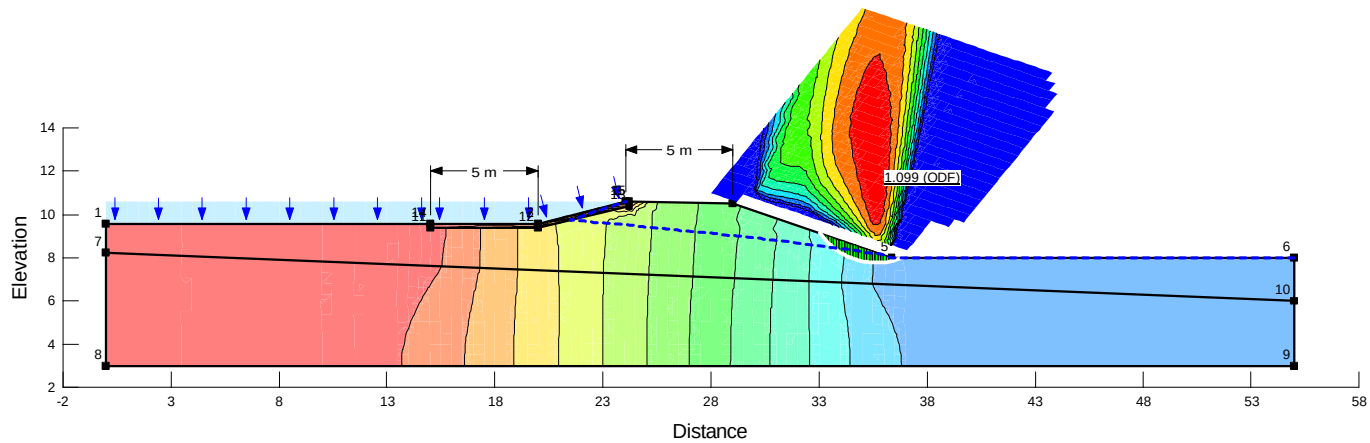
EC7 DA1-C2 DR (5m Offset Lined)

Wrexham SS Seepage Analysis (Liner).gsz

08/10/2024

1:350

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Undrained Shear Strength (kPa)
■	Clay Liner (UD)	Undrained (Phi=0)	18				50
■	Firm Clay (UD)	Undrained (Phi=0)	18				50
■	Loose Sand & Gravel	Mohr-Coulomb	18	0	30	0	



EC7 DA1-C2 UD (5m Offset Lined)

Wrexham SS Seepage Analysis (Liner).gsz

08/10/2024

1:350

Appendix B – GI Report

Appendix C – Slope/W Outputs

Appendix D – Seep/W Outputs