JAMES associates
Geological, Mining and Development Consultants

# Ffos-y-Fran

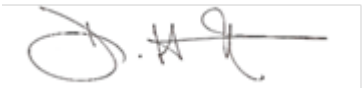
## Geotechnical Stability Report (March 2026)

**Prepared for:**
**Merthyr (South Wales) Limited**

**Prepared by:**
**JAMES ASSOCIATES**


Prepared by:

D Higgins MSc DIC BSc (Hons)



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Geotechnical Specialist



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## EXECUTIVE SUMMARY

On behalf of Merthyr [South Wales] Limited [MSW], James Associates [JA] has been appointed to prepare a Geotechnical Stability Report [GSR] to consider and assess details of the proposed final site restoration features as set out in the planning application and Environmental Statement submitted to MTCBC in February 2025. The GSR provides details of the geotechnical assessments to support the proposals which demonstrate that the proposed features, designed to enhance biodiversity will represent stable, safe, long-term landscape features.

Coaling operations ceased at the Ffos-Y-Fran Reclamation Site in November 2023, and the site is now in care and maintenance before entering its final restoration phase subject to planning approval. This report provides details of the designs and methodologies on how the site will be restored to a long-term and safe landscape feature.

The proposed designs are supported by a review of the extensive database relating to the site geology, geotechnical analysis of structures, along with operational experience gained on this site and a number of other large opencast coal operations undertaken in the South Wales Coalfield Area, over a period of many years. Several sites have been restored in similar ways with features similar to those proposed at Ffos-y-Fran.

This report has been compiled by geotechnical specialists with extensive experience in the opencast mining and quarrying industries in the UK and overseas.

Appointed as geotechnical specialist to all of the principal opencast coal contractors operating in the UK, including UK Coal, Scottish Coal, Celtic Energy and Hargreaves on multi-million tonne operations, extending over a period in excess of 20 years.

A significant proportion of the experience has been gained in the South Wales Coalfield advising operators in all matters relating to geotechnical stability, design and safe operating procedures both during working and restoration phases.

## 1.0 INTRODUCTION

The report provides details of the following:

- Description of current site conditions.
- Details of the proposed final site restoration landforms.
- A summary of geological conditions, with details of previous mineworking for coal and ironstone, geological structure, rock types within the working sequence, site investigation boreholes.
- A summary of the site hydrogeological conditions.
- Summary review and findings from previous geotechnical site reports with details of approved designs for excavated faces.
- Details of excavated face performance during site operations.
- Final restoration designs for residual excavation faces along the southern and eastern sidewalls, and mitigatory design measures appropriate for the proposed after-use.
- Summary review and comments on the findings of initial pre-site commencement stability analyses for tip structures OB1, OB2, and OB3.
- Details of 'actual' construction methodology for overburden mounds OB1, OB2, and OB3.
- Details of tip stability during site operations.
- Proposed remedial earthworks, supported by stability analyses and construction methodology for the re-construction of the western side of overburden mound OB1, which has previously failed.
- Details of any further remedial works which are considered necessary following the assessment of the long-term stability of tips OB1, OB2 and OB3.
- Proposed earthworks for the lower-level extension to the backfill slope, with associated stability analyses and construction methodology.
- Details of water treatment structures which will be retained. Background construction details and proposals for any remedial works where considered to be necessary.

## 2.0 Legislation and Policy / Relevant Guidance

2.1 All Excavation Faces and Tips have been designed, operated, and managed in compliance with the requirements of The Quarries Regulations 1999.

2.2 In addition to the required compliance during the active mining phase there is also a requirement for compliance with the regulations during the restoration phase.

2.3 Under Regulation 6.4- General Duties of the Operator

'*The operator shall ensure that in the event of the abandonment of or ceasing of operations at a quarry, the quarry is left, so far as reasonably practicable, in a safe condition'.*

2.4 Under Regulation 45 guidance note 353. states that

*When a quarry closes, any remaining excavations or tips must be left in a safe condition [Regulation 6[4]. Tips as defined in the Mines and Quarries (Tips) Act 1969 will, on abandonment of the quarry, become Part II tips and under that Act, which is enforced through the Environmental Protection Act 1990. HSE should be notified of the quarry closure (see Regulation 45).*

*2.5 Furthermore, Regulation 45 guidance note 354 states 'In the case of such tips, the abandonment notification needs to include the information gathered during geotechnical assessments. This information will be passed on to local authorities who are responsible for enforcing Part II of the Mines and Quarries (Tips) Act 1969.*

As is required in Regulation 5.31 'Duties of the person entitled to work the quarry'-

*'The owner of a dis-used tip at an abandoned quarry is responsible for its safety as explained in Part 11 of the Mines and Quarries [Tips] Act 1969'*

2.6 The Disused Mine and Quarry Tips [Wales] Act 2025 similarly requires tips to be safe. The legislation, which has yet to receive Royal Assent will require all registered tips which either pose a threat to human welfare by reason of instability or could pose such a threat in the event of instability, to be confirmed to be safe or made safe.

## 3.0 Background

### 3.1 Site Location

The National Grid Reference for the approximate site centre for Ffos-Y-Fran is E.308000.N.206500

### 3.2 Site Description

The site, which commenced operations in 2005, was initially operated by Miller Argent [South Wales] and then purchased by the current owner, Merthyr [South Wales] Limited in January 2016. The site is over 400 hectares in area, and the operations involved the reclamation of significant areas of derelict land associated with historic coal and ironstone mining activities along with the development of an opencast mining operation which removed many of these mining liabilities to enable the required restoration works to be achieved.

The original planning application proposed that upon completion of the mining operations, the exhausted workings would be infilled using excavated materials contained in three overburden mounds [OB1, OB2, and OB3] constructed above original ground level around the periphery of the mining void. These mounds were constructed, inspected and maintained throughout the life of the mine by a geotechnical specialist.

It is now proposed that the alternative final restoration proposals for the site, which offers improved biodiversity and environmental benefits [as described in in the planning application and ES]. This will entail the three overburden mounds remaining in their existing locations and broadly retaining their current form.

In addition, it is proposed there will be several sections along the southern and eastern final sidewalls, where exposed rock faces will remain as a part of the proposed final restoration design, together with a lake feature in the bottom of the void which effectively represents the level of the rebounded groundwater.

This report provides background geological, geotechnical and historical operational details to support the proposed alternative final restoration designs which are presented in the above drawing. Where necessary detailed stability analyses which demonstrate long-term stability for the proposed restoration designs are presented which also consider any potential impacts that climate change may have on stability., as a precautionary measure. Also presented is an assessment of the potential nature of any failure should it ever occur in the future and its likely consequences in the surrounding environment.

## 4.0 Information Referred To

Several sources of information have been used in the compilation of this report. These include data collected during site investigations, operational records gathered during the life of the mine, geotechnical information from Ffos-y-Fran and adjacent sites, and regional experience from other opencast coal operations within the South Wales Coalfield.

### 4.1 Existing Site Information

The following information has been referenced:

- R. Edwards. Geotechnical Site Report dated November 2005
- Ordnance Survey and Historical land plans
- Published geological survey plans
- Records for abandoned underground mineworkings in Ironstone and Coal
- Site Investigation work as detailed in the R. Edwards report
- Piezometric information
- Coal Seam Digital Terrain Models produced using site investigation data, which define the geological structure for the site.
- Other site records, geotechnical assessments and inspections, etc prepared in compliance with the Quarries Regulations 1999.

### 4.2 Historic Information from adjacent Opencast Coal Sites

Site records for the following sites were consulted in the compilation of the above report.

- Royal Arms Corp. 1959. Which extracted coals between the Two Feet Nine and Lower Four Feet Seams. No instabilities were recorded in either tips or excavated faces.
- Cae Harris. 1963 to 1974. Located to the northwest of the site. Extracted coals between the Little and Lower Four Feet Seams. No major instabilities recorded. Only minor collapse into the underlying ironstone workings.
- Trecatti. 1975 to 1984. Located immediately to the north northeast of the site. Operated in the same sequence as the FLRS. No recorded instabilities in either tips or excavated faces.
- Incline Top. 1991 to 1993. Lies to the west of the FLRS .Operated in the Little to Lower Four Feet section. Minor wedge-type instability in the Penydarren Fault Area and collapse into underlying ironstone workings.
- Great White Tip. 1993 to 1996. Lies to the west of the FLRS . Worked the Rhaslas to Lower Four Feet Seams. Recorded laminated clays in the glacial drift and occasional perched water in the drift. No significant instabilities were recorded.

- Four Winds. 1958. Worked the Gorllwyn Seam. No instabilities recorded.

The significance of the above examples is that the sites are located in very close proximity to the FLRS site and operated within sections of the same part of the stratigraphical sequence and in similar structural domains. There is no documentary evidence for the occurrence any significant instabilities in rock faces or overburden / backfill tips on any of the above sites and It is therefore considered reasonable to expect that similar rock face and tip conditions may be expected on the FLRS site.

### 4.3 Information from recent Opencast Sites in the South Wales Coalfield

There are several recently completed opencast coal mining sites in the immediate vicinity of the site which operated from the 1980's through to 2020's where alternative final restoration features involving landscapes which include substantial above ground overburden mounds and residual rock faces, similar to what is proposed for the FLRS site, have been accepted by local authorities as long-term final site restoration features.

The following sites are specifically cited:

- Nant Helen – located at Cae Hopkin near Abercrave. Operated since the 1970's initially under contract to British Coal Opencast Executive and latterly by Celtic Energy.
- East Pit -located at Gwaun Cae Gurwen near Pontardawe. Operated since the 1970's, initially as above then latterly by Celtic Energy.
- Selar- located at Blaengwrach in the Neath Valley. Operated since the early 2000's by Celtic Energy.
- Margam- located near Pyle. Operated since the 1970's, latterly by Celtic Energy.

## 5.0 Baseline Conditions

The current landforms which are present on site are shown in site survey drawing number 25-247-D-001 (Site Plan) which has been annotated to enable the easy identification of the excavated faces and tip structures referred to in the following text.

### 5.1 General

1. Active coaling operations ceased at the site in November 2023.
2. During the later stages of coaling operations, and for a short period following the cessation, some of the remedial works as recommended by the appointed site geotechnical specialist were undertaken along various sections of rock face to improve long-term stability.
3. Details of the various works, both completed and to be completed, are illustrated in photographs 1 to 6 and schematic cross-sections 1,2,3, and 4.
4. The various works included the removal of sections of rock face which were exhibiting potential for the future development of significant rock fall from the upper sections of faces. These works have been completed.
5. In addition, earthworks along accessible benches were undertaken, including the concealment of exposed coal seams and the construction of earth bunds along the toe of excavation faces designed to contain any future spalling of rock fragments. The concealment is designed to remove the potential temptation for members of the public extracting coal from the exposures.
6. These works were inspected by representatives of the Coal Authority [now the Mining Remediation Authority] following cessation of coaling to ensure no ‘dangers’ remained from old abandoned underground mineworkings, i.e., shafts, adits and collapsed ground.

### 5.2 Rock Faces

#### 5.2.1 Southern Highwall

The southern highwall has an approximate southwest / northeast orientation, is inclined towards the northwest and represents the deepest part of the excavation at approximately 178 metres below ground level.

The highwall comprises a number of individual excavated faces typically up to 15 metres in height, separated by intermediate horizontal benches of approximately 5 metres in width, which generally are positioned at coal seam horizons.

The proposed maximum face height exposed above the proposed final restoration rest water level in the base of the quarry void will be approximately 100 metres. This is due to seasonal

variations in groundwater level which has been calculated by a detailed hydrogeological assessment.

Historically, the face has been subject to fault related localised instability, the most recent being the area in which the North northwest / South southeast trending Dowlais Fault intersected the sidewall. During operations, this area was worked under the guidance of Geotechnical Specialists in accordance with geotechnical assessments, risk assessments, safe systems of work, surveys and inspections. The affected area is now fully concealed by the backfill tip, BF1, and has no relevance with respect to the stability of the exposed rock face.

Minor areas in the upper section of the currently exposed highwall have been affected by horizon specific low angle thrust faulting, where localised block / slab spalling has in areas removed support from the over-lying strata.

The affected areas occur in locations which are isolated from any potential points of access, either above or below.

### 5.2.2 Eastern Sidewall

The eastern sidewall comprises a number of access ramps/ working benches between which there are sections or ‘packets’ of individual faces separated by intermediate safety benches.
In the southern to mid- sections of the sidewall the rockface is concealed by large scree slopes which are the result of instabilities associated with approximately north / south orientated faulting, which during operations produced major instability.

The faulting has been fully excavated and removed within the southern to mid- sections of the sidewall and is now only present at the northern end of the north / south orientated excavation panels, occurring around the Big Seam horizon.

Individual rock faces have been excavated to approximately 65$^{o}$ to sub-vertical angle which is determined by a combination of blast geometry, excavator dig geometry and break-out along the natural planes within the strata, i.e. jointing, faulting and bedding. During excavation, faces were continually ‘dressed’ back to competent material to remove potentially problematic material which at some point could become detached from the face. This procedure leads to localised variations in the angle. Faces generally show acceptable overall stability, though commonly contain areas where block spalling has and will continue to occur due to natural weathering processes.

No major currently active instability is evident in the sidewalls, nor is any expected to occur. Throughout the life of the site significant instabilities have all been fault related.

Historically, there have been a number of faults intersected during operations, with the final one

being the un-named fault which is currently exposed in the sidewall at the northern end of Cut 27. The section of sidewall to the east lies behind the fault [which has been fully excavated and removed]. At the faults point of intersection, the sidewall has been stabilised by grading the strata on either side of its point of intersection to remove material which otherwise had the potential to spall from the face.

Within the more competent strata where pervasive jointing is present, block spalling is evident and is likely to continue into the future. Where this occurs, the overall stability of the sidewall slope will not be compromised as the extent of the spalling is unlikely to extend beyond a few metres behind the crest of individual faces.

The sidewall varies in height from approximately 25 metres at the northern end to approximately 120 metres at the southern end.

### 5.3 Tips

The principal solid tips [as per The Quarries Regulations 1999 definitions] on the site are three overburden mounds OB1, OB2, OB3, and the main backfill tip BF1, the locations of which are shown on drawing number 25-247-D-001 (Site Plan).

#### 5.3.1 Overburden Mound OB1

OB1 was constructed in two phases, between October 2007 and March 2009 and then continued between June 2012 and to completion in March 2015. Topsoil and subsoil was stripped from the ‘footprint’ and an extensive underdrainage system was installed prior to the commencement of tipping operations. OB1 covers an area of approximately 30 hectares.

Prior to any tipping taking place all topsoil and subsoil was stripped from the footprint of the tip area. An extensive undertip drainage system was installed prior to tipping, This system comprised a network of granular drainage blankets and perforated carrier drains which collect seepage and discharge via perimeter drainage channels into the site surface water management system.

The first phase of construction of OB1 consisted of the placement of 7.7M m³, of which 37% was superficial materials (consisting predominantly of glacial till, old colliery tip material) and 63% was Coal Measures strata. The second phase of construction of OB1, which involved a northern and western extension, consisted of the placement of 4.6M m³, of which 5% was superficial materials and 95% was Coal Measures strata.

The original ground level beneath the tip sloped at a gradient of approximately 1 in 14 from the north-east to the south-west, falling from a level of 425mAOD to 395mAOD. The tip reaches a maximum elevation of 475mAOD, the upper surface of the tip is slightly domed in order to shed

surface water. The side slopes of the tip are at a gradient of 1V in 2H for the individual slopes, with overall slope gradients of 1V in 2.5H.

The western facing slope has been affected by significant instability, which occurred in August 2022 and involved a rotational-type failure which occurred due to the oversteep excavation of the slope to move the 'footprint' of OB1 further north in preparation for excavation to enable the coal extraction in Cuts 26, 27 and 28 to be achieved. Due to the failure, the ground profile is currently highly irregular and comprises a hummocky lower section with a large back scar, standing at 40° from horizontal, which defines the eastern limit of the significant movement. The length of the back scar is approximately 250 metres, with a vertical displacement of approximately 40 metres, and has remained largely inactive in recent years.

On inspection, there is no evidence of any active slope failures and there are no historical records of any of the other slopes of the tip having been affected by instability.

### 5.3.2 Overburden Mound OB2

Prior to tip construction topsoil and subsoil were stripped from the 'footprint' and over 1.1 million $m^3$ of solid measures to an approximate depth of 20 metres was excavated beneath the eastern half of the proposed tip area to recover coal from the underlying Hafod Coal Seam.

OB2 was constructed between October 2007 and March 2009, a total of 4.9M $m^3$ of material were placed in OB2. The composition of OB2 is 37% superficial deposits and 67% Coal Measures strata. The tip covers an area of approximately 15 hectares.

The tip does not have any formal sub-tip drainage system installed. The excavation into the solid measures beneath the tip is likely to facilitate drainage through the natural jointing system and in addition provides an important 'key' to the structure.

The original ground level falls at a gradient of 1 in 14, in a south-westerly direction from the northern corner of OB2, falling from a level of 420 m AOD to 389 m AOD at its south-eastern corner. The tip rises to an elevation of 459 m AOD and has a rounded tip. The side slopes for the tip are at a gradient of 1V in 2H for the individual slopes, the overall slope gradients vary due to the presence of benching and roads being present on the side slopes.

On inspection, the mound can be observed to be well vegetated / naturalised, and there is no evidence of any active slope failures nor historical records of the structure having been affected by instability.

### 5.3.3 Overburden Mound OB3

OB3 was constructed in two phases, between June 2009 and October 2012 and between July 2013 and May 2015. Again, prior to the commencement of tipping operations all topsoil and subsoil was stripped from the tip 'footprint'. The first phase comprised 21.8M m³, consisting of 10% superficial materials and 90% Coal Measures strata. The second phase comprised 2.8M m³, consisting of 2% superficial materials and 98% Coal Measures strata. OB3 covers an area of approximately 87 hectares.

Prior to construction of OB3 over 2 million $m^3$ of excavation to the Hafod Seam [20 metres depth] took place in the eastern and western parts of the tip footprint

The original ground level falls at a gradient of 1 in 13, in a north to south direction, falling from a level of 376 m AOD along its northern edge to 335 m AOD at its southern edge. The tip rises to an elevation of 410 mA OD and it has a slightly domed upper surface. The side slopes for the tip are for the most part at a gradient of 1V in 2H for the individual slopes, the overall slope gradients are generally around a gradient of 1V in 2.4H. There is a section of slope along the toe of OB3 at the southern end of the western slope which is steeper at 1V in 1.6H, the steep section of slope forms the lower 18m of the tip over a length of 270m.

The upper surface of OB3 currently accommodates an access road leading up to the 'Monster Mountain' recreational area, which consists of an off-road racing track.

On inspection, there is no evidence of any active slope failures. Historically, minor instabilities in the toe areas affecting limited sections of slope have occurred, these were primarily due to the localised effects of surface water run-off, or more recently minor excavations to increase access track width. The latter has been rectified by reinstating the material which was initially removed.

A small-scale localised instability also occurred in 2014 / 15 in the northeastern face during a period of settlement following the addition of an extra 'leg' of excavated material. The feature was for a period of time monitored under the guidance of the geotechnical specialist and has subsequently been confirmed to be stable.

### 5.3.4 Backfill Tip BF1

The Backfill Tip, as the name suggests was constructed through the placement of material back into the worked-out void. The outer slopes of the tip grade down to the A4060 along its western and northern boundary and to Bogey Road to the south. These slopes profiles vary between 1V in 5H and 1V in 7H and have been restored to agricultural after-use.

The inner slope of the Backfill Tip, the slope above the excavation void, was the advancing slope

of the tip. The slope has the access ramp to the base of the excavation traversing across it from south to north, the width of the road is on average 35m. The slope above the access ramp has been graded to 1V in 2.7H and covered with soils. These areas were cultivated and seeded to grass in 2024 / 25 and will be returned to agricultural afteruse.

There is no evidence of any current instability in Backfill Tip structure nor historical records indicating that any have occurred in the past. Some surface water related scouring is evident with minor localised slumps of recently placed soils which have become saturated due to anomalous water conditions in 2024 / 25.

No records of any extensive perched water emergences from the tip faces exist, however a few scattered minor seepages are currently evident on the inner slope of the tip. These are likely related to localised variations in the permeability of the material within the tip, probably related to the varying degrees of compaction of the backfill materials as a consequence of the nature of the tipping operations. Inconsistencies can occur due to the locations of haul roads, which due to heavy vehicle trafficking, can lead to higher levels of compaction.

## 6.0 Site Geology

### 6.1 Made-up Ground

Made-up Ground on the site comprised colliery spoil and mine waste, beneath which topsoil and subsoil of varying thicknesses occur, plus some alluvium and glacial drift, and previous opencast backfill deposits.

### 6.2 Glacial Drift

Glacial Drift comprises marginally cohesive moraine tills, with significant boulders and fine sand grade materials. Some sections contained laminated clay horizons which occurred close to rockhead and displayed low to medium plasticity.

During site exploration no detailed site investigations were undertaken in the superficial deposits. The various parameter values used in the original Geotechnical Site Report analyses were based upon information from adjacent sites.

### 6.3 Rockhead Interface

Extensive borehole exploration on the site has enabled the rockhead interface, i.e., the junction between superficial deposits and the underlying solid strata to be defined with a high degree of accuracy. Drawing 25-247-D-002 (Rockhead Contour Plan) provides details of the interface which has relevance with respect to the location, approved design, and construction of the large overburden mounds OB1, OB2 and OB3, are proposed to remain as final restoration features with only the western face of OB1 needing significant re-grading works.

The interface can be observed to vary both in gradient and direction of inclination around the site, details of which have been utilised in the various models used in initial stability analyses for the site overburden mounds.

### 6.4 Solid Measures

The section of strata worked on the site extends up from the Lower Four Feet Seam to the Soap Rider Seam and is of Lower to Middle Coal Measures age.

The sequence is dominated by mudrocks, i.e., mudstones and siltstone with occasional sandstone, along with numerous coal seams and ironstone bands.

Whilst weathering can be observed to several metres below surface, the effects of significant surface weathering can be observed to a depth of approximately 20 metres and in places up to 40 metres where strata have been affected by shallow level mining induced fracturing.

## 6.5 Geological Structure

### 6.5.1 Bedding

The site is located on the northern rim of the South Wales syncline and comprises strata which are generally gently inclined towards the southeast at a gradient of approximately 1 vertical to 12 horizontal. Extensive borehole exploration on the site undertaken by British Coal, comprising 1,515 open holes, 168 partially cored holes and 12 stratacores, has enabled digital terrain models to be created for the base of each of the seams.

In 2007 a further 90 boreholes [total 1668 metres -including 49.9m of core drilling] were drilled in the area of the southern overburden mound [OB3].

### 6.5.2 Faulting

Two northwest to southeast orientated normal faults have been intersected during operations, the Penydarren Fault which displaced the measures to the southwest by approximately 25 metres and the Dowlais Fault which had a displacement of approximately 16 to 30 metres.

Due to their orientation with respect to the southern sidewall, i.e., a 90$^{o}$ intersection, any instability likely to occur would be localised and contained within the immediate vicinity of the fault. This was seen to be a correct assumption.

Both faults have been worked through and are now fully concealed by the in-pit backfill tip.

Further low angle thrust faulting has been intersected at several horizons within the sequence, which due to its approximately east northeast / west southwest orientation has not resulted in any significant stability issues, other than at a localised level. Whilst thrust faulting can be observed at a number of locations around the exposed faces, the only currently observable effects can be seen at the eastern end of the southern sidewall in the upper section where due to localised failure, overhanging strata can be seen. It may be possible to remove much of this area by re-grading from the surface as a part of the final restoration proposals.

### 6.5.3 Jointing

Jointing is well developed at several horizons especially in the more competent siltstones and sandstones.

Generally, two orthogonal sets are present which are formed approximately perpendicular to the natural bedding.
The principal orientations are:

J1 – 030$^{o}$ / 080$^{o}$ and 210$^{o}$ / 260$^{o}$.
J2 – 120$^{o}$/ 170$^{o}$ and 300$^{o}$ /350$^{o}$.

### 6.6 Previous Underground Mineworkings

The site area has a long history of underground mineworkings for ironstone and coal which extend back several centuries. Many of the workings have been recorded though some of the earlier ones are not and have only been identified by site investigation works and subsequent excavation on site.

#### 6.6.1 Ironstone

The sequence of measures extracted within the site exposed areas of shallow patchwork workings between the Two Feet Nine and Gorllwyn Seams which are thought to date back between 150 and 250 years.

Further and more extensive ironstone workings, at 5 levels, were undertaken in the measures beneath the pavement of the site extending between the Lower Four Feet Seam and Garw Seam with the shallowest being in the Spotted Ironstone horizon.

Ironstone working in the area had ceased by 1876.

#### 6.6.2 Coal

Both underground and small-scale opencast coal mining operations have historically been undertaken on / beneath the site.

##### 6.6.2.1 Underground

Seams between the Garw and Two Feet Nine Seams were worked between 1831 and 1912, along with some in the 1940’s and 50’s.

All seams other than the Three Coals Rider and Little Rider Seams have been previously worked to some degree.

All of the recorded workings were undertaken by pillar and stall technique. No longwall or shortwall extraction was undertaken. Consequently, the collapse effects associated with the workings tend to have a limited vertical extent, which from observations made on site can be seen to be limited to 5 to 10 metres above the seam horizon.
Additional much earlier workings for shallow-level coal and possibly ironstone were undertaken

by bell pit mining technique. No records for these workings were available.

#### 6.6.2.2 Opencast

Minor historic crop coal workings were encountered during operations on the site; all were small-scale of no significance and have been fully removed.

### 6.7 Shafts and Adits

Within the site boundary there were 57 recorded adits within the excavation area, and 61 shafts, of which 52 were within the excavation area. During the mining operation all encountered structures were fully excavated.

## 7.0 Hydrogeology

### 7.1 Made-up Ground

Prior to the operations commencing in 2007, the Made-up Ground on site comprised of colliery spoil, reworked opencast backfill and associated soil horizons. Groundwater flow within these materials was typically limited and controlled by the heterogeneous nature of the deposits, with localised seepages occasionally observed at the base of spoil tips or within backfilled areas. Pre-commencement, minor water 'makes' were identified from the base of colliery spoil tips and areas of previous opencast activity, although the flow rates and volumes of water were observed to be insignificant.

### 7.2 Drift Deposits

Due to surface gradients and the generally low hydraulic conductivity of the Drift deposits, the volume of infiltration is considered likely to be insignificant. The drift was concluded likely to contain minor perched aquifers located within the sandier horizons contained within it. During the operational phase of Ffos-y-fran no major 'makes' of water from the drift were recorded.

### 7.3 Bedrock

With respect to the bedrock and 'other' measures, an assessment on the potential effects of the mining operation on the hydrogeology of the site and surrounding area was formerly undertaken by R.G Edwards (Independent Consulting Engineering Geologist) and reported in the Environmental Statement *(Ffos-y-Fran Land Reclamation Scheme – Environmental Statement – May 2003 – Chapter 12)*.

### 7.4 General Observations

This assessment identified the presence and importance of the 'Dowlais Free Drainage System' and found that the underground drainage of the site is controlled by an extensive system of inter-connected old mine workings and cross drives. The Penydarren, Nant Llesg, Bute and possibly the Penrhyeol Watercourses recorded on abandonment plans, were found to function as main drainage routes carrying mine water to discharge points at ground level. The Black Ball Watercourse west of the Dowlais Fault and a supplementary and deeper watercourse, were found to carry the bulk of the groundwater to the Nant Morlais Valley.

The assessment also identified three potentially connected 'groundwater bodies' with different piezometric surfaces, bounded by the Pennydarren and Dowlais faults. It was concluded that post mining and following the recovery of groundwater levels, base flows in the Nant Morlais would return to those that existed prior to working of the surface mine.

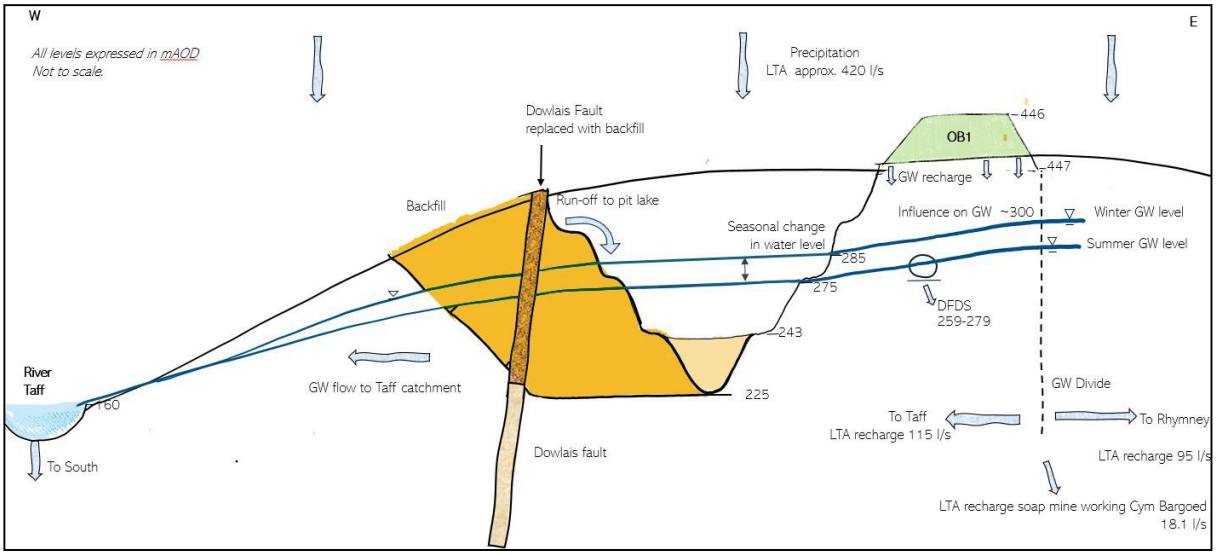
As part of the proposed alternative *Ffos-y-fran Final Restoration Strategy (MTCBC Planning Application P/25/0037 refers, validated 20th Feb 2025)* an Environmental Statement (ES) was prepared which included a review of the existing body of hydrogeological studies and other available information, to demonstrate how the conceptual understanding of the site hydrogeology has developed over time. A '*Hydrogeology Technical Report' (dated 24th January 2025)* was prepared by Groundwater Science and submitted at '*Volume 3, Appendix 8'* of the ES.

The scope of this hydrogeological assessment (2025) included both consideration of potential changes to groundwater levels and availability for relevant groundwater receptors, and the long-term pit lake level fluctuations following implementation of the proposed alternative restoration scheme.

As a result, the conceptual hydrogeological model has been updated with the added benefit of recent monitoring and field investigations. This has included spot flow surveys of nearby stream courses to characterise the magnitude of surface water discharges from the site area relative to those measured during equivalent surveys in 1996, and tests undertaken within the pit void itself to characterise backfill infiltration rate and hydraulic conductivity.

This work provides evidence that the conceptual model put forward in the 2003 ES remains largely valid, and that existing drainage systems within the site area, such as the Dowlais Free Drainage System, remain instrumental in controlling groundwater levels and discharges from the site. There is no clear and obvious evidence to suggest that the mechanisms and distribution of groundwater drainage from the site have varied in any discernible manner relative to the pre-mining situation. This is thought to be due to the permeable nature of the backfill which has been emplaced where the coal measures have been mined out, and limited impact of the mining activities on the main drainage mechanisms underlying the pit.

Regular monitoring of the pit lake level since cessation of dewatering in July 2023 has also provided insights into the interaction between the pit lake and surrounding groundwater system. A conceptual hydrogeological cross-section of the pit void is illustrated below which shows the main components of the groundwater flow system in the pit are primary flow pathways and main surface water receptors.




Conceptual hydrogeological cross-section of the pit void *('Hydrogeology Technical Report' - 24th January 2025 – Groundwater Science)*

Presently, the pit lake has recovered to a water level in equilibrium with surrounding groundwater and monitoring has shown that the water level fluctuates seasonally in response to variations in rainfall and evaporation. Post restoration, the water level in the pit lake is predicted to fluctuate between 275 and 285 metres AOD. The water balance model indicates that a maximum post-restoration pit lake level of approximately 286 m AOD may be expected, with a corresponding volume of 1,140,000 m³ which represents approximately 12% of available storage within the void.

These projections or simulations from the model suggest that the pit lake level remains more than 40 metres below the spill point of the void in the northern section of the site thus rendering the level of risk of overtopping as negligible and the event being highly unlikely.

## 8.0 Geotechnical Site Management

The site from its commencement has been managed in full compliance with the requirements of The Quarries Regulations 1999.

### 8.1 Operational Details

The geotechnical management of the site between the period April 2007 to 2013 was under the control of a full time resident geotechnical engineer [M Jones].

From 2013 present the site has been geotechnically managed by a number of geotechnical specialist contractors who have provided geotechnical services enabling the site to comply with the requirements of The Quarries Regulations 1999.

Records have been reviewed [and are available should they be required], which clearly demonstrate that excavation and tipping operations have been undertaken in accordance with the approved designs as defined in the initial R. Edwards report dated November 2005 [a copy of which can be made available on request]. Where variations to the initially approved designs were necessary, geotechnical appraisals and assessments were undertaken prior to implementation.

### 8.2 Pre-commencement

The Quarries Regulations 1999 clearly define the requirements to ensure that a safe working environment is produced for all surface mining and quarrying operations.

Implicit in this requirement is that sites are adequately investigated to a reasonable level such that all aspects of the site Geology, Hydrogeology, and Site History can be taken into account enabling safe, geotechnically approved designs for excavation faces and Tips and safe working methodologies to be defined.

British Coal, between 1985 and 1995 drilled 1,515 openhole boreholes, 168 partially cored boreholes and 12 stratacores, the latter which produced continuous cores of the entire working sequence.

In addition, Miller Argent, in 2007 drilled a further 90 boreholes with 49.9 metres of cored sections.

Approximately 1205 of the boreholes were geophysically logged using the bed resolution density [BRD], long spaced density [LSD], and natural Gamma method which provides information on lithology type and thickness, and water level,

Initial detailed investigations into the previous mineworking history and site hydrogeology were also undertaken.

A detailed Geotechnical Site Report was compiled by R. Edwards, dated November 2005, and the operations commenced on site in 2007.

The report provided the following information:

- Background Geological, Hydrogeological and Historical Mining Details.
- Designs for the construction of excavations through Made-Up-Ground, Drift deposits, and Solid Strata.
- Designs for the construction of above ground overburden storage mounds, screening mounds, and in-pit backfill.
- Designs for excavated slopes through solid measures
- Largely assumed parameter values for materials, based on published data and information gained from numerous opencast operations in the South Wales Coalfield.
- Stability analyses in support of the proposed designs for excavations and tips.

### 8.3 Operational Phase

Operations on site commenced in 2007.

From the date of commencement up until 2013 geotechnical management on the site was undertaken by a full-time resident Geotechnical Engineer, following which the site was managed by external consultants.

Routine geotechnical management of the earthworks involved in the excavation of rock slopes along with the construction of three overburden mounds OB1, OB2, OB3, and in-pit backfill tip, BF1, along with regular geotechnical appraisals and assessments was undertaken continuously through the life of the site.

### 8.4 Assessment Methodology

In compliance with the requirements of The Quarries Regulations 1999 and prior to their construction all tips [both solid and liquid] and excavation faces were Geotechnically Appraised and, where dictated by the definitions contained in the above Regulations, Geotechnically Assessed. The various designs adopted on the site have been based upon extensive borehole information gained by British Coal Opencast Executive, assessment of historic underground ironstone and coal abandoned mineworkings plans, groundwater monitoring data, published geological information, experience gained in similar sites in the South Wales Coalfield, and geotechnical laboratory test data for the materials likely to be encountered during the working of

the site.

During the operational phase of the site routine collection of geological data, to include strata inclination, structural disturbances, i.e., faulting and folding, the location and effects of abandoned underground mineworkings, and any groundwater inflows, was undertaken.

In addition to the collection of the above information, the site, in compliance with Regulation 34 '*Operators duties in relation to excavations and tips which are significant hazards [notifiable excavations and tips]',* was subject to routine quarterly geotechnical assessments [Regulation 33] undertaken by the appointed geotechnical specialist.

The geotechnical site management of the operation has enabled a firm understanding of the geological conditions and engineering characteristics of the solid rock faces and tipped deposits to be achieved which has informed the designs for the proposed final site restoration features. The level of site management has enabled a good understanding of the performance of the strata to the process of excavation, and the ability of tipped overburden deposits to remain stable in the constructed tip structures.

## 9.0 Mitigation Measures

Upon the completion of coaling operations in November 2023 a detailed inspection of all tips and excavation faces was undertaken by the Geotechnical Specialist and site management.

An assessment of the potential remedial works which may be necessary to provide a long-term, stable, and safe final restoration, was undertaken and used to inform the final site designs. Where applicable the need for public access has been included within the assessment.

Since the cessation of coaling operations some of the recommended remedial works have been implemented with the outstanding items to be completed when the major restoration works commence.

### 9.1 Solid Tips

The split of superficial material to Coal Measures strata excavated from the site and hence included within the tips is approximately 10% to 90%. Of the Coal Measures strata moved site records show that 40% of it had to be blasted prior to excavation. The excavation equipment used to move the overburden materials had a 15m³ capacity bucket, hence it was capable of moving very large blocks of rock. Therefore, it is not considered appropriate or possible to undertake a meaningful intrusive site investigation of the tipped materials. The amount of rock, the size of the rock blocks and strength of the rock would make it impossible to drill boreholes through the tipped materials and in-situ testing would not give meaningful results. In addition, laboratory testing of material which is so coarse would not be feasible.

In order to derive shear strength parameters to allow stability analysis to be undertaken on the proposed final slope profiles for each of the tip structures a back analysis has been undertaken on the steepest section of slope on OB3. This section of slope has been stable since its construction, which is at least 11 years ago. For the purposes of the back analysis it has been assumed that the slope in its current condition has a Factor of Safety (FoS) of 1.

Given the proportion of rock within the tips it is considered that taking a purely frictional approach to the material in the tips is appropriate. The back analysis has determined an internal angle of friction for the tip material of 33°, the analysis is appended.

#### 9.1.1 Backfill Slope BF1

It is proposed to re-engineer the lower section of the backfill slope, which currently comprises a benched profile with slopes of varying inclination, to produce a single unbenched slope with an overall gradient of approximately 1V to 2.7H [19° from horizontal].

The re-grading will entail elements of ‘cut’ to remove material currently lying above the restoration profile envelope, and ‘fill’, to generate the proposed overall profile in the lower area which is currently over-steep.

The proposed fill area is in the lower section of the tip which currently lies beneath the final rest-water level in the lake feature. Before filling is undertaken the water level will be reduced then the lower level of the tip constructed using ‘suitable material’, which will be approved by the Geotechnical Specialist. The material will be placed in compacted layers in accordance with the Specification of Highway Works.

Stability analyses have shown that the proposed design, gives a minimum SF (Safety Factor) in excess of 1 for combinations 1 and 2, copies of the analyses are included in Appendix 1, demonstrating that the proposed re-design will produce a long-term stable landscape feature. The locations of the cross sections analysed are shown on Drawing Number 24-012-D-001.

On completion of the regrading works soil making materials will be placed on the slope to the level of the lowest predicted water level and these will be hydraseeded to establish vegetation cover.

### 9.1.2 Overburden Mound OB1

OB1 has been affected by large-scale full tip height instability along its western facing side which has arisen due to the lower level of the tip being re-excavated to enable the coaling limit to be achieved, as described earlier in the report. It is proposed to reconstruct the western slope of OB1 be re-profiling it to a gradient of 1V in 2.5H. This will involve a cut and fill exercise to achieve the design slope.

Stability analyses of the existing northern, eastern and southern sides of OB1 have been undertaken using Eurocode 7 DA1. These highlight that sections of these slopes would be considered too steep to ensure long-term stability, returning a SF of less than 1. It is therefore proposed that the following will regrading works will be undertaken:

- The northern slope should be regraded to form a single 1V in 2.5H slope, based on a cut and fill exercise.
- The lower slope of the southern side will be regraded to 1V in 2H by reducing the mid-height bench width by approximately 7m.

The stability analyses for the regraded slope sections returns a SF of >1 for all slope sections, copies of the analyses are included in Appendix 2. The locations of the cross sections analysed are shown on Drawing Number 24-012-D-001.
The excess material from these regrading works can be incorporated into the remedial works to

the western slope of OB1.

### 9.1.3 Overburden Mound OB2

Stability analyses have been undertaken for the western and southern slopes of OB2, as these are considered to represent the worst-case scenarios, using Eurocode 7 DA1. The results of the stability analyses show SF values of >1 for all slope sections, copies of the analyses are included in Appendix 3. The locations of the cross sections analysed are shown on Drawing Number 24-012-D-001.

### 9.1.4 Overburden Mound OB3

Stability analyses have been undertaken for five cross-sections through the side slopes of OB3 using Eurocode 7 DA1. The locations of the cross sections are shown on Drawing Number 24-012-D-001. These highlight that sections of these slopes would be considered too steep to ensure long-term stability, returning a SF of less than 1. It is therefore proposed that the following will regrading works will be undertaken.

- The lower slope of the western side of the tip at its southern end.
- The lower slope of the eastern side of the tip above the water treatment lagoons.

The stability analyses for the regraded slope sections returns a SF of >1 for all slope sections, copies of the analyses are included in Appendix 4.

The excess material from these regrading works can be incorporated into the regrading works to the lower slope of the Backfill Tip.

## 9.2 Liquid Tips (Lagoons)

### 9.2.1 Flooded Quarry Void

1. As a part of the site restoration, it is proposed to allow the quarry void to flood and naturally reach a final rest water level which is likely to fluctuate seasonally.
2. The anticipated final rest water level is expected to vary between 275 and 285 m AOD, with a ‘worst case’ level of 286 m AOD. This water level lies at least 40 metres below the lowest ‘spill-point’.
3. A detailed hydrogeological assessment ‘Hydrogeological Technical Report’ dated 24/ 01/ 25 [Groundwater Science Stuart Daley and Associates] determined that the ‘worst case’ lake water level would be 290 metres AOD. This projected level takes into account the potential impact of climate change.
4. Stability analyses have demonstrated that the varying rest water level will not have any de-stabilising effect on the stability of the re-graded backfill slope.

Stability analyses have demonstrated that the predicted rest water level will not adversely affect the stability of the re-graded backfill slope or the exposed bedrock slopes forming the southern and eastern sidewalls.

The projected lake level lies significantly below the crest elevations of the surrounding slopes and therefore does not introduce additional pore water pressures within the tipped materials or bedrock slopes.

The formation of the lake is expected to provide a stabilising influence on the lower sections of the slopes by maintaining saturation conditions and reducing weathering effects.

The final lake will therefore represent a stable long-term landscape feature and will form a key component of the final restoration proposals.

### 9.2.2 Residual Lagoons

A number of lagoons and water treatment areas will be retained and form a part of the final site restoration. The structures were all excavated into original and / or previously made-up-ground and have remained stable throughout the life of the site. Subject to these structures being un-affected by any future engineering works, they should remain stable in perpetuity.

## 9.3 Excavation Faces

Extensive field-based information is available for the performance of the solid strata which will form the final slopes along the southern and eastern sides of the site.

The prime considerations are degree of surface weathering [which can extend as deep as 20 metres and sometimes up to 40 metres below ground level], and orientation and shear strength characteristics of planar discontinuities within the rockmass, i.e., bedding, jointing and faulting.

### 9.3.1 Southern Sidewall

1. The southern sidewall is the ‘highwall’ and defines the deepest part of excavation on the site, reaching a maximum depth of approximately 150 metres below original ground level.
2. Initial stability analyses demonstrated that the wall would have an acceptable level of stability with computed Factor of Safety values ranging between 1.17 and 3.18.
3. The site restoration will involve some residual faces being retained and left exposed above the final [highest anticipated] rest-water level of 285 m AOD, to a height of approximately 100 metres.
4. The residual individual faces are inclined at approximately 65° [as measured from

horizontal] with intermediate 5 metres wide flat benches producing an overall slope profile of approximately 1 vertical to 1 horizontal [45°].

5. As the operation progressed from west to east, three NNE/SSW orientated normal faults were encountered which displaced the strata to the west. The westernmost being the Penydarren Fault and the easternmost the Dowlais Fault, with an un-named one between the two.
6. The faults orientations with respect to that of the sidewall was such that only localised disturbance around the point of intersection was experienced.
7. All three structures have been fully concealed by the backfill deposits.
8. The upper section of the sidewall extending to approximately 5 to 6 metres below surface level comprises strata which have been affected by surface weathering processes resulting in a reduction in their intrinsic strength characteristics. In mitigation it is proposed to grade the upper slope sections producing a slope gradient of approximately 1 vertical to 2 horizontal [26.5°] which will produce a long-term stable feature.
9. Towards the eastern end of the sidewall the strata lying above the 'Q' Seam have been affected by multiple low angle thrust dislocations [faults]which have resulted in sections of bedding plane defined strata falling from the face leaving un-supported rock in the face. Ideally, it is proposed to remove the potential for moderately large sabs of strata spalling from the face by extending slope re-grading down to the base of the disturbance in the affected zone. The operational feasibility of undertaking this operation in a safe manner will be assessed by site management and the geotechnical specialist. If not possible, an alternative strategy possibly involving extended isolation of the slope crest area will be assessed.
10. During the initial design stage detailed slope stability analyses were undertaken to identify and assess the potential modes of failure which could affect the sidewall. No significant areas of concern were identified other than in the immediate vicinity of the various faults which would be intersected. Various potential modes of failure were identified, the impact of which was determined would be localised, small-scale and only of possible significance as a safety consideration during the mining operational phase.

### 9.3.2 Eastern Sidewall

1. The eastern sidewall varies in height from approximately 20 to 30 metres at the northern end to over 120 metres at the southern end. Initial stability analyses demonstrated the wall to have a computed Factor of Safety of between 1.14 and 2.7.
2. During the latter stages of the operation the eastern sidewall has been affected by significant instability as it has been developed towards the east due to the presence of normal faulting which had an orientation close to that of the sidewall and a displacement towards the west.
3. Large scale spalling of strata extending several tens of metres up the face were

experienced resulting in the formation of extensive scree cones down the faces.

4. As the excavation advanced towards the east the fault / sidewall point of intersection migrated towards the north and can now be observed to be present around the Big Seam horizon at the northern end of the site.
5. At the southern end and mid- section of the east wall the fault has been removed by the advancing excavation and where it remains at the northern end various remedial stabilising works have been undertaken.
6. Remedial works have included the removal of any adversely inclined and dilated strata from faces and the re-grading / backfilling at the point of intersection. The works are considered to be sufficient to ensure the long-term stability of the affected section of wall.
7. Further remedial works have included the re-grading of a high-level corner-point along the mid-section of the wall where badly dilated strata were present which had the potential to topple forwards.
8. Where coal seams have been exposed in final sidewalls which could be accessible to the general public from the remaining benches.
9. Schematic drawings 1 and 2 provide details of the proposed remedial design, which, in addition to the concealing of seams, it is proposed to install rock-gutters to contain any rocks which may occasionally spall from the faces.

### 9.3.3 Management of Risk from Instability

It can be expected that small-scale instabilities and rockfalls will occur from the remaining rock faces. However, it is proposed that there will be no public access adjacent to the remaining rock faces, the area will be closed off by bunding and appropriate fencing to prevent access. In addition, perennial shrubs, such as brambles, will be encouraged to grow in order to also create a dense natural barrier to deter trespass.

## 10.0 Monitoring

### 10.1 Operational Phase

Operations on the site during the restoration phase will be undertaken in compliance with the requirements of the Quarries Regulations 1999. Ultimately this is for the delivery of a site which is, upon the completion of the works , left in **'a safe condition'** [Regulation 6[4]]'.

It is therefore proposed that during the restoration phase the appointed geotechnical specialist will undertake periodic site inspections and remain 'on call' for the duration of the works.

### 10.2 Post-Operational Phase

Following the final completion of the site restoration works the appointed geotechnical specialist will confirm that the site has been restored in compliance with the consented designs and has been left in a safe condition.

A formal site completion report will be issued.

For the first three years following the completion of restoration works an annual site inspection by the appointed geotechnical specialist will be undertaken and the findings of the inspection submitted to the local planning authority who under Part II of the Mines and Quarries (Tips) Act 1969, assumes responsibility for the monitoring of the site.

## 11.0 Conclusions

A detailed review of archival information, site investigation data, operational records and current site conditions has been undertaken in order to assess the long-term geotechnical stability of the proposed final restoration features at the Ffos-y-Fran site.

The assessment has considered the geological and hydrogeological conditions present across the site, together with the performance of excavated slopes and tipped structures observed throughout the operational life of the mine. The extensive borehole database, operational geotechnical records and the experience gained during nearly two decades of mining operations have provided a high level of confidence in the understanding of the ground conditions and the engineering behaviour of the materials encountered.

The principal geotechnical features which will remain following restoration comprise the overburden mounds OB1, OB2 and OB3, the in-pit backfill slope BF1, the residual rock faces forming the southern and eastern sidewalls of the excavation, and the restored quarry void which will form a permanent water body. Stability analyses and engineering assessments have been undertaken for these structures in order to confirm their long-term stability under the proposed restoration configuration.

The analyses undertaken for the overburden mounds demonstrate that, following the proposed reprofiling works, the slopes will achieve acceptable Factors of Safety. Remedial works are proposed to sections of OB1 and OB3 where the current slope geometry is considered steeper than desirable for long-term stability. These works primarily comprise regrading through cut-and-fill earthworks to produce overall slope gradients of approximately 1V:2.5H, which are considered appropriate for the material types present within the tips.

The backfill slope BF1 will be re-engineered to produce a consistent slope profile with an overall gradient of approximately 1V:2.7H. Stability analyses demonstrate that the proposed geometry provides satisfactory stability and will represent a safe long-term landform. The works will involve controlled earthworks and compaction of suitable fill materials to ensure the required stability is achieved.

The southern and eastern rock sidewalls have been assessed based on their structural geology, operational performance and previously undertaken stability analyses. The exposed rock faces have demonstrated generally stable behaviour during the operational life of the mine, with instabilities largely limited to localised fault zones or small-scale weathering-related spalling. The proposed restoration design retains a number of residual rock faces above the final lake level, with localised regrading proposed in areas where near-surface weathered strata or structural disturbances could otherwise present a long-term instability risk. These measures will ensure that

the residual slopes remain stable and that any future rockfall events are small-scale and contained within the lake area. There will be no public access to the areas below the residual rock faces.

The hydrogeological assessment indicates that the quarry void will gradually fill with groundwater to a final equilibrium water level expected to lie between approximately 275 m AOD and 285 m AOD, with a conservative worst-case level of 286 m AOD. This water level lies significantly below the lowest potential spill point and will not adversely affect the stability of surrounding slopes or tipped structures. The formation of the lake will represent a stable and permanent feature within the restored landscape.

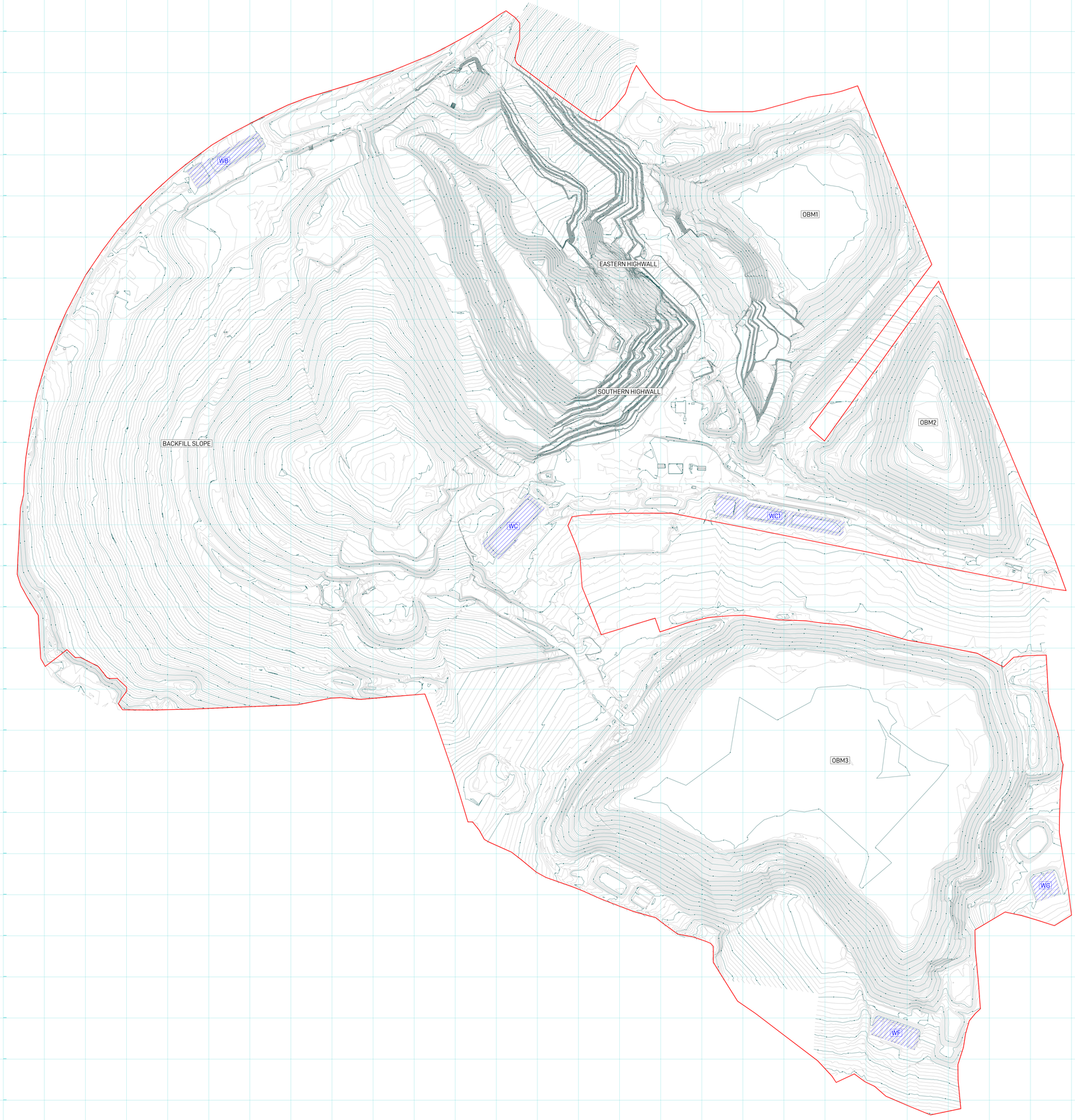
The residual lagoons and water treatment structures which will remain on site have demonstrated stable performance throughout the operational phase of the site and are expected to remain stable in the long-term, provided they are not significantly modified by future engineering works.

Geotechnical management will continue during the restoration phase through periodic inspections undertaken by the appointed Geotechnical Specialist. Following completion of the restoration works, a completion report will be prepared confirming that the site has been restored in accordance with the approved designs and left in a safe condition, as required by the Quarries Regulations.

On the basis of the assessments undertaken and subject to the implementation of the mitigation and reprofiling works described in this report, it is concluded that the proposed restoration landforms at the Ffos-y-Fran site will be geotechnically stable and capable of remaining as long-term landscape features.

The restoration proposals are therefore considered to satisfy the requirements of Regulation 6(4) of the Quarries Regulations 1999, which requires that, upon cessation of operations, a quarry is left so far as reasonably practicable in a safe condition.

# DRAWINGS




NOTES

1. ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED.

| Rev. | Revision Detail | Drawn | Date |
|---|---|---|---|
| 01 | First Issue | VR | 06/02/26 |

CLIENT:

MERTHYR SOUTH WALES

PROJECT:

FFOS-Y-FRAN

TITLE:

SITE PLAN

| DRAWN: | CHECKED: | DATE: |
|---|---|---|
| VR | DH | FEB '26 |
| SCALE: | ORIGINAL SHEET SIZE: | STATUS: |
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DRAWING NO.: 25-247-D-001

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NOVA GEO CONSULTING

Unit 7
1 Lower Bar
Newport, Shropshire
TF10 7BE

E-mail: info@novageo.co.uk

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|---|---|---|---|
| 01 | First Issue | RB | 01/01/24 |

CLIENT:

MERTHYR SOUTH WALES

PROJECT:

FFOS-Y-FRAN

TITLE:

ROCKHEAD CONTOUR PLAN

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REVISION: 01

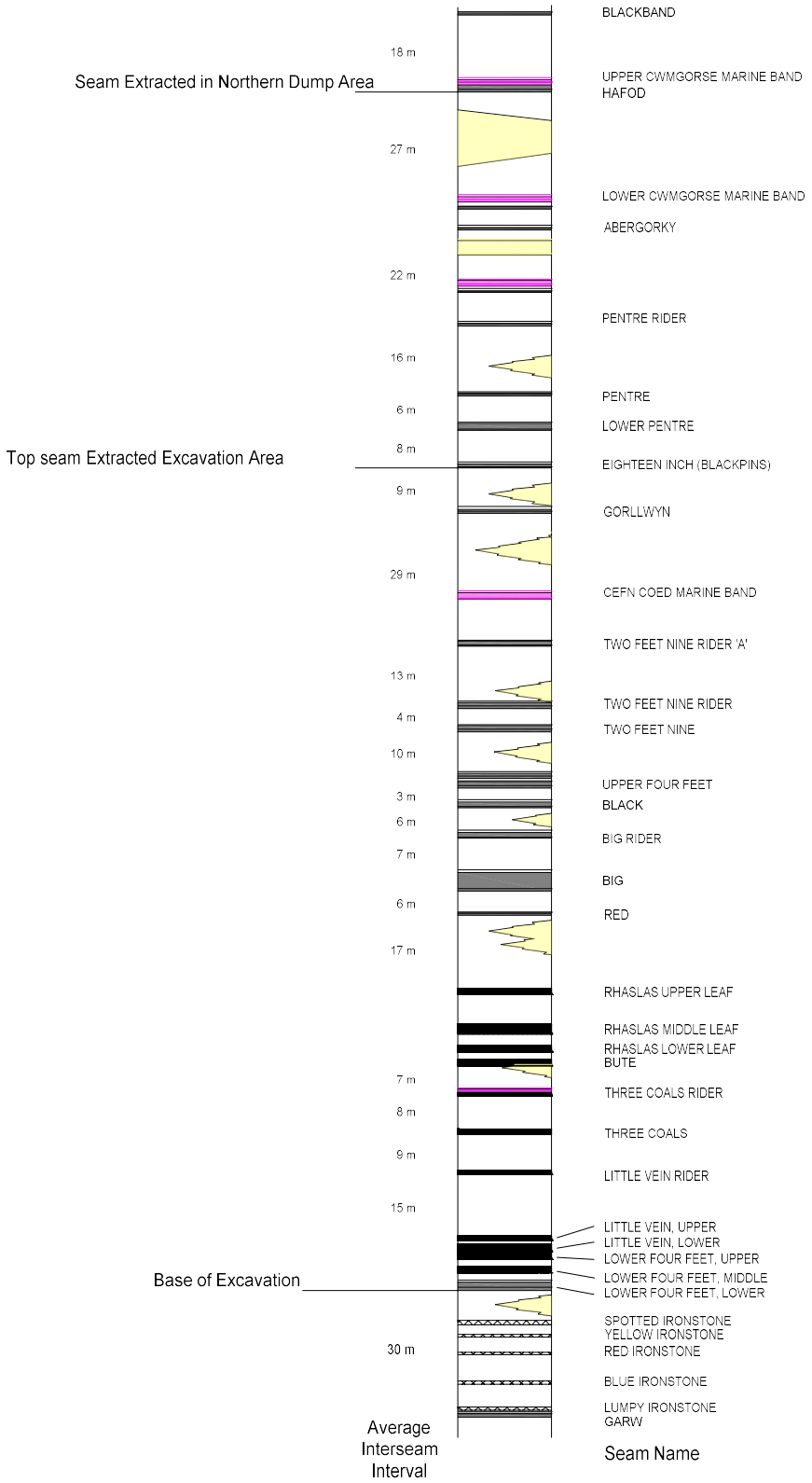
NOVA GEO CONSULTING

Unit 7
1 Lower Bar
Newport, Shropshire
TF10 7BE

E-mail: info@novageo.co.uk

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# Generalised Geological Section of Strata Succession




NOTES:

1. ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED.

Key:

- Ironstone
- Sandstone
- Coal
- Marine band (usually claystone)
- Predominantly claystones

| REV. | REVISION DETAIL | DRAWN | DATE |
|---|---|---|---|
| 01 | FIRST ISSUE | VR | 04/02/26 |

CLIENT: MERTHYR SOUTH WALES

PROJECT: FFOS-Y-FRAN

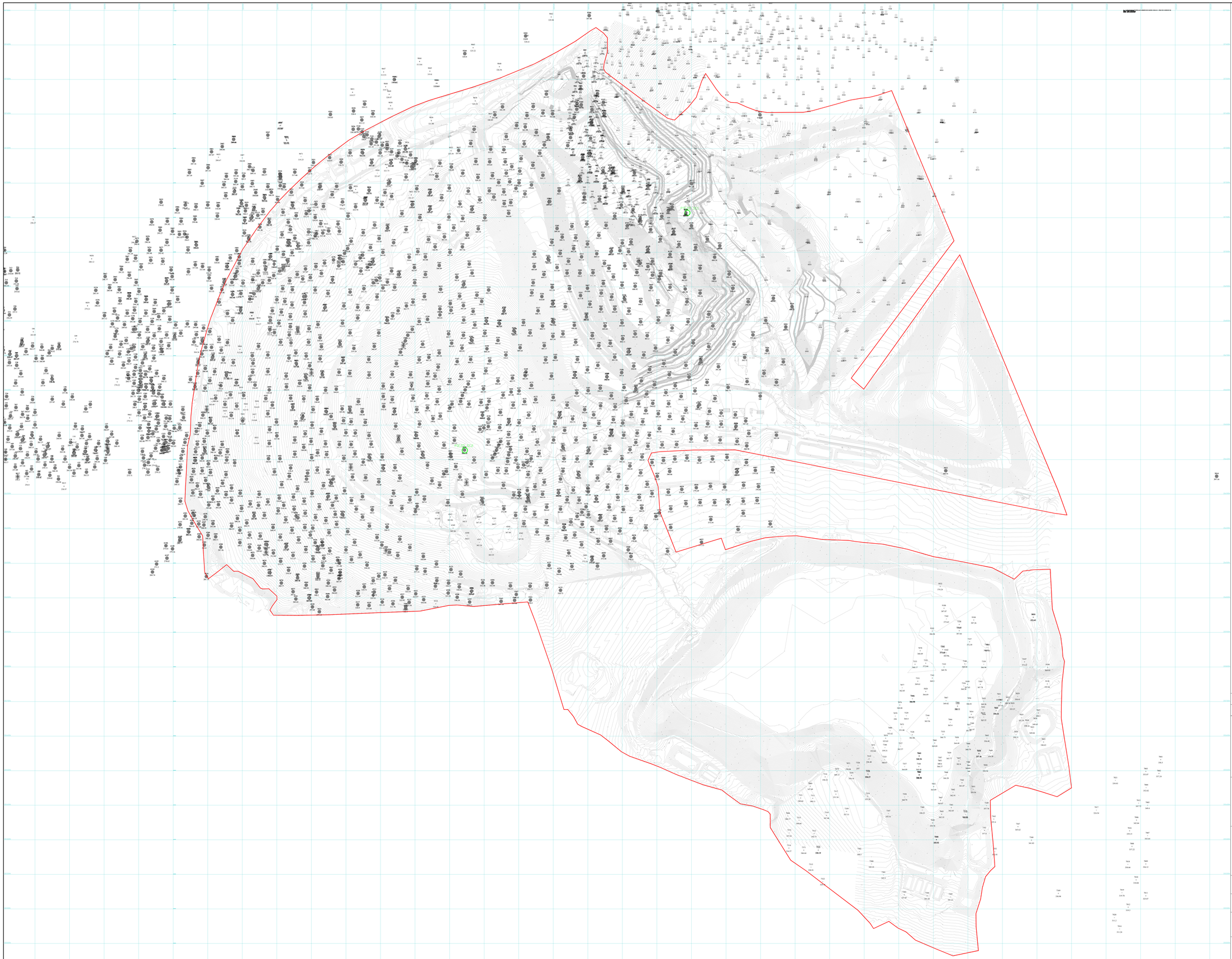
TITLE: GENERALISED VERTICAL SECTION


NOVA GEO CONSULTING
Unit 7
1 Lower Bar
Newport, Shropshire
TF10 7BE
E-mail: info@novageo.co.uk
NOVA GEO CONSULTING LTD


| DRAWN: | CHECKED: | DATE: |
|---|---|---|
| VR | RB | FEB '26 |
| SCALE: NTS | ORIGINAL SHEET SIZE: A4 | STATUS: DRAFT |

DRAWING NO.: 25-247-D-003

REVISION: 01




NOTES

1. ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED.

Key:

- Site Boundary
- 5129 Borehole Number / Openhole (OH) / 388.64 Collar Level
- 4203 Borehole Number / Openhole (OH) / 406.95 Collar Level
- 9031 Borehole Number / Openhole (OH) / 331.27 Collar Level
- 5129 Borehole Number / Openhole (OH) / 388.64 Collar Level
- 4203 Borehole Number / Openhole (OH) / 406.95 Collar Level
- 9031 Borehole Number / Openhole (OH) / 331.27 Collar Level
- SC1 & SC2 Piezometers / Cored Holes
- Trecatty South Boreholes (OBM1 Area)

N

| Rev. | Revision Detail | Drawn | Date |
|---|---|---|---|
| 01 | First Issue | VR | 06/02/26 |

CLIENT:

MERTHYR SOUTH WALES

PROJECT:

FFOS-Y-FRAN

TITLE:

BOREHOLE LOCATION PLAN

| DRAWN: | CHECKED: | DATE: |
|---|---|---|
| VR | RB | FEB '26 |
| SCALE: 1:3500 | ORIGINAL SHEET SIZE: A0 | STATUS: DRAFT |

DRAWING NO. 25-247-D-001 REVISION: 01

NOVA GEO CONSULTING

Unit 7
1 Lower Bar
Newport, Shropshire
TF10 7BE

E-mail: info@novageo.co.uk

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NOTES

1. ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED.

KEY:

Shaft Locations

Adit Locations

| Rev. | Revision Detail | Drawn | Date |
|---|---|---|---|
| 01 | First Issue | VR | 06/02/26 |

CLIENT:

MERTHYR SOUTH WALES

PROJECT:

FFOS-Y-FRAN

TITLE:

SHAFT AND ADIT LOCATION PLAN

| DRAWN: | CHECKED: | DATE: |
|---|---|---|
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DRAWING NO.: 25-247-D-005

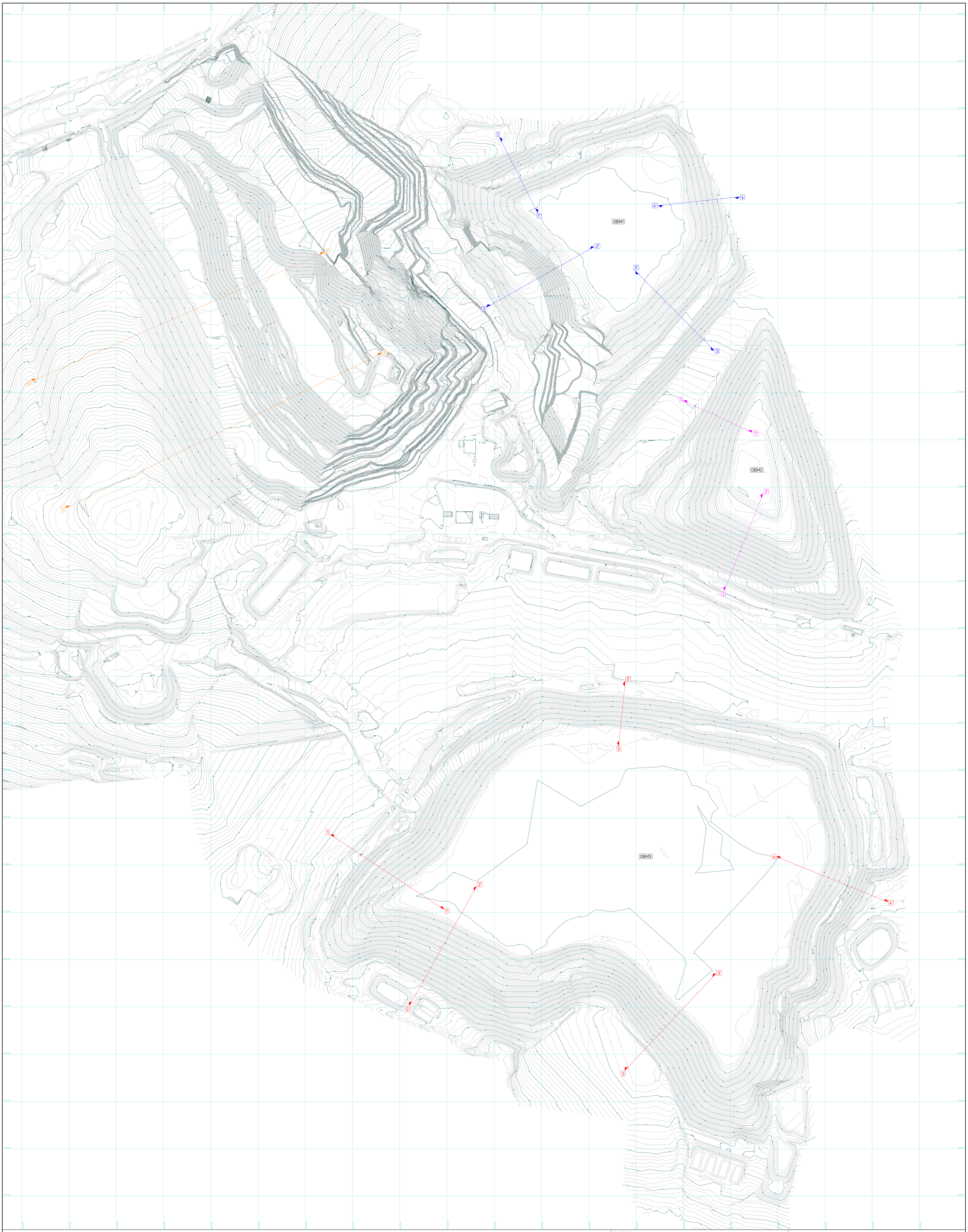
REVISION: 01

NOVA GEO CONSULTING

Unit 7
1 Lower Bar
Newport, Shropshire
TF10 7BE

E-mail: info@novageo.co.uk

NOVA GEO CONSULTING LTD




NOTES

1. ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED.

KEY

- OBM1 STABILITY ANALYSIS SECTIONS
- OBM2 STABILITY ANALYSIS SECTIONS
- OBM3 STABILITY ANALYSIS SECTIONS
- BACKFILL TIP STABILITY ANALYSIS SECTIONS

| REV. | REVISION DETAIL | DRAWN | DATE |
|---|---|---|---|
| 01 | FIRST ISSUE | VR | 05/02/26 |

CLIENT:

MERTHYR SOUTH WALES

PROJECT:

FFOS-Y-FRAN

TITLE:

CROSS SECTION LOCATION PLAN

NOVA GEO CONSULTING

Unit 7
1 Lower Bar
Newport, Shropshire
TF10 7BE

E-mail: info@novageo.co.uk

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| DRAWN: | CHECKED: | DATE: |
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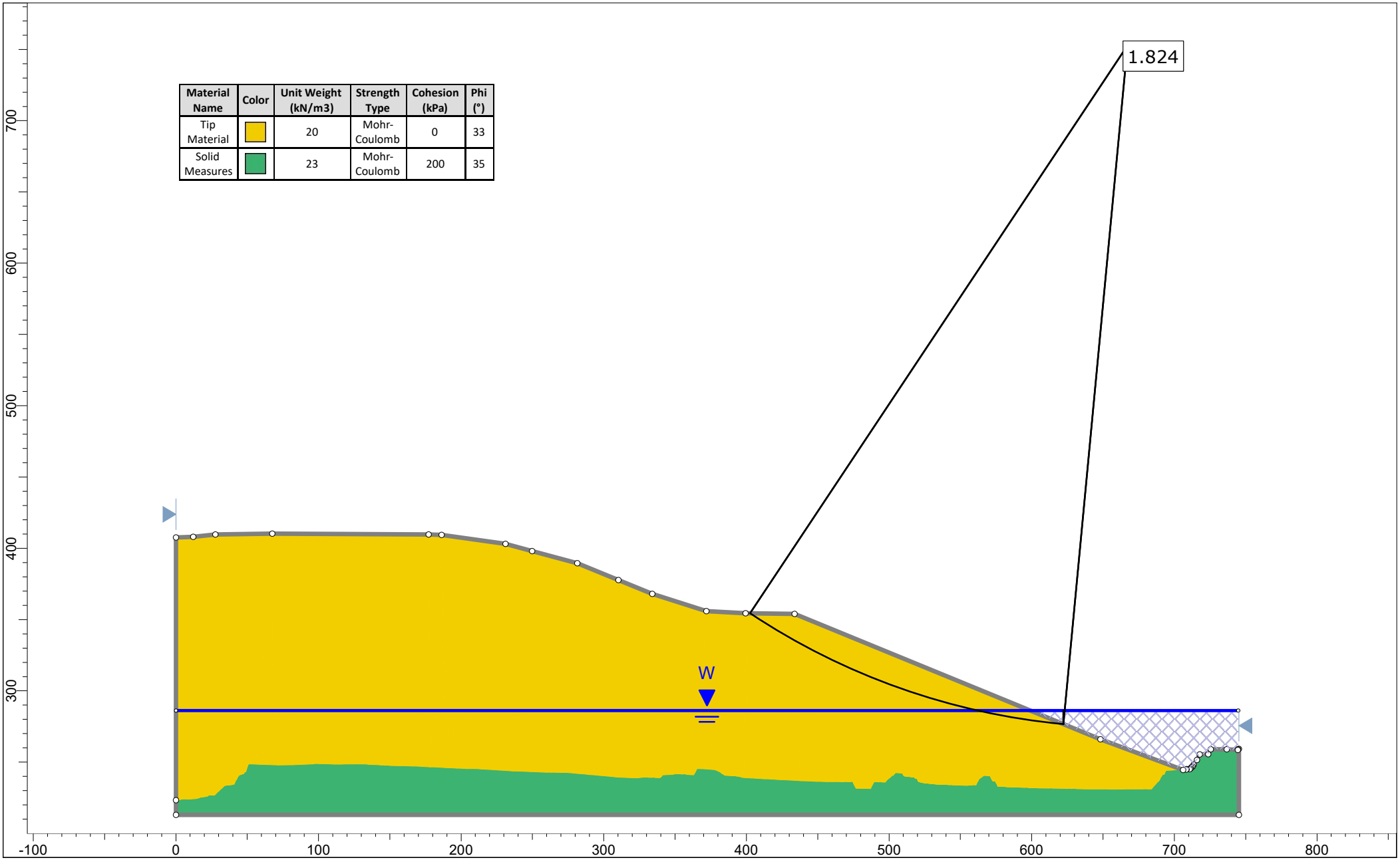
DRAWING NO. 24-012-D-001

REVISION: 01

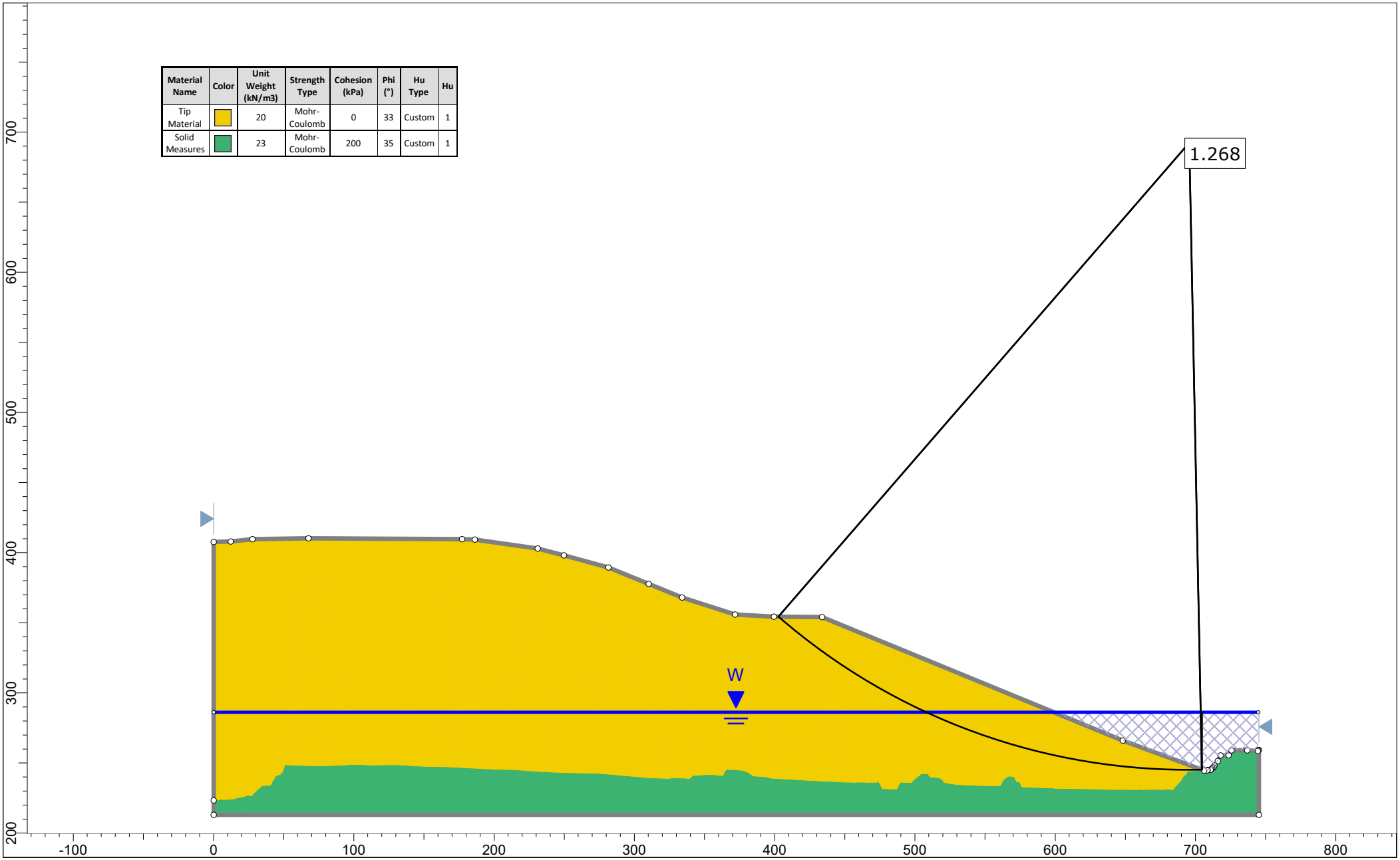
# APPENDIX 1

# Backfill Slope Stability Analyses

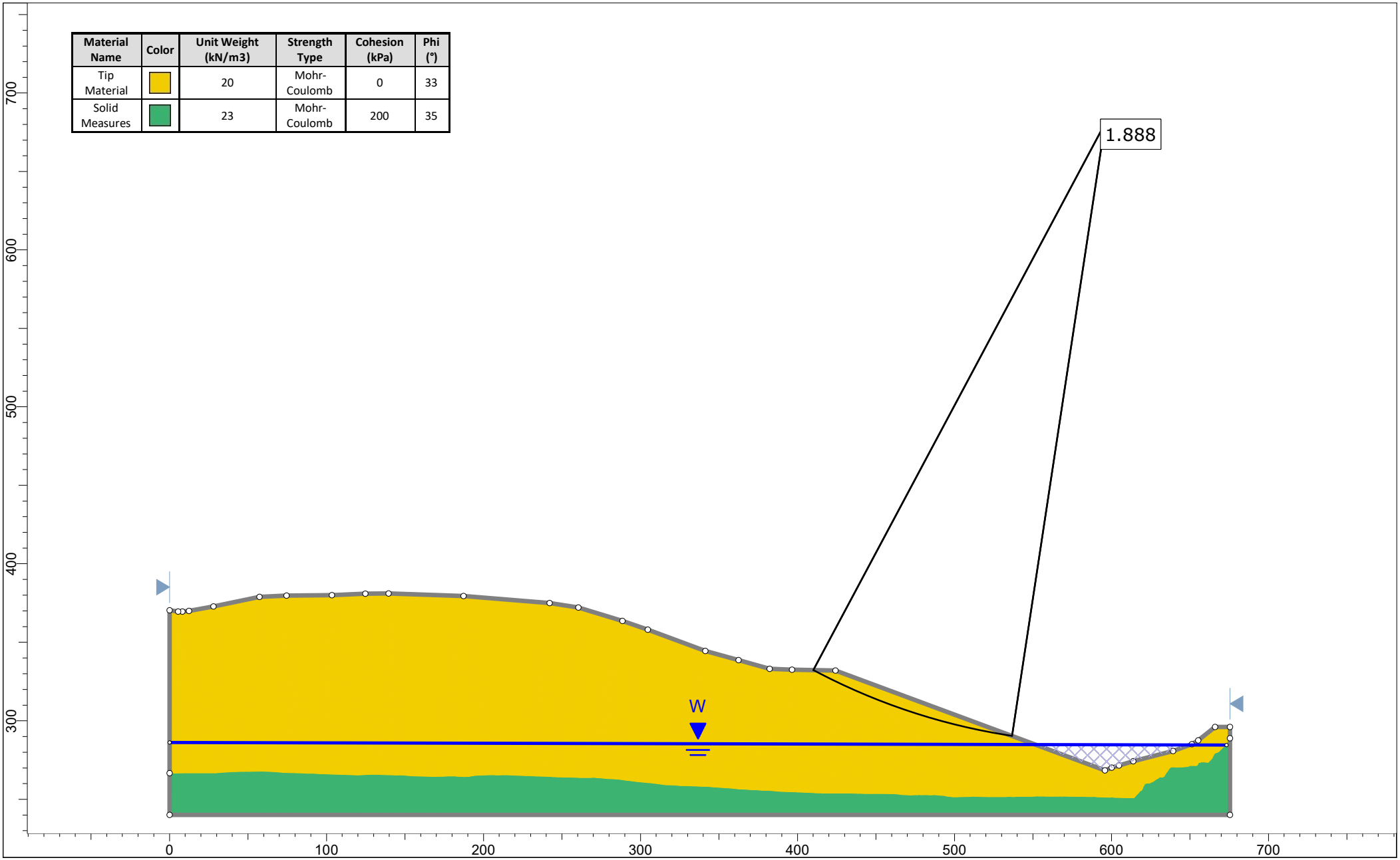
| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (°) |
|---|---|---|---|---|---|
| Tip Material | | 20 | Mohr-Coulomb | 0 | 33 |
| Solid Measures | | 23 | Mohr-Coulomb | 200 | 35 |



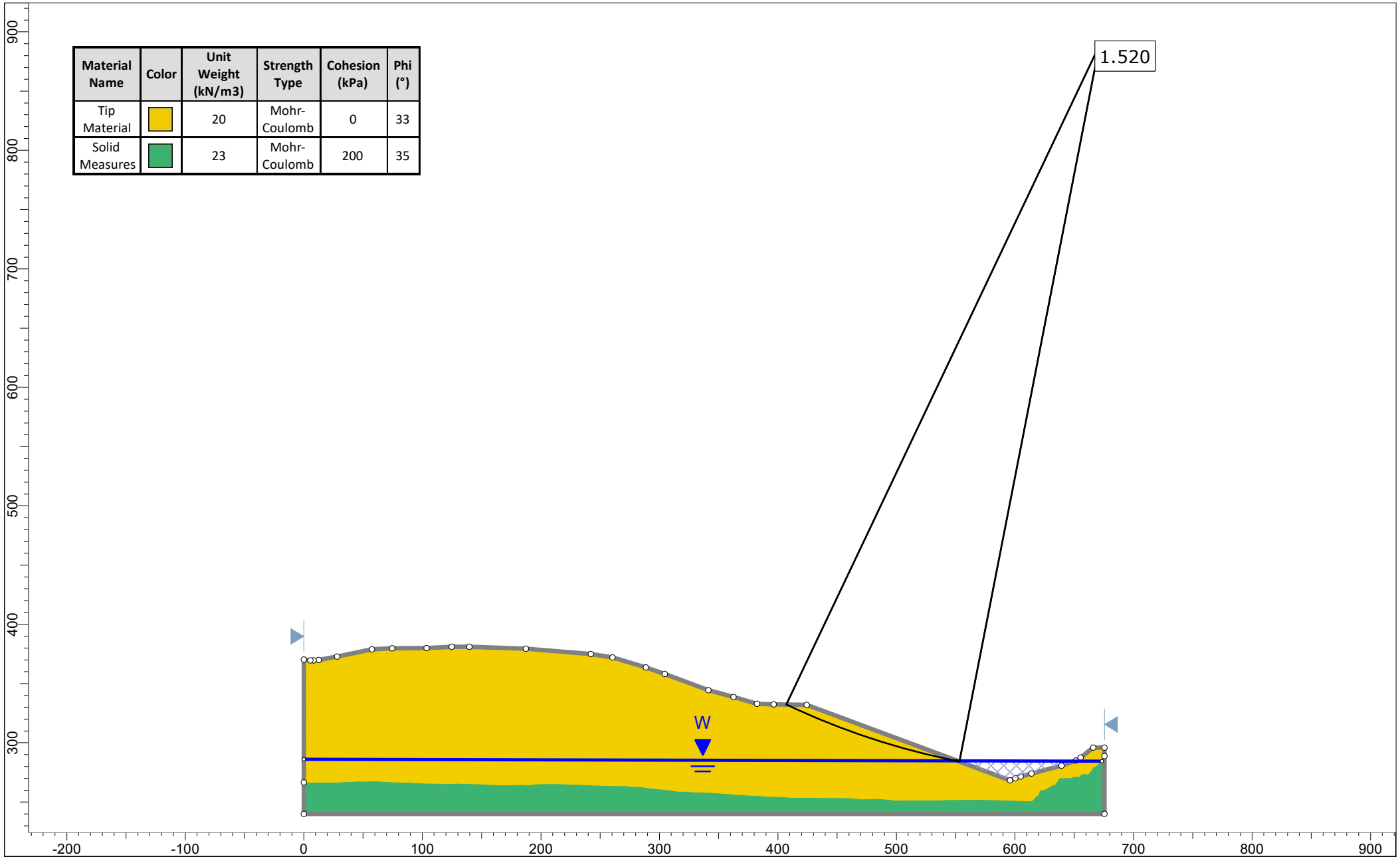
| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (°) | Hu Type | Hu |
|---|---|---|---|---|---|---|---|
| Tip Material | | 20 | Mohr-Coulomb | 0 | 33 | Custom | 1 |
| Solid Measures | | 23 | Mohr-Coulomb | 200 | 35 | Custom | 1 |



| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (°) |
|---|---|---|---|---|---|
| Tip Material | | 20 | Mohr-Coulomb | 0 | 33 |
| Solid Measures | | 23 | Mohr-Coulomb | 200 | 35 |



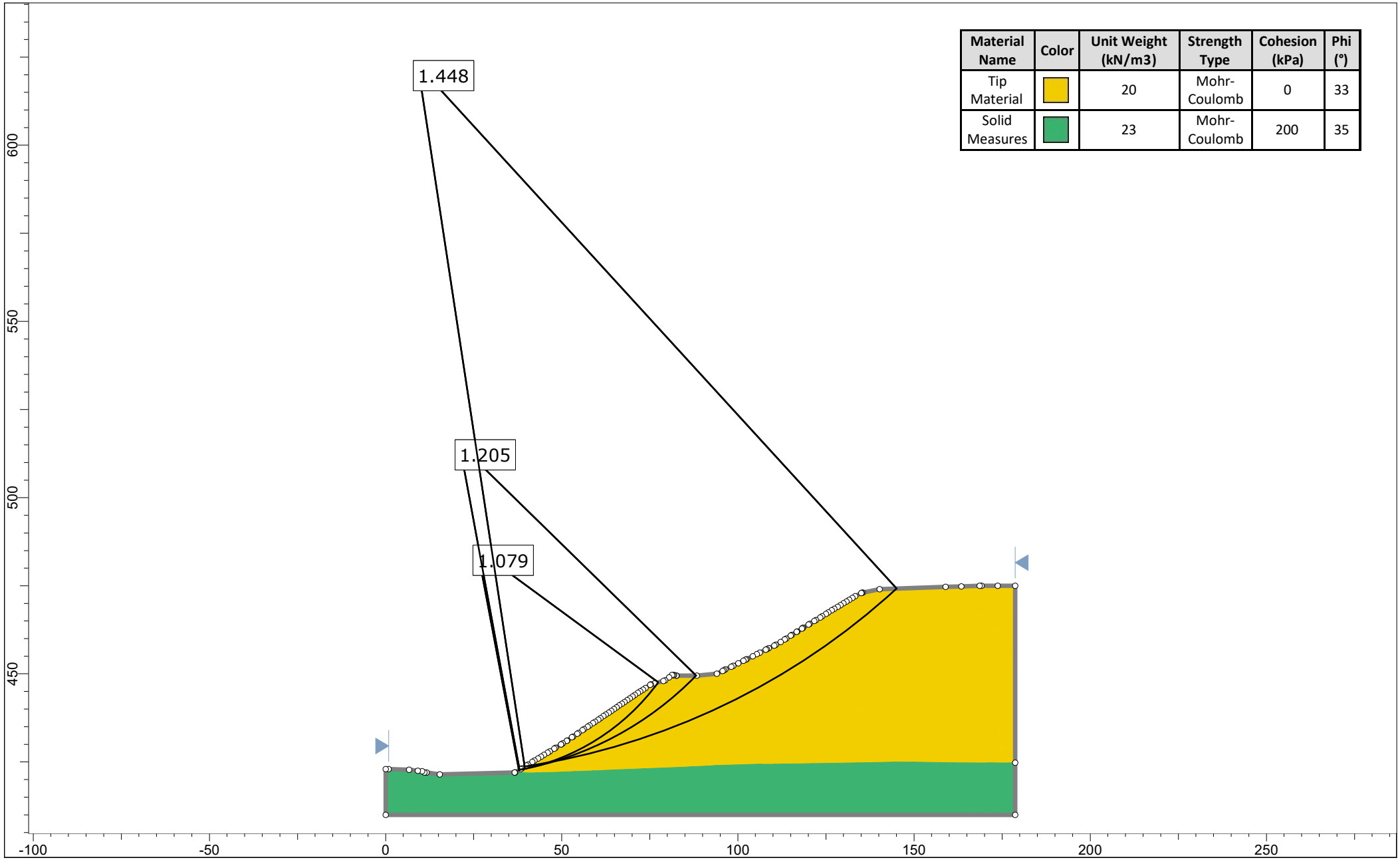
| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (°) |
|---|---|---|---|---|---|
| Tip Material | | 20 | Mohr-Coulomb | 0 | 33 |
| Solid Measures | | 23 | Mohr-Coulomb | 200 | 35 |

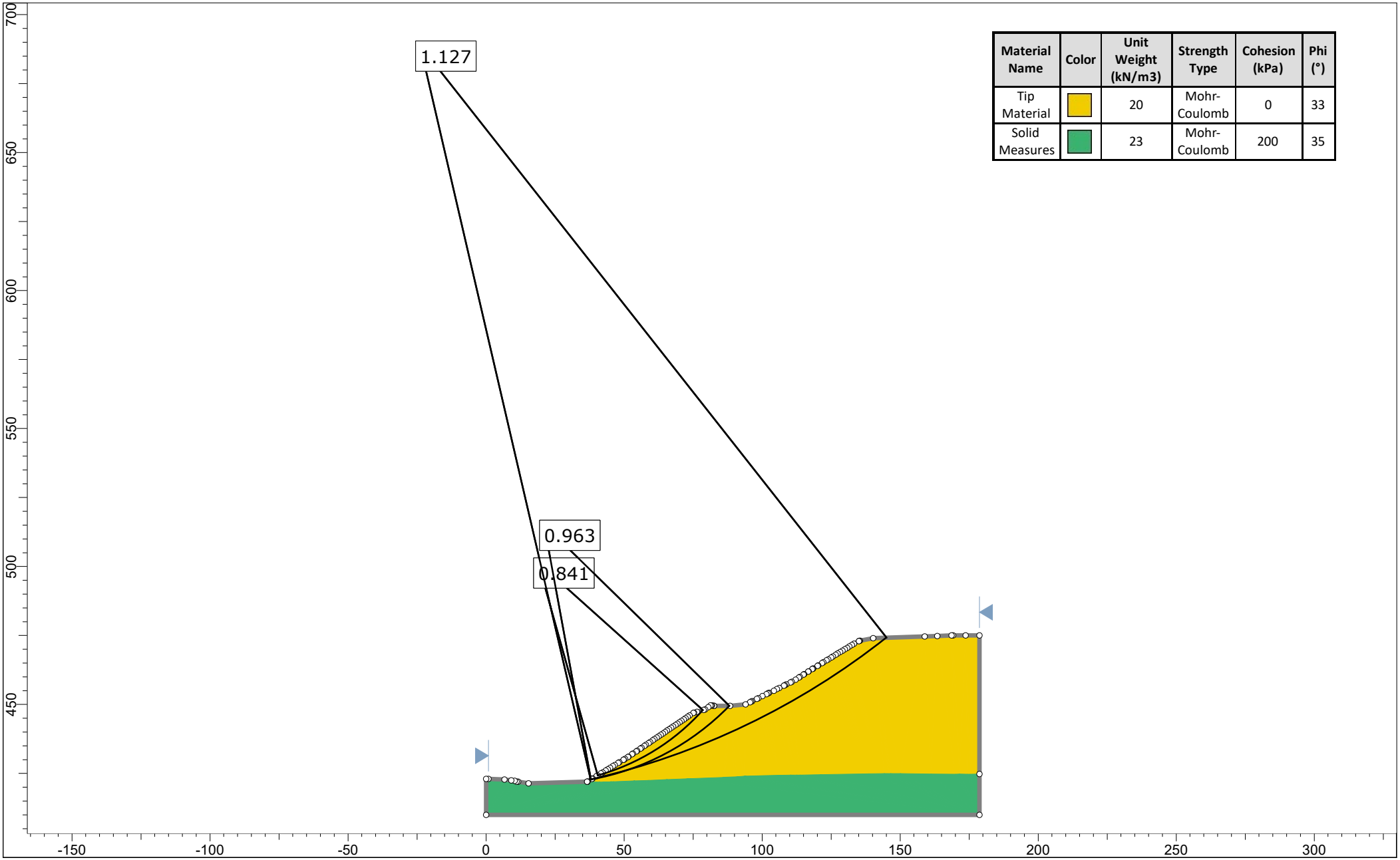


# APPENDIX 2

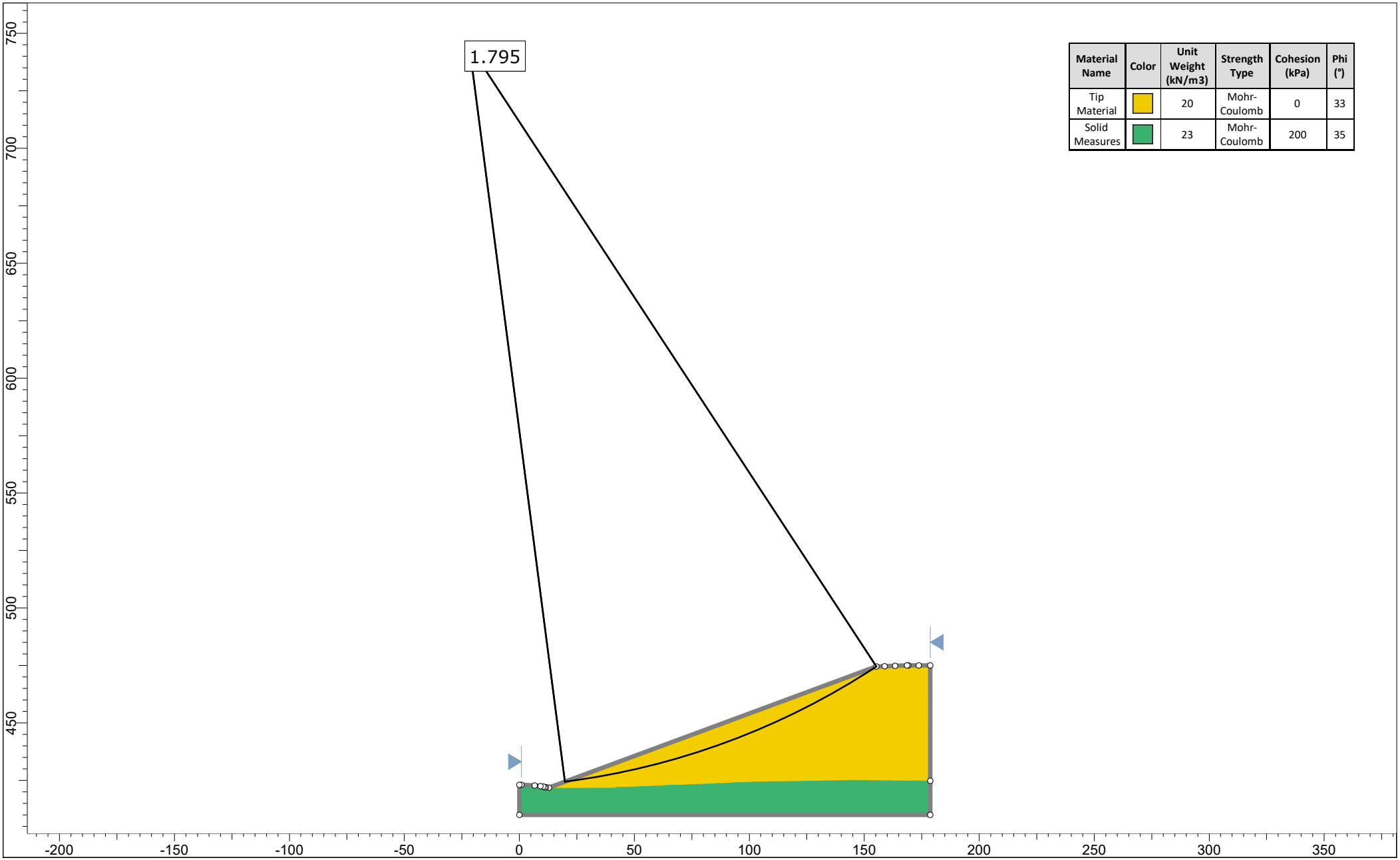
# OB1 Stability Analyses

| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (°) |
|---|---|---|---|---|---|
| Tip Material | | 20 | Mohr-Coulomb | 0 | 33 |
| Solid Measures | | 23 | Mohr-Coulomb | 200 | 35 |

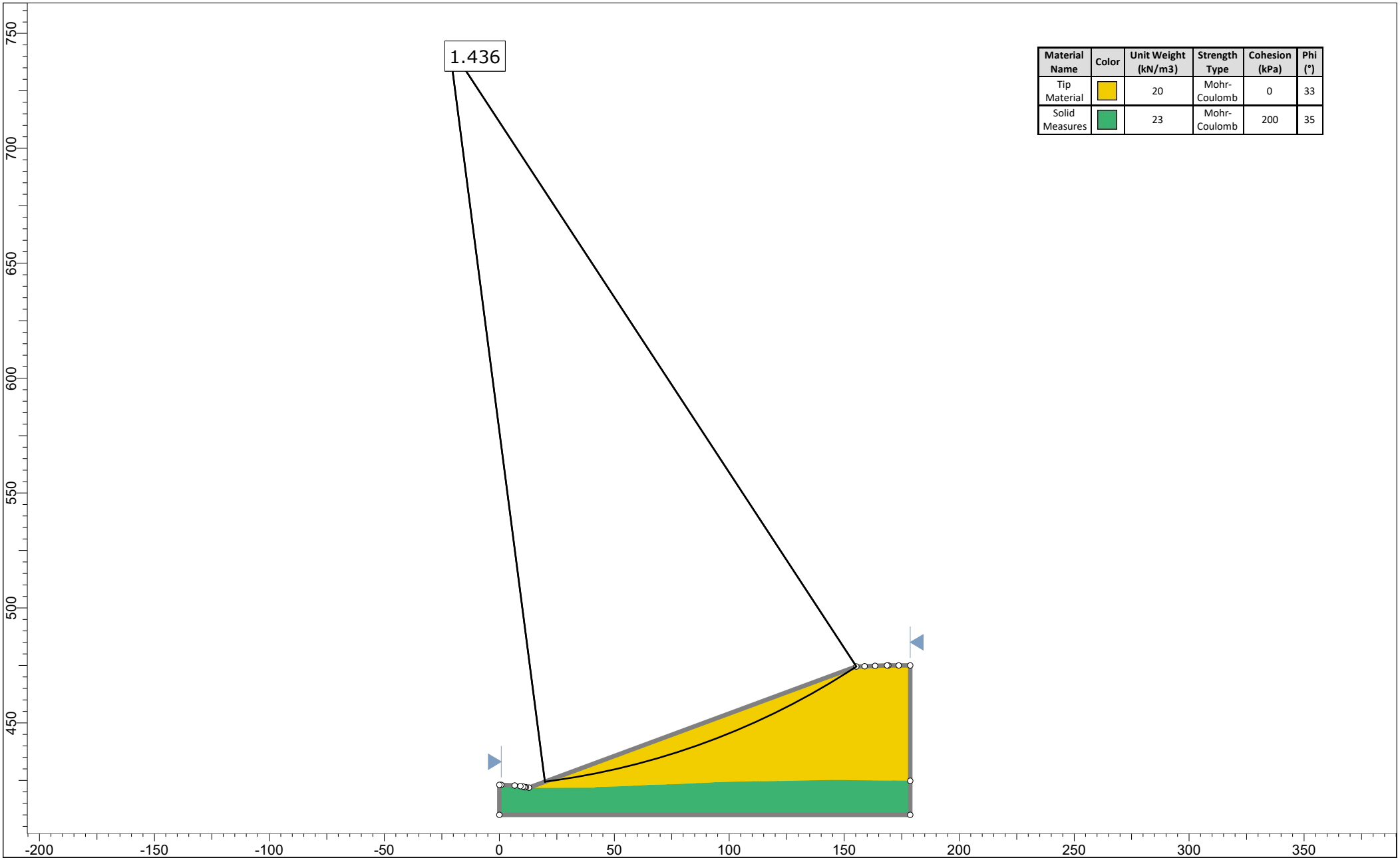


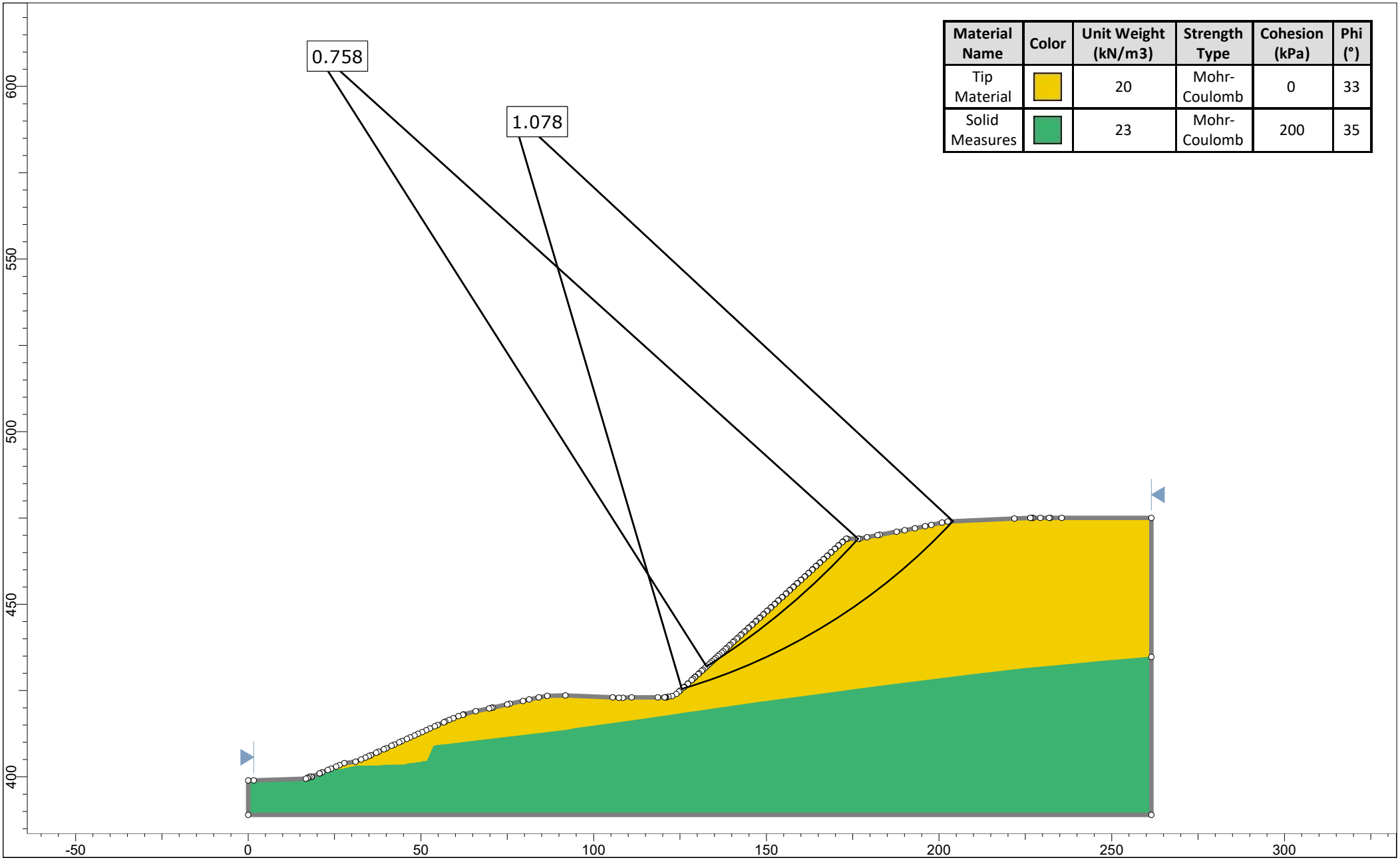



| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (°) |
|---|---|---|---|---|---|
| Tip Material | | 20 | Mohr-Coulomb | 0 | 33 |
| Solid Measures | | 23 | Mohr-Coulomb | 200 | 35 |

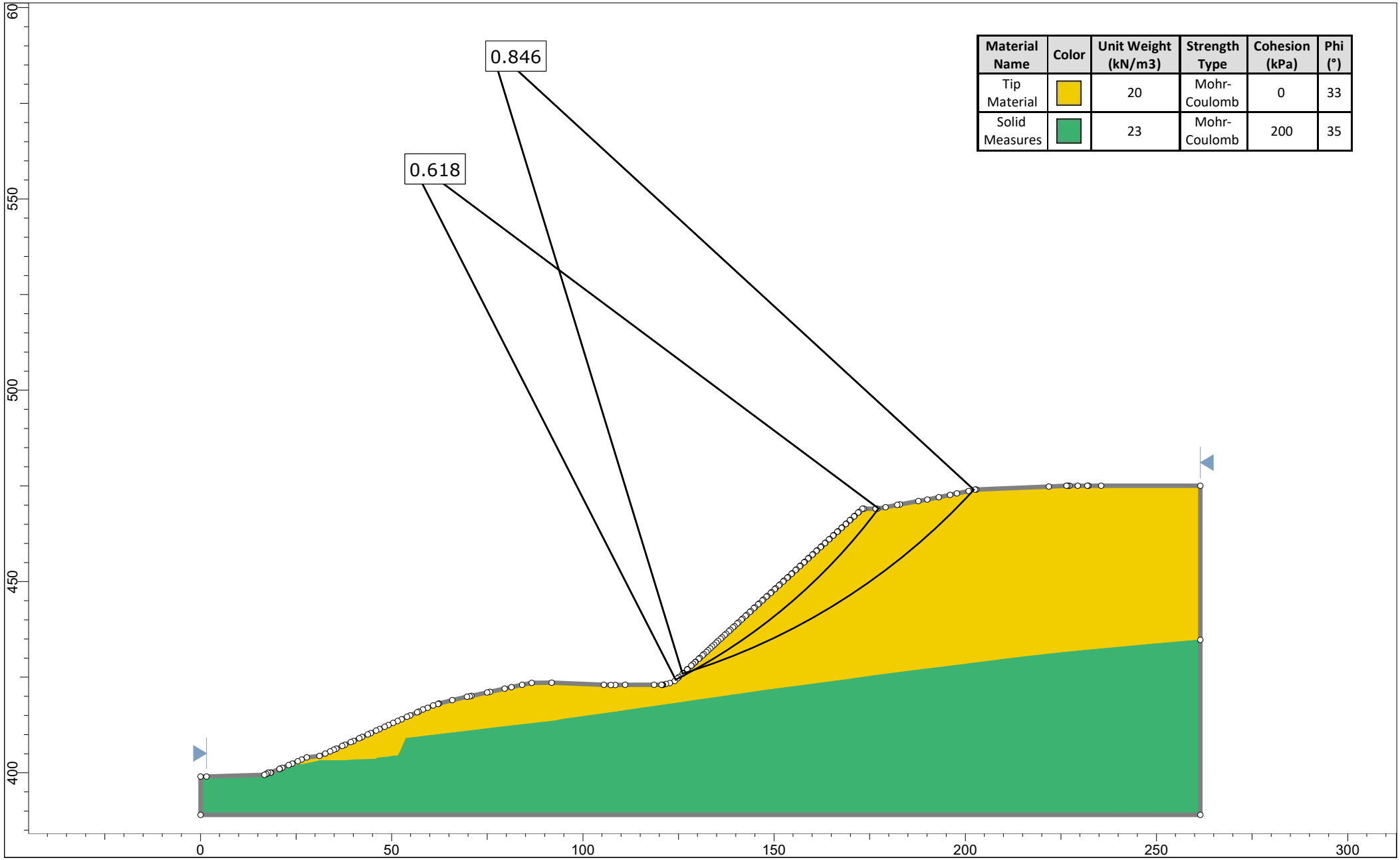



| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (°) |
|---|---|---|---|---|---|
| Tip Material | | 20 | Mohr-Coulomb | 0 | 33 |
| Solid Measures | | 23 | Mohr-Coulomb | 200 | 35 |

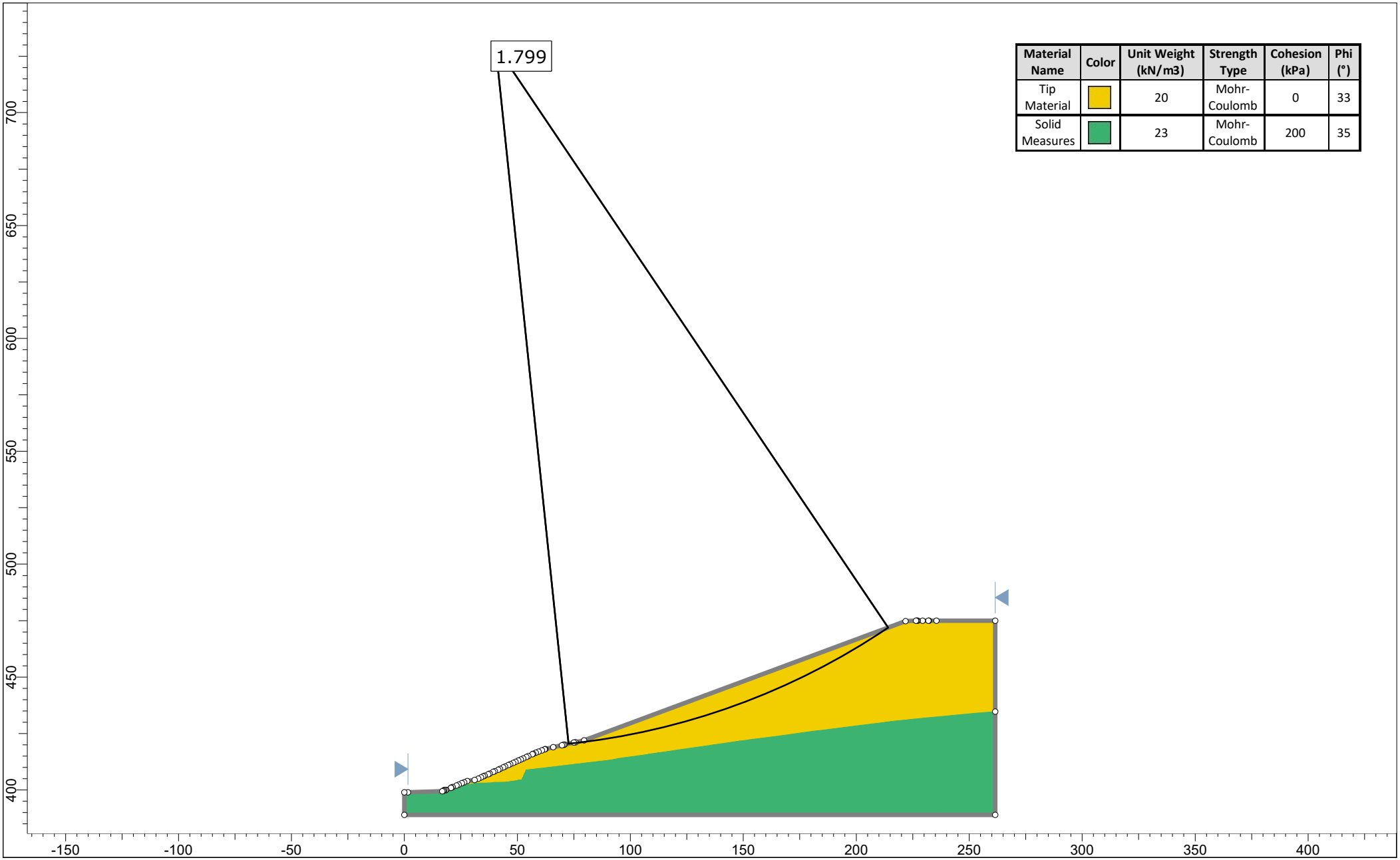

1.436
Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (°)
Tip Material | 20 | Mohr-Coulomb | 0 | 33
Solid Measures | 23 | Mohr-Coulomb | 200 | 35
750
700
650
600
550
500
450
-200
-150
-100
-50
0
50
100
150
200
250
300
350

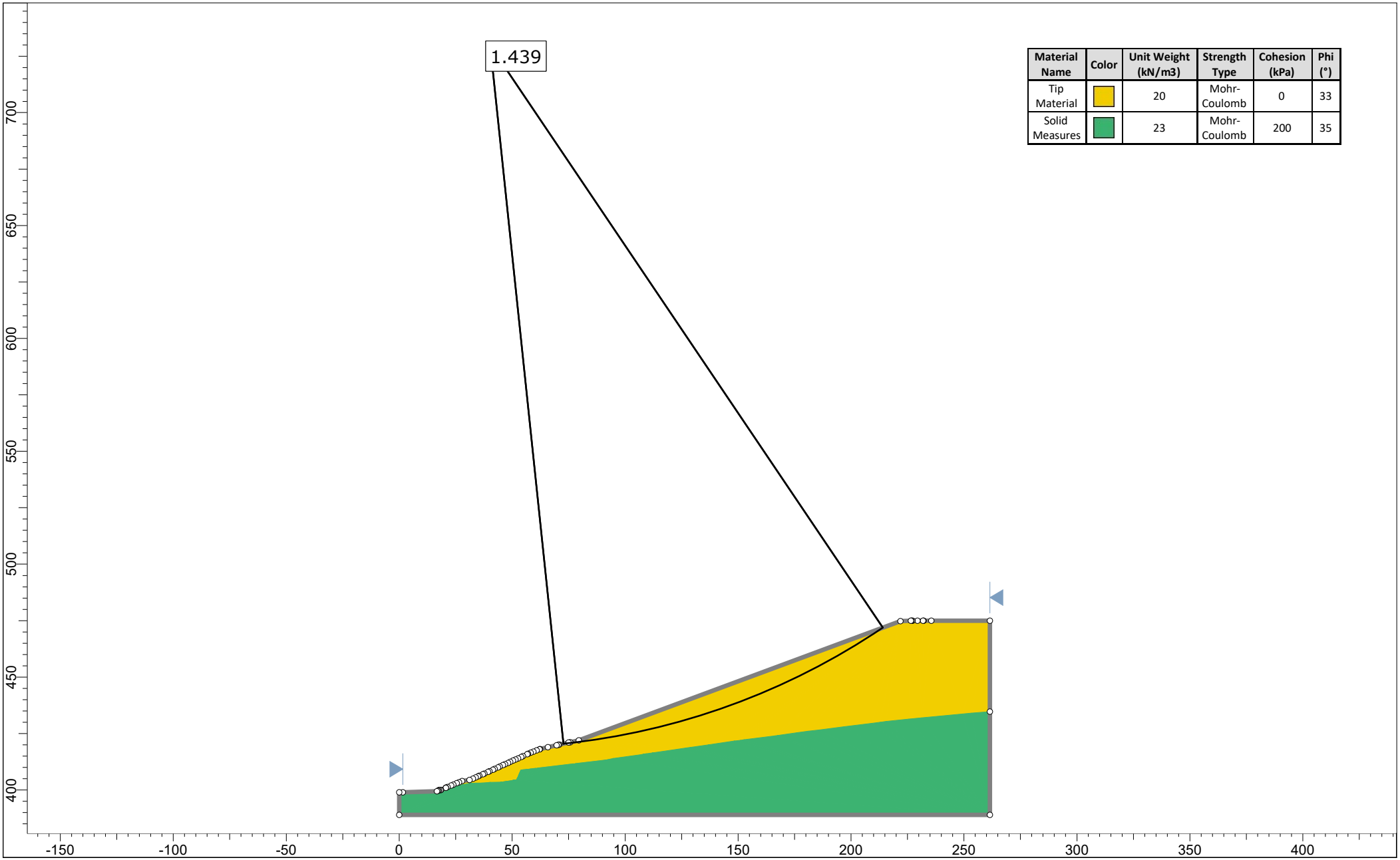


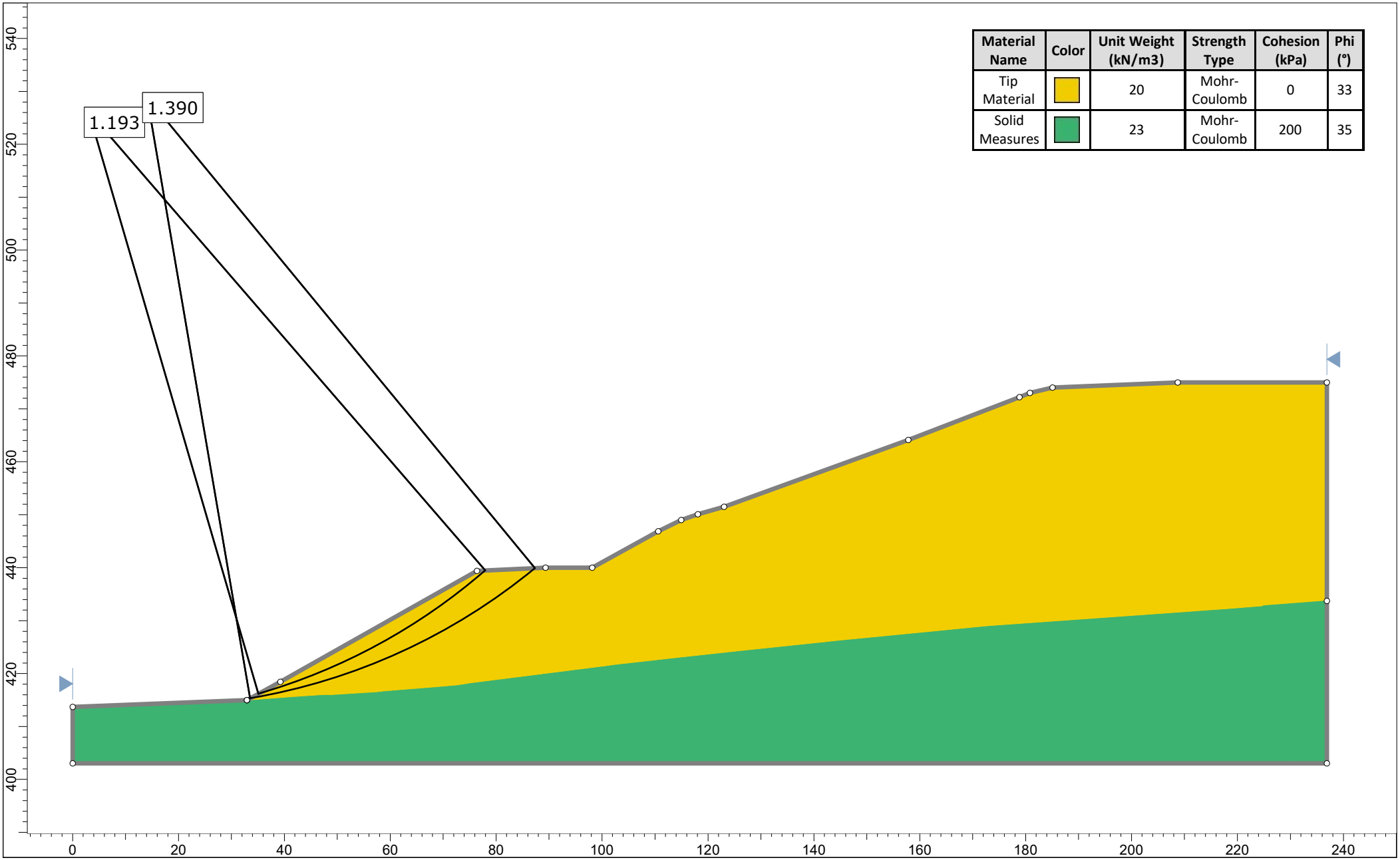

| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (°) |
|---|---|---|---|---|---|
| Tip Material | | 20 | Mohr-Coulomb | 0 | 33 |
| Solid Measures | | 23 | Mohr-Coulomb | 200 | 35 |



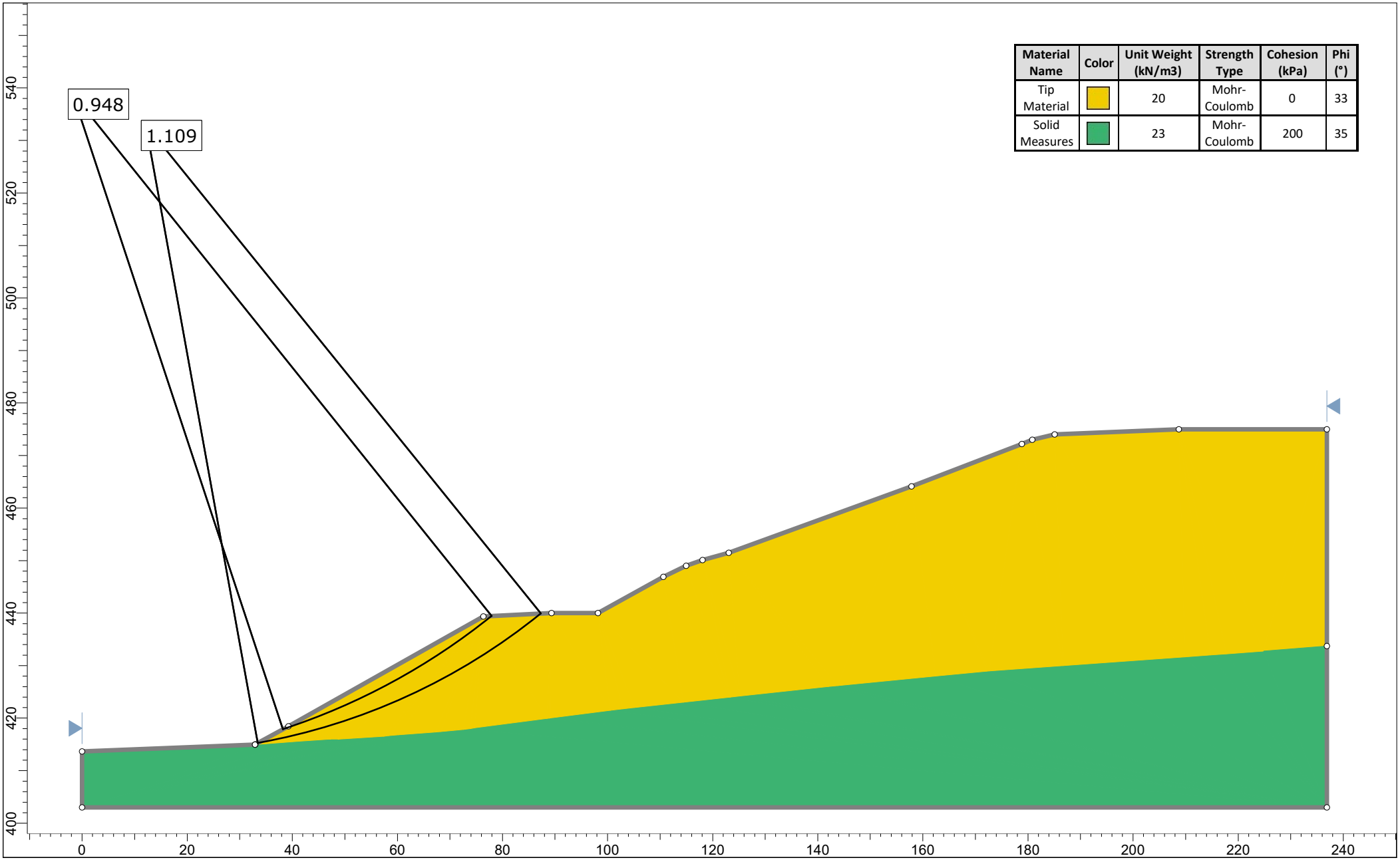

| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (°) |
|---|---|---|---|---|---|
| Tip Material | | 20 | Mohr-Coulomb | 0 | 33 |
| Solid Measures | | 23 | Mohr-Coulomb | 200 | 35 |

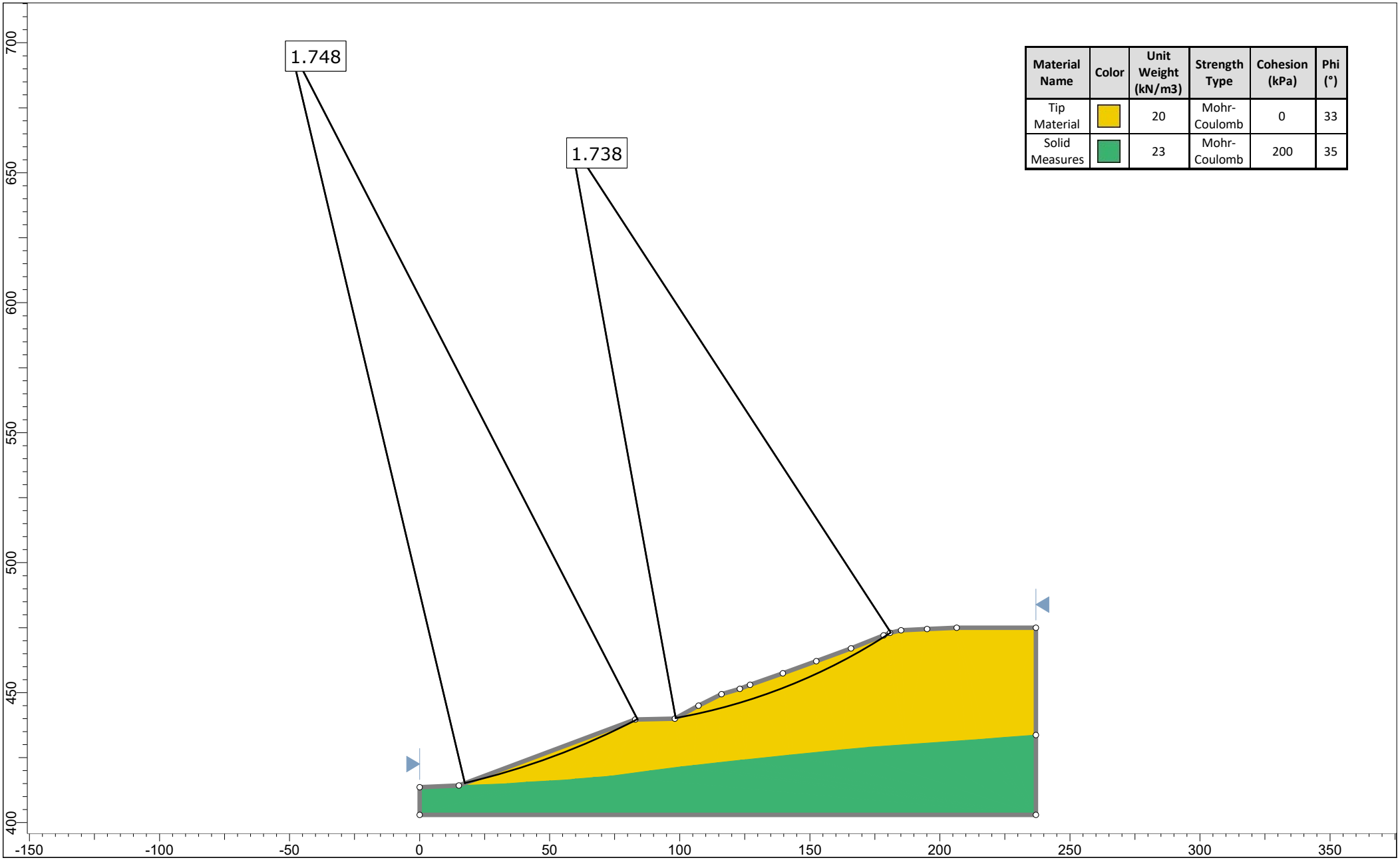

1.799
Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (°)
Tip Material | 20 | Mohr-Coulomb | 0 | 33
Solid Measures | 23 | Mohr-Coulomb | 200 | 35
700
650
600
550
500
450
400
-150
-100
-50
0
50
100
150
200
250
300
350
400

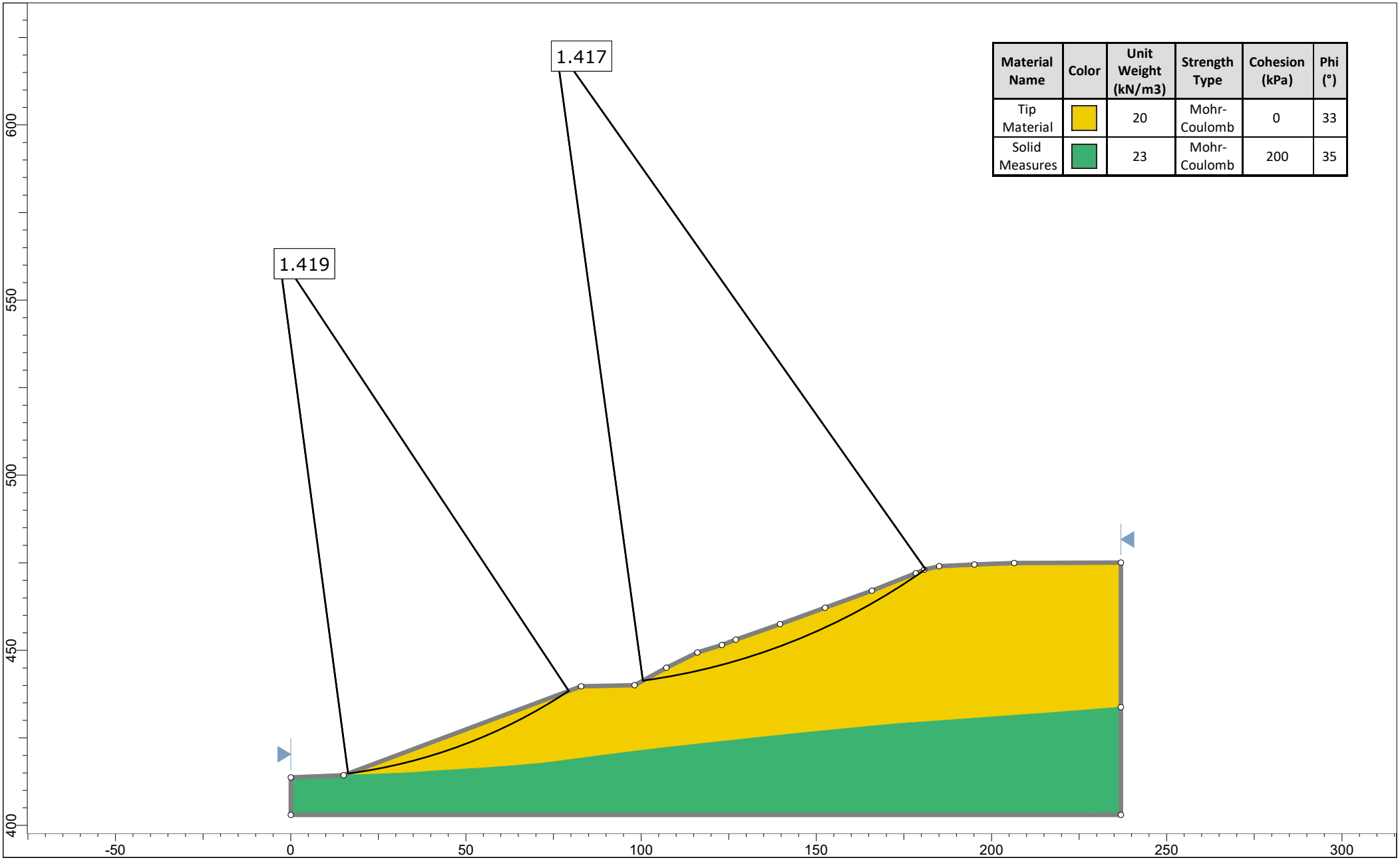

1.439
Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (°)
Tip Material | 20 | Mohr-Coulomb | 0 | 33
Solid Measures | 23 | Mohr-Coulomb | 200 | 35
700
650
600
550
500
450
400
-150
-100
-50
0
50
100
150
200
250
300
350
400



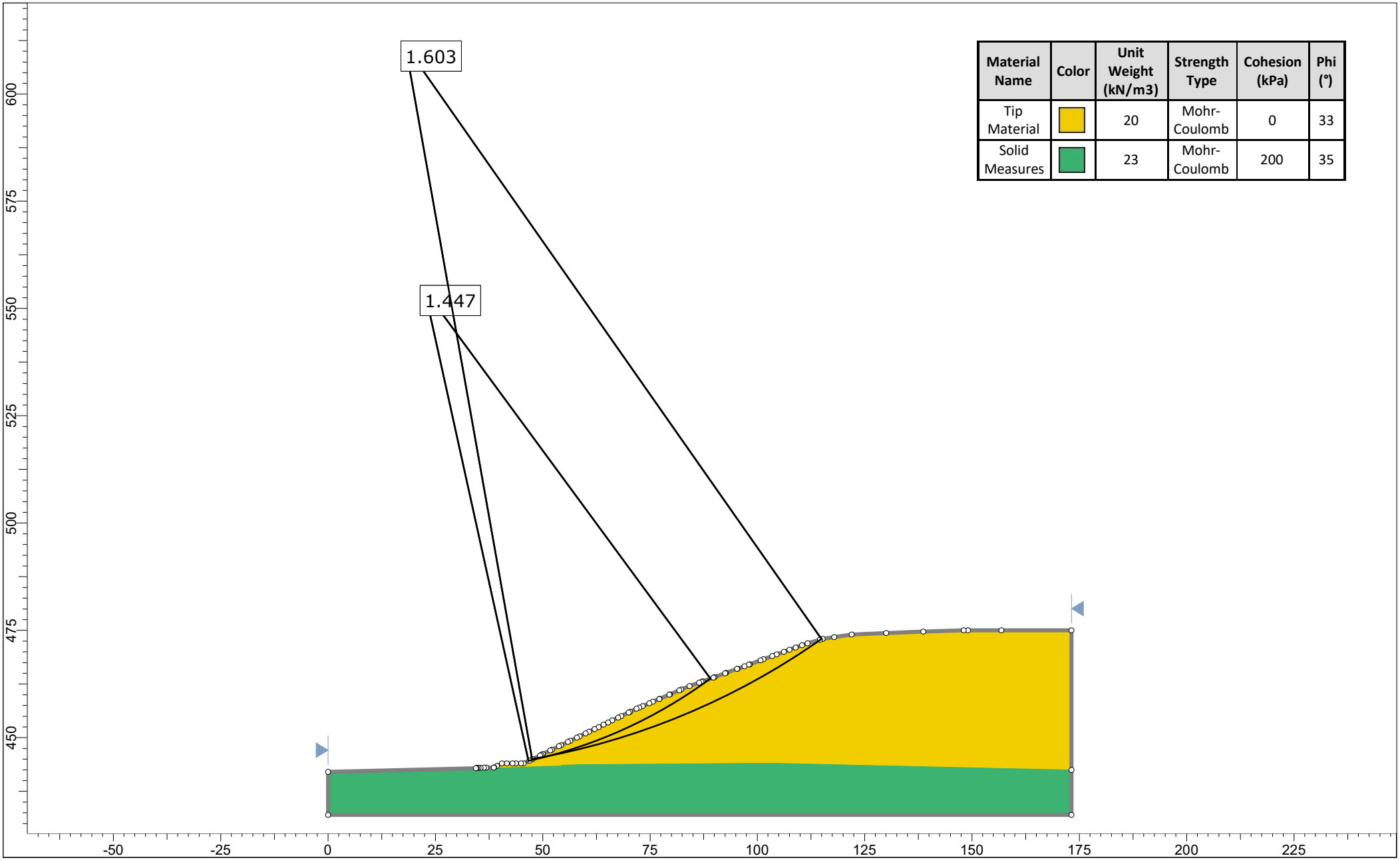

| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (°) |
|---|---|---|---|---|---|
| Tip Material | | 20 | Mohr-Coulomb | 0 | 33 |
| Solid Measures | | 23 | Mohr-Coulomb | 200 | 35 |


0.948
1.109
Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (°)
Tip Material | 20 | Mohr-Coulomb | 0 | 33
Solid Measures | 23 | Mohr-Coulomb | 200 | 35
540
520
500
480
460
440
420
400
0
20
40
60
80
100
120
140
160
180
200
220
240

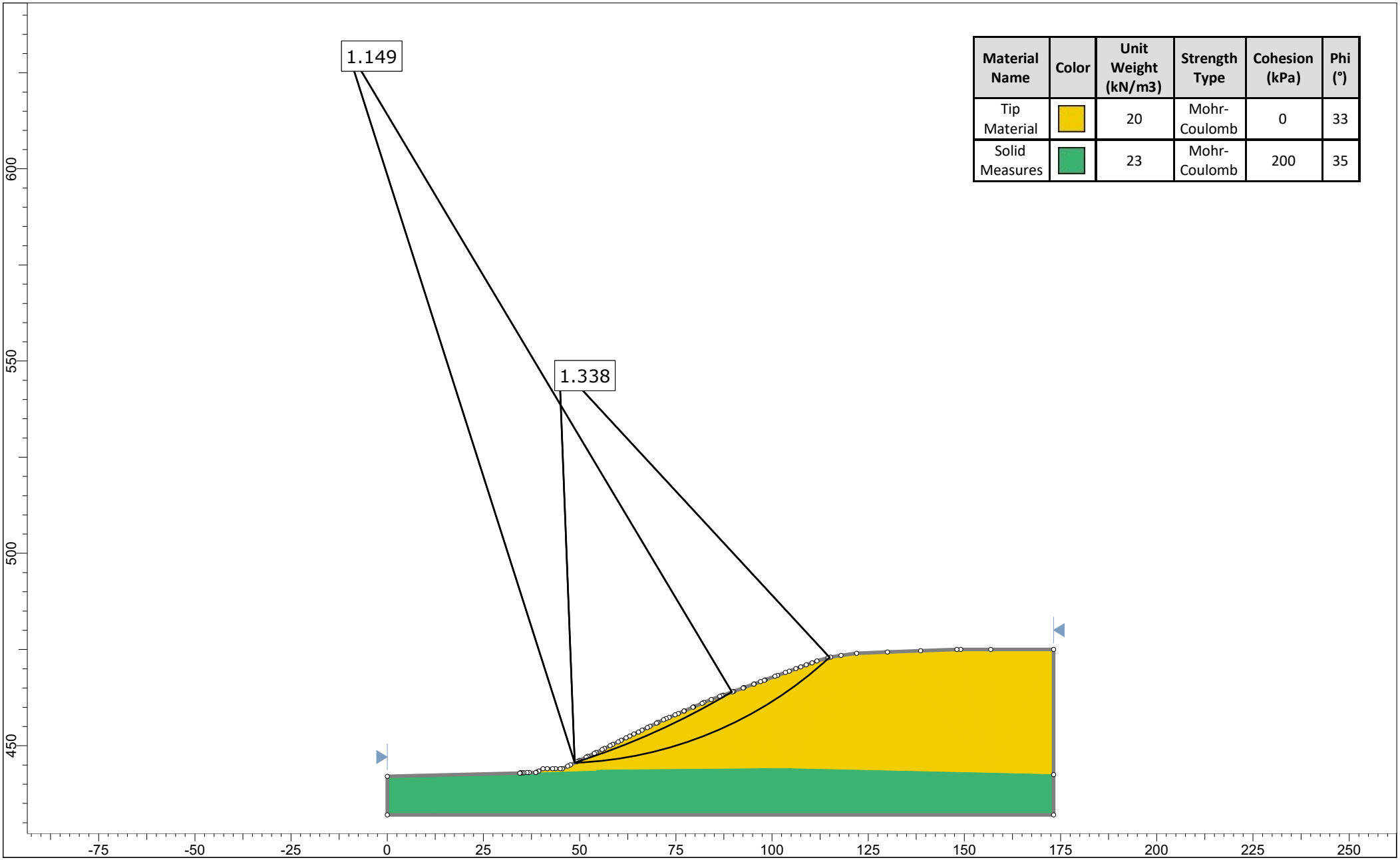

1.748
1.738
Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (°)
Tip Material | 20 | Mohr-Coulomb | 0 | 33
Solid Measures | 23 | Mohr-Coulomb | 200 | 35
700
650
600
550
500
450
400
-150
-100
-50
0
50
100
150
200
250
300
350




| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (°) |
|---|---|---|---|---|---|
| Tip Material | | 20 | Mohr-Coulomb | 0 | 33 |
| Solid Measures | | 23 | Mohr-Coulomb | 200 | 35 |



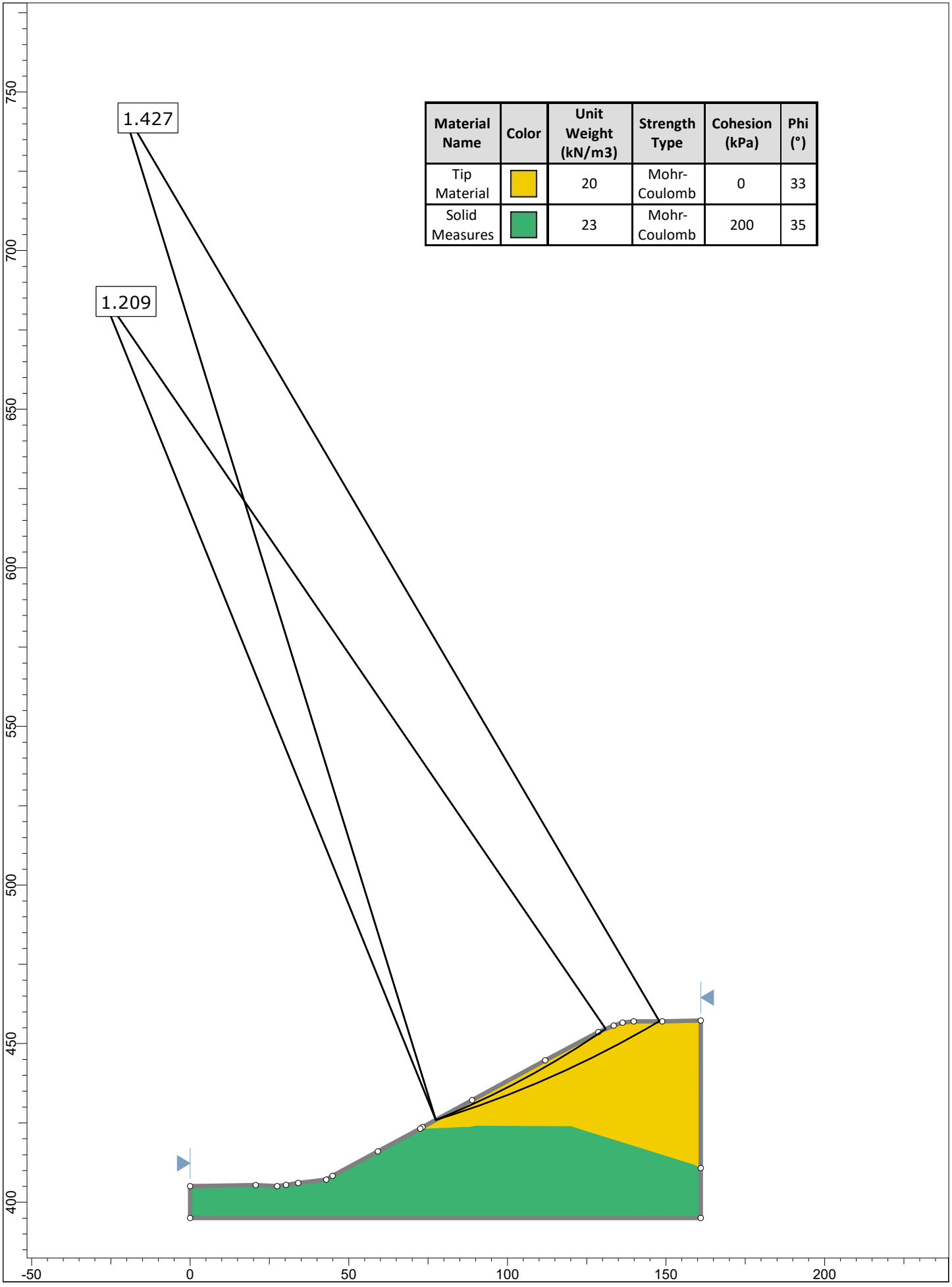

| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (°) |
|---|---|---|---|---|---|
| Tip Material | | 20 | Mohr-Coulomb | 0 | 33 |
| Solid Measures | | 23 | Mohr-Coulomb | 200 | 35 |



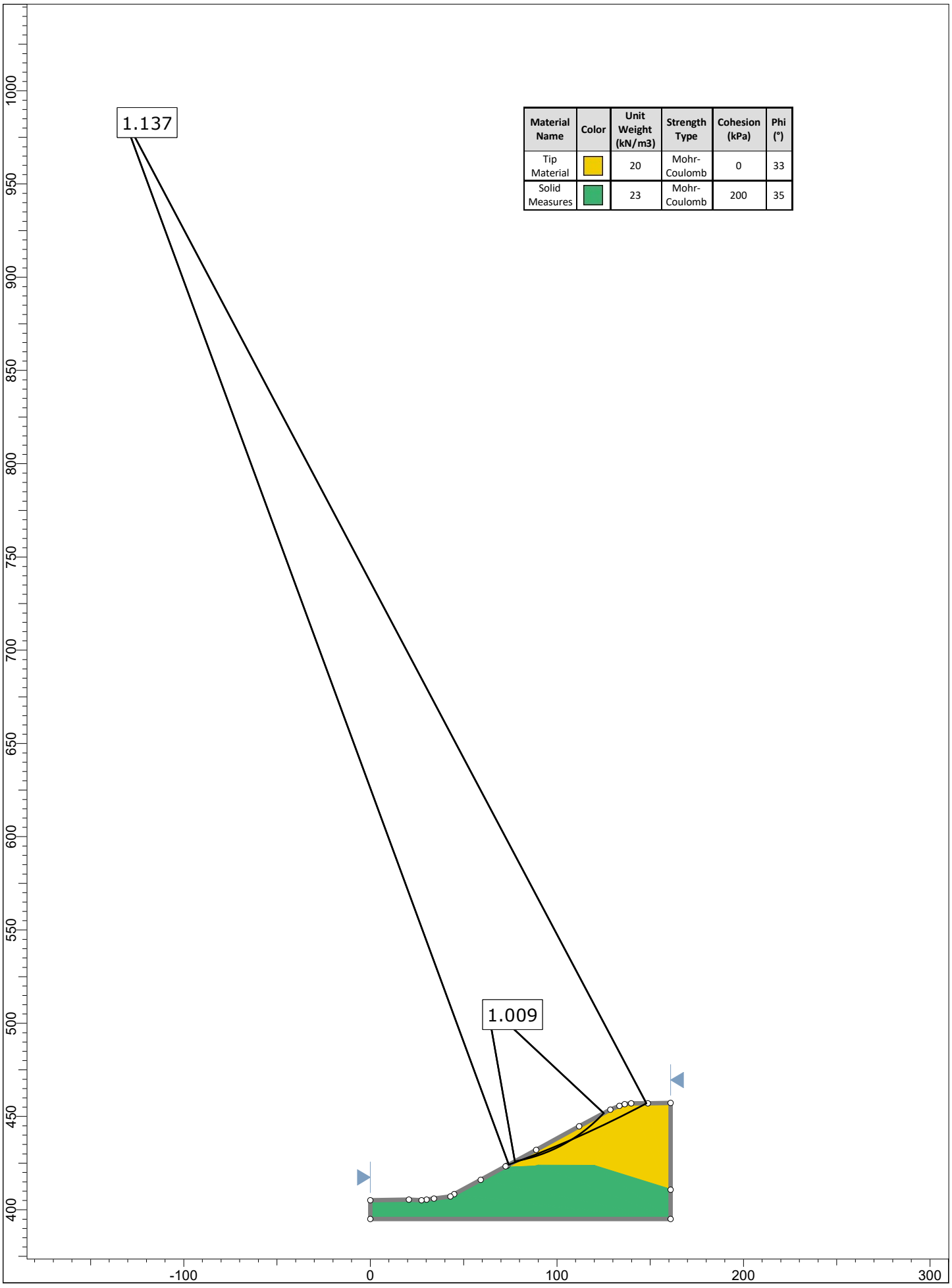

| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (°) |
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| Tip Material | | 20 | Mohr-Coulomb | 0 | 33 |
| Solid Measures | | 23 | Mohr-Coulomb | 200 | 35 |

# APPENDIX 3

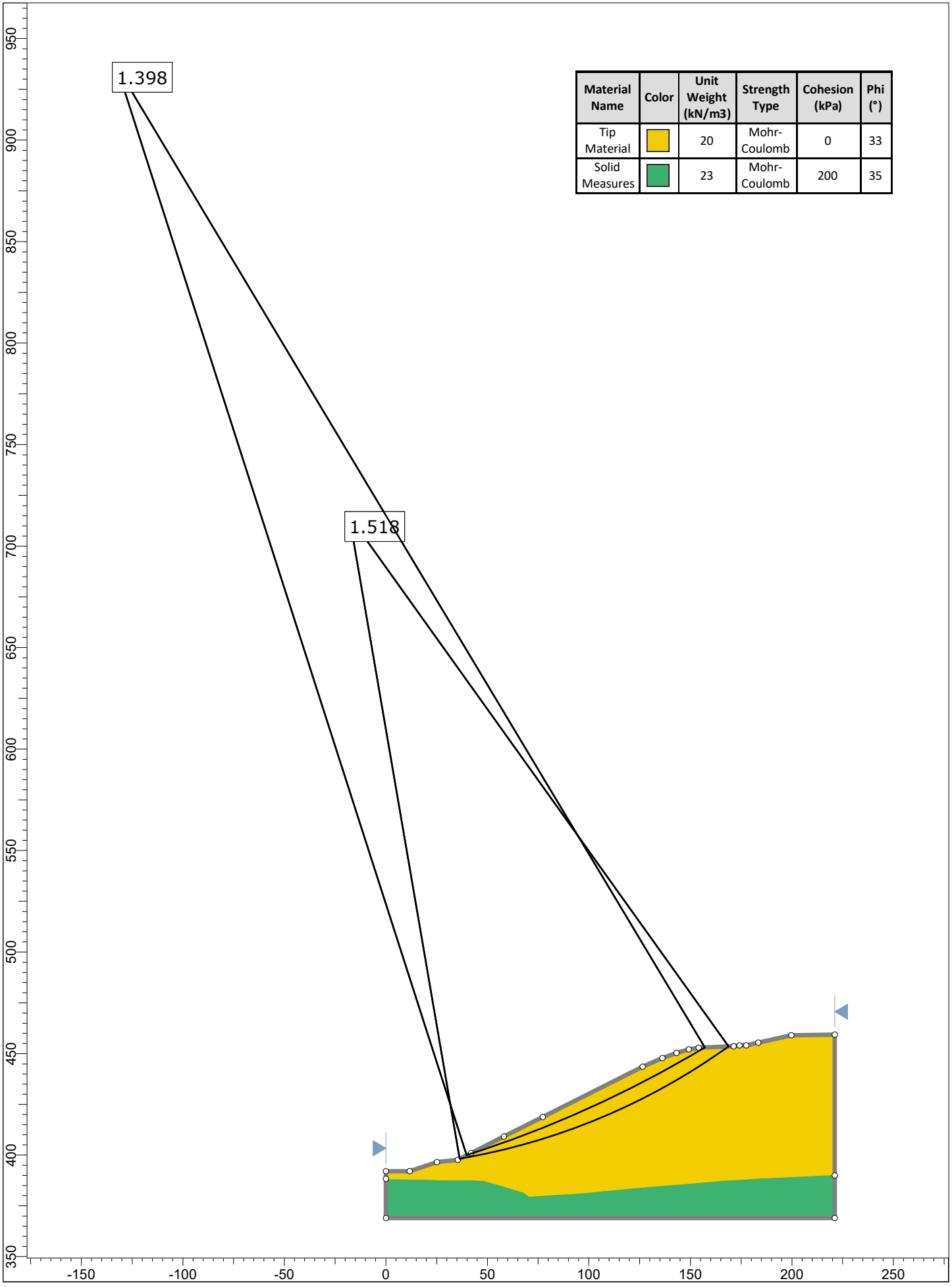
# OB2 Stability Analyses




| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (°) |
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| Tip Material | | 20 | Mohr-Coulomb | 0 | 33 |
| Solid Measures | | 23 | Mohr-Coulomb | 200 | 35 |

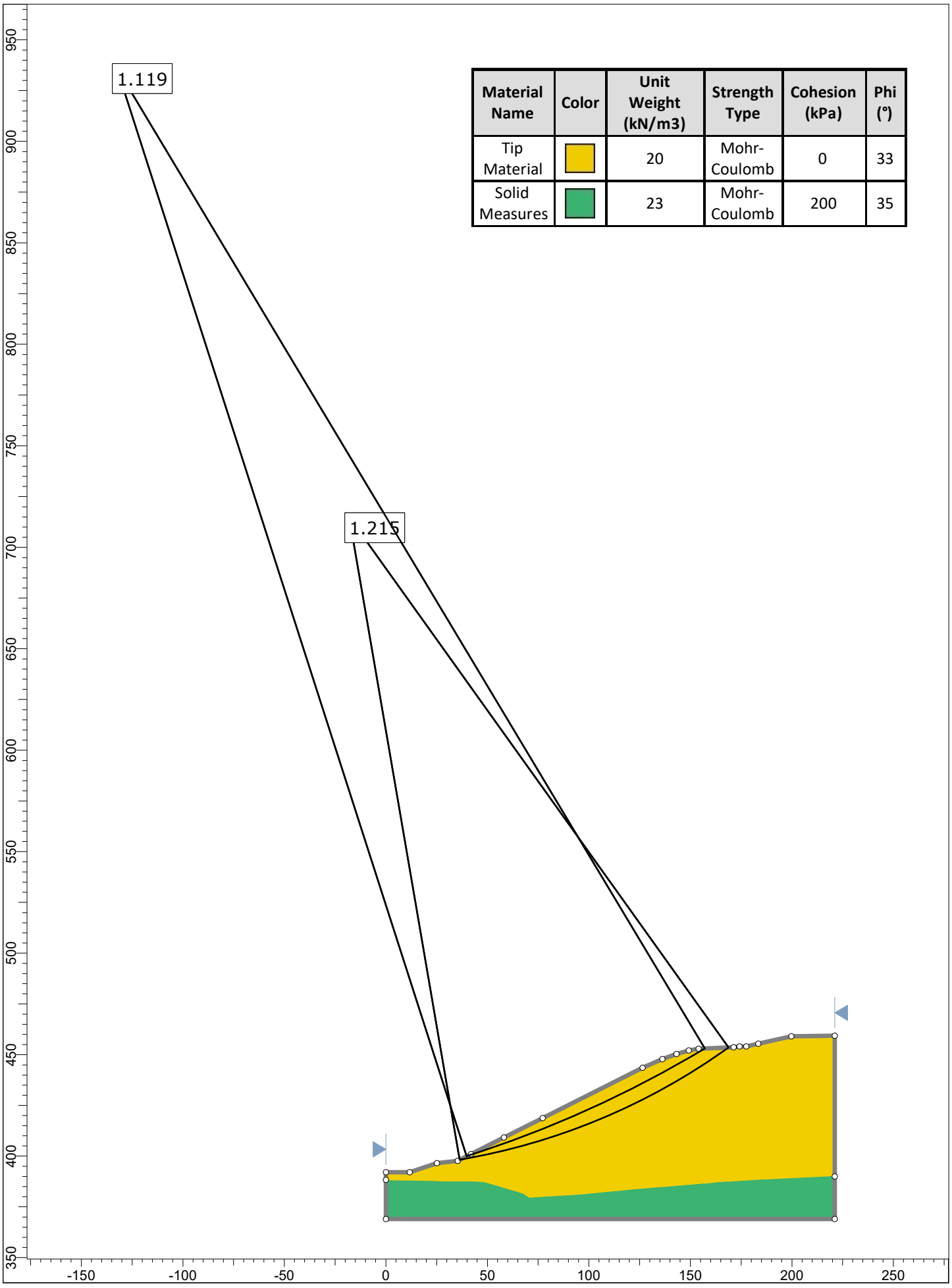



| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (°) |
|---|---|---|---|---|---|
| Tip Material | | 20 | Mohr-Coulomb | 0 | 33 |
| Solid Measures | | 23 | Mohr-Coulomb | 200 | 35 |



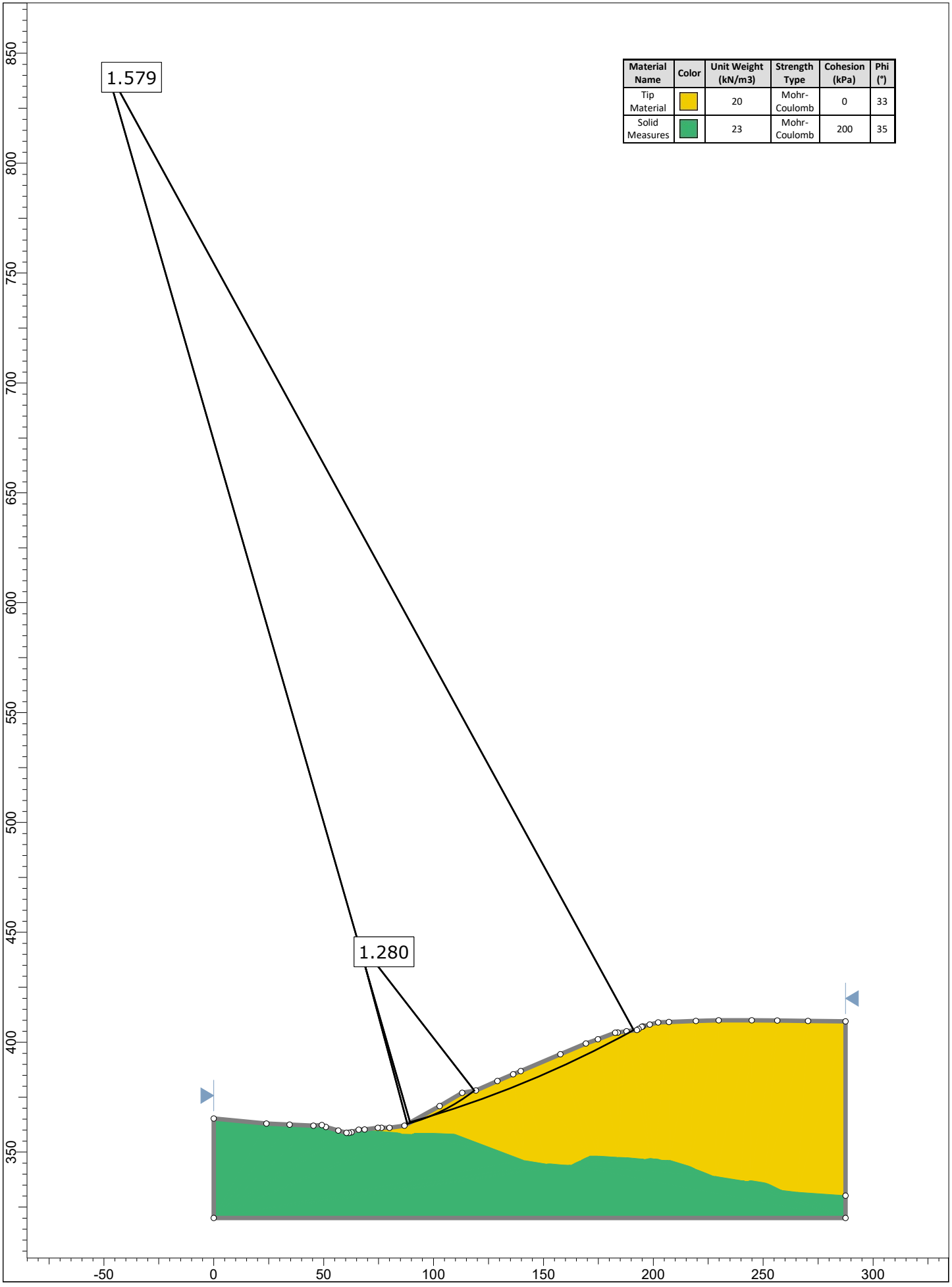

| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (°) |
|---|---|---|---|---|---|
| Tip Material | | 20 | Mohr-Coulomb | 0 | 33 |
| Solid Measures | | 23 | Mohr-Coulomb | 200 | 35 |

| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (°) |
|---|---|---|---|---|---|
| Tip Material | | 20 | Mohr-Coulomb | 0 | 33 |
| Solid Measures | | 23 | Mohr-Coulomb | 200 | 35 |

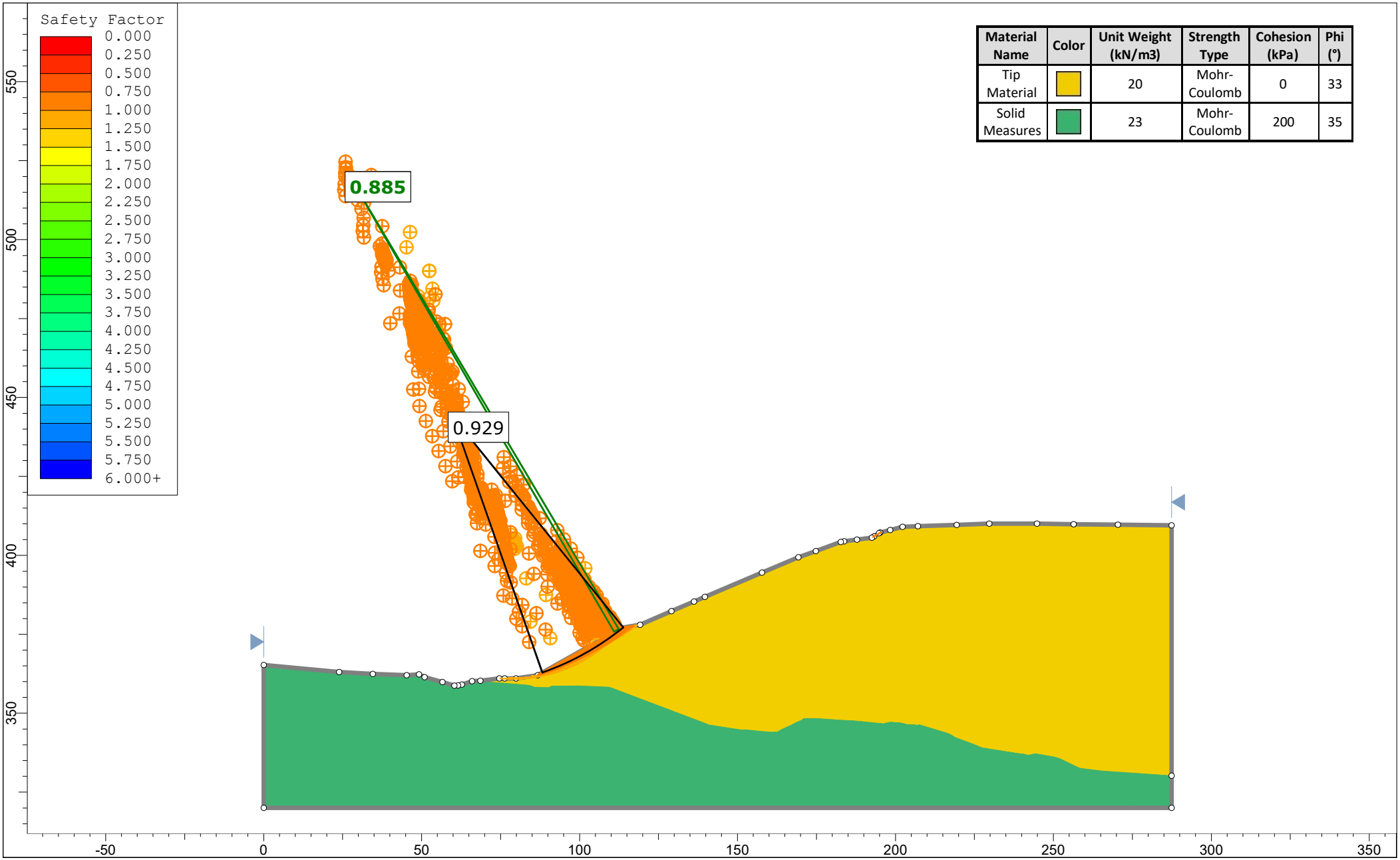


# APPENDIX 4

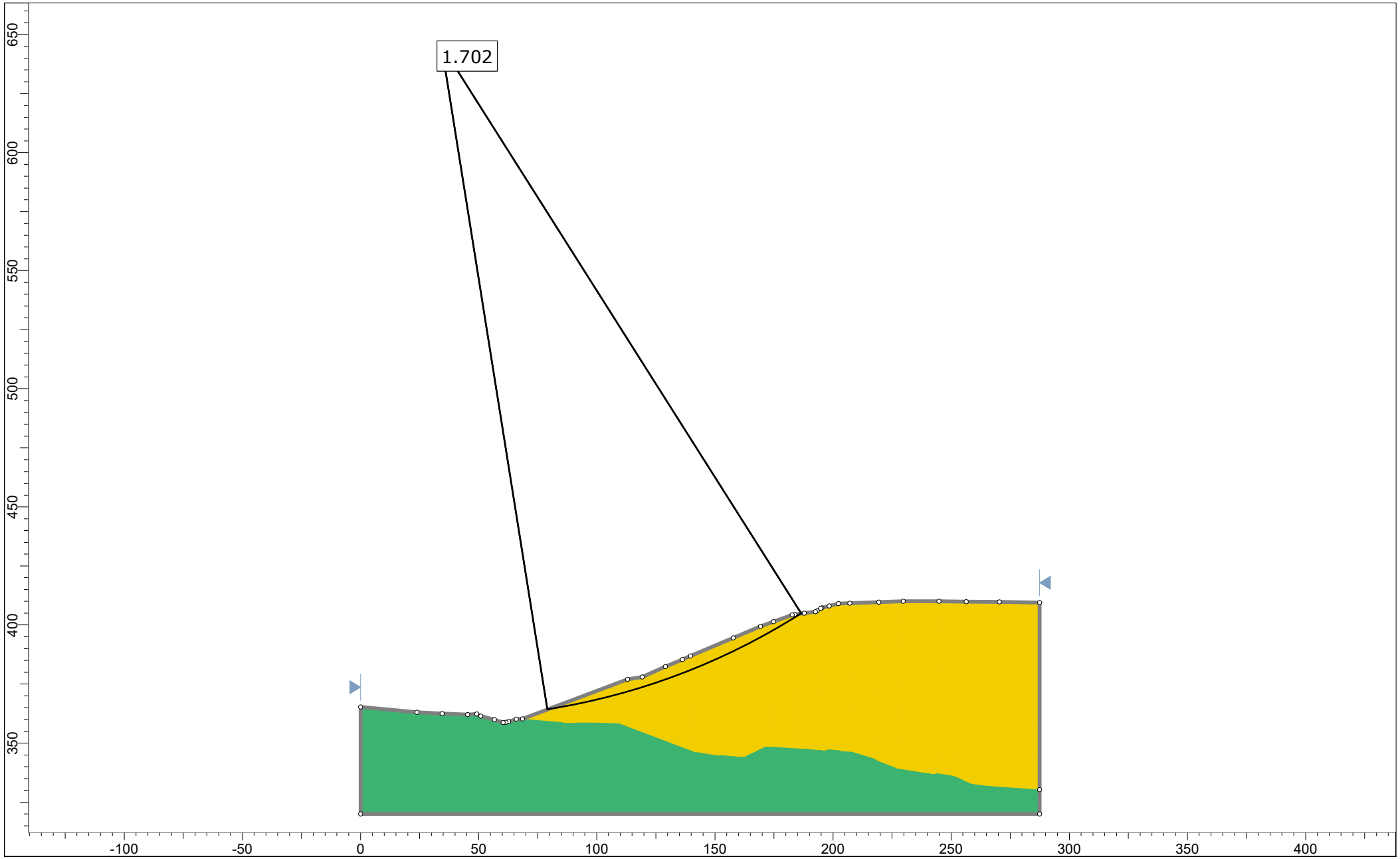
# OB3 Stability Analyses




| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (°) |
|---|---|---|---|---|---|
| Tip Material | | 20 | Mohr-Coulomb | 0 | 33 |
| Solid Measures | | 23 | Mohr-Coulomb | 200 | 35 |



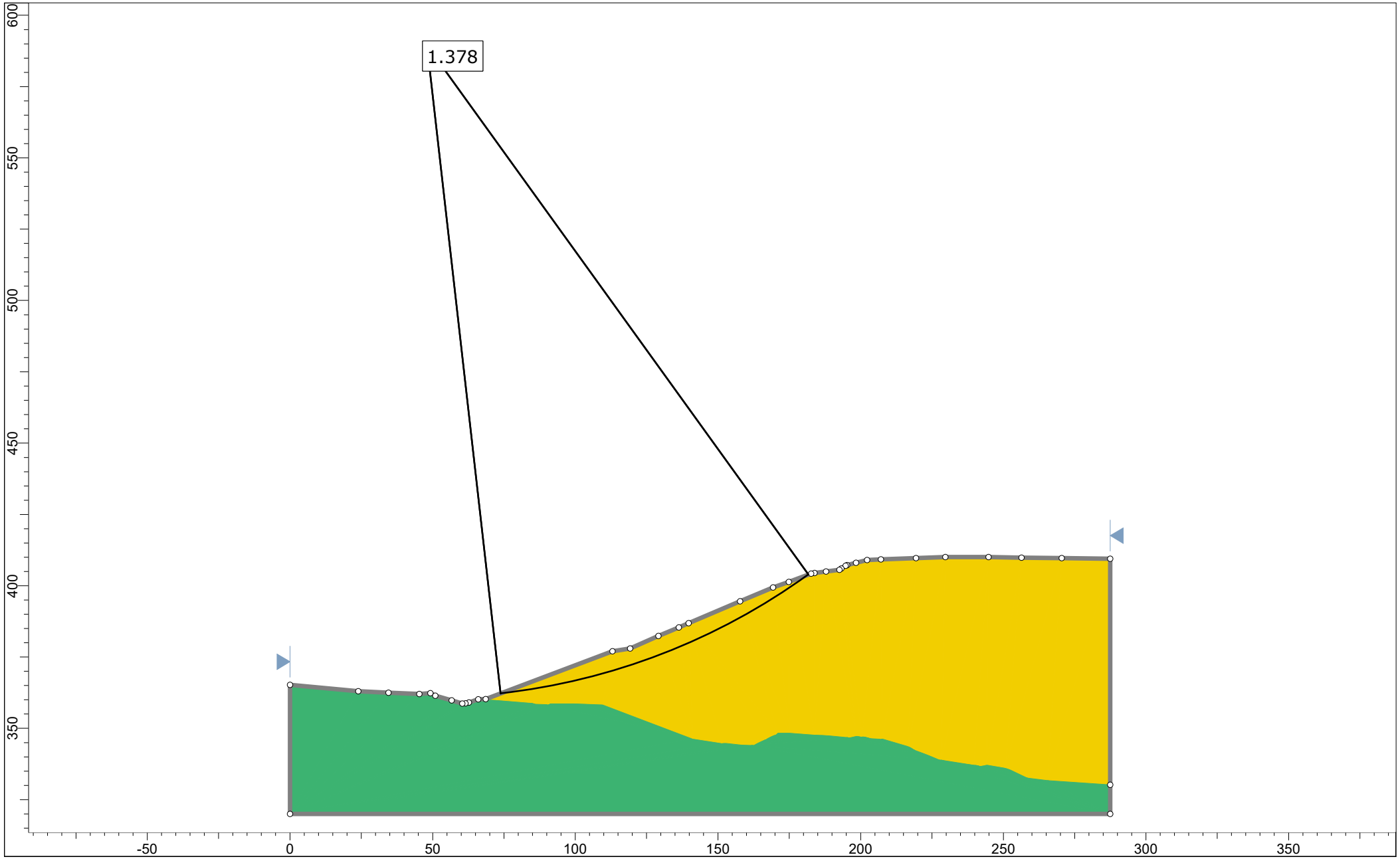

| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (°) |
|---|---|---|---|---|---|
| Tip Material | | 20 | Mohr-Coulomb | 0 | 33 |
| Solid Measures | | 23 | Mohr-Coulomb | 200 | 35 |

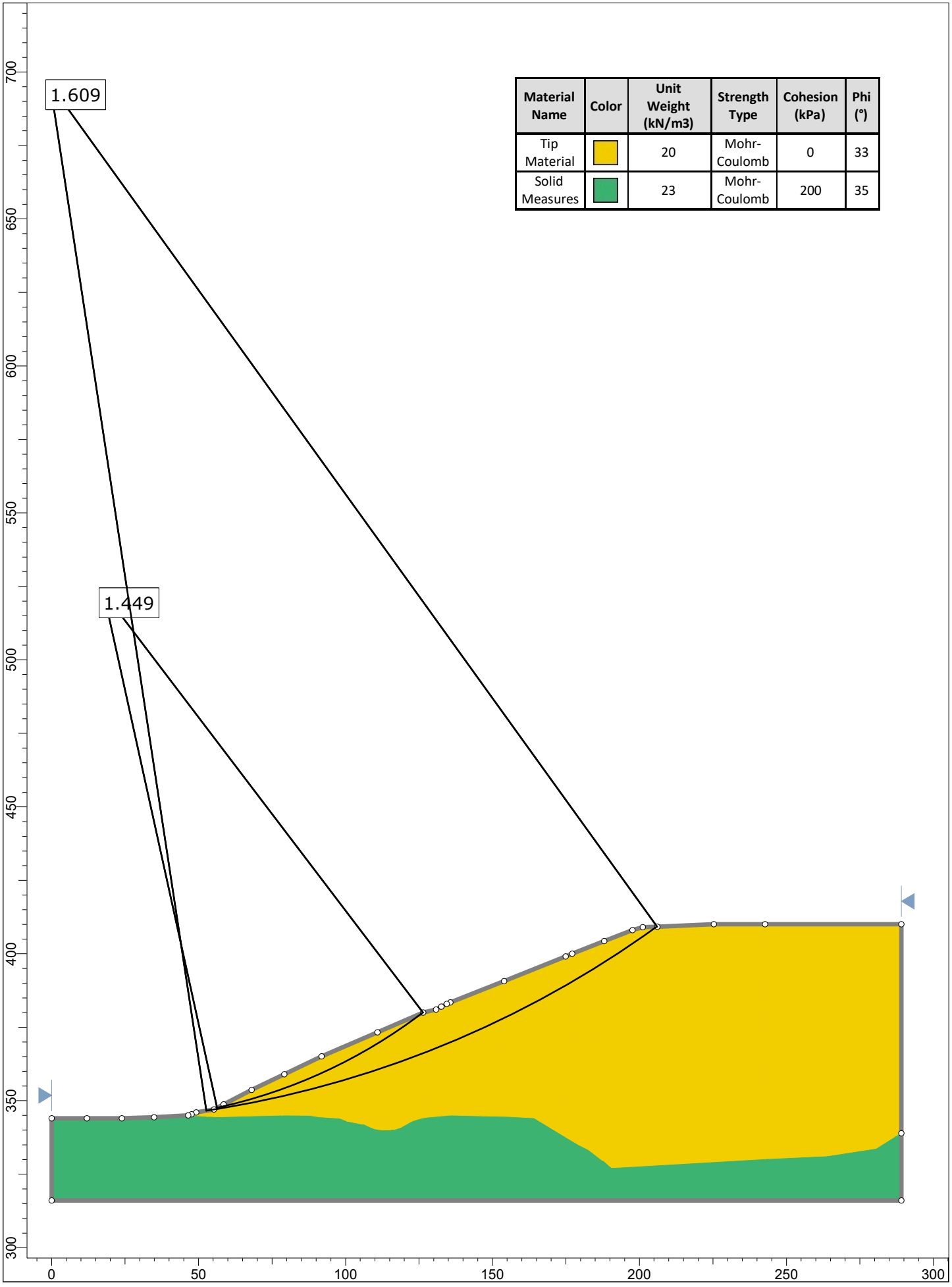



XS 1 Regraded - Eurocode 1

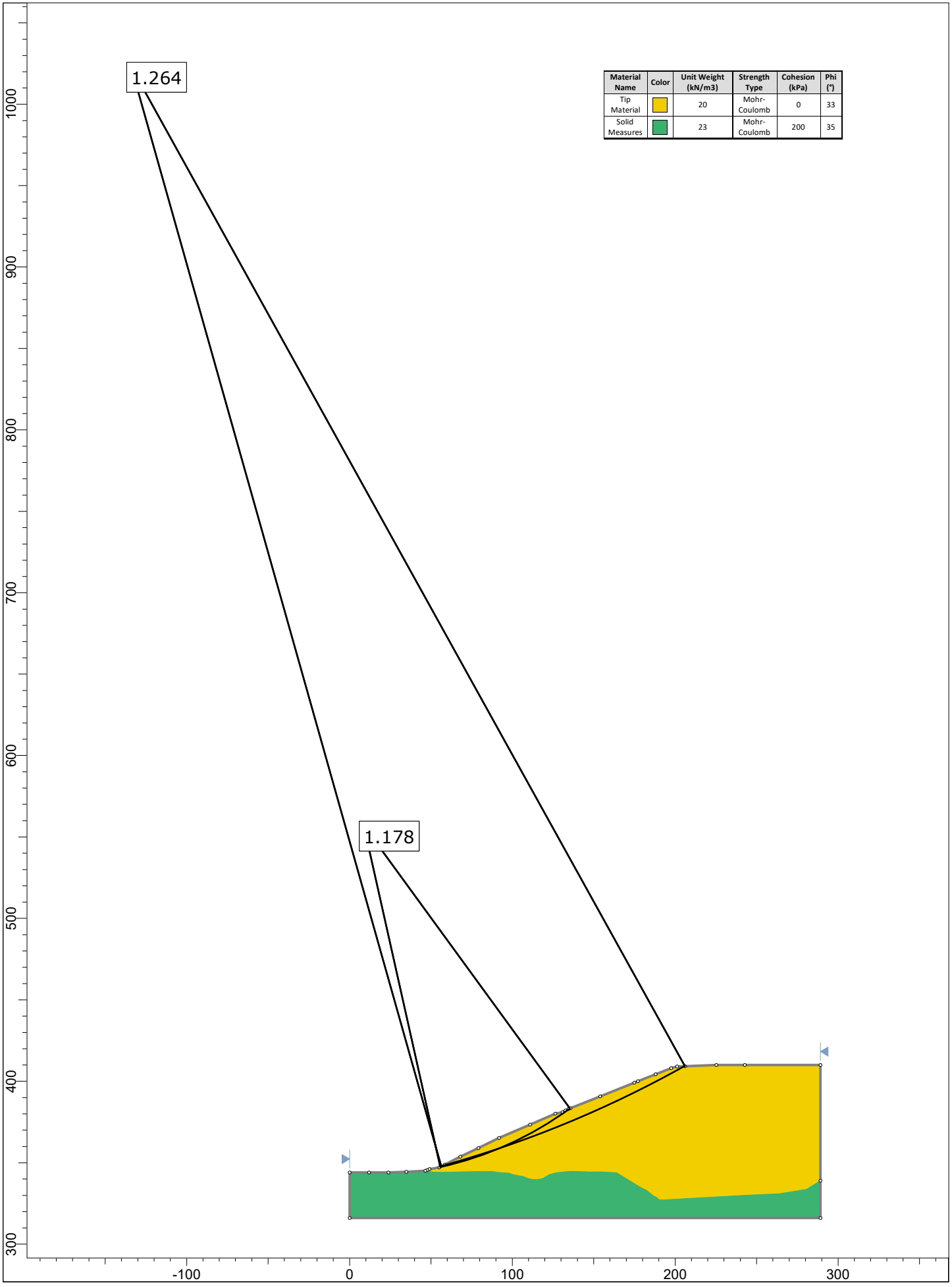
OVERBURDEN MOUND 3

23/01/2026, 10:44:52

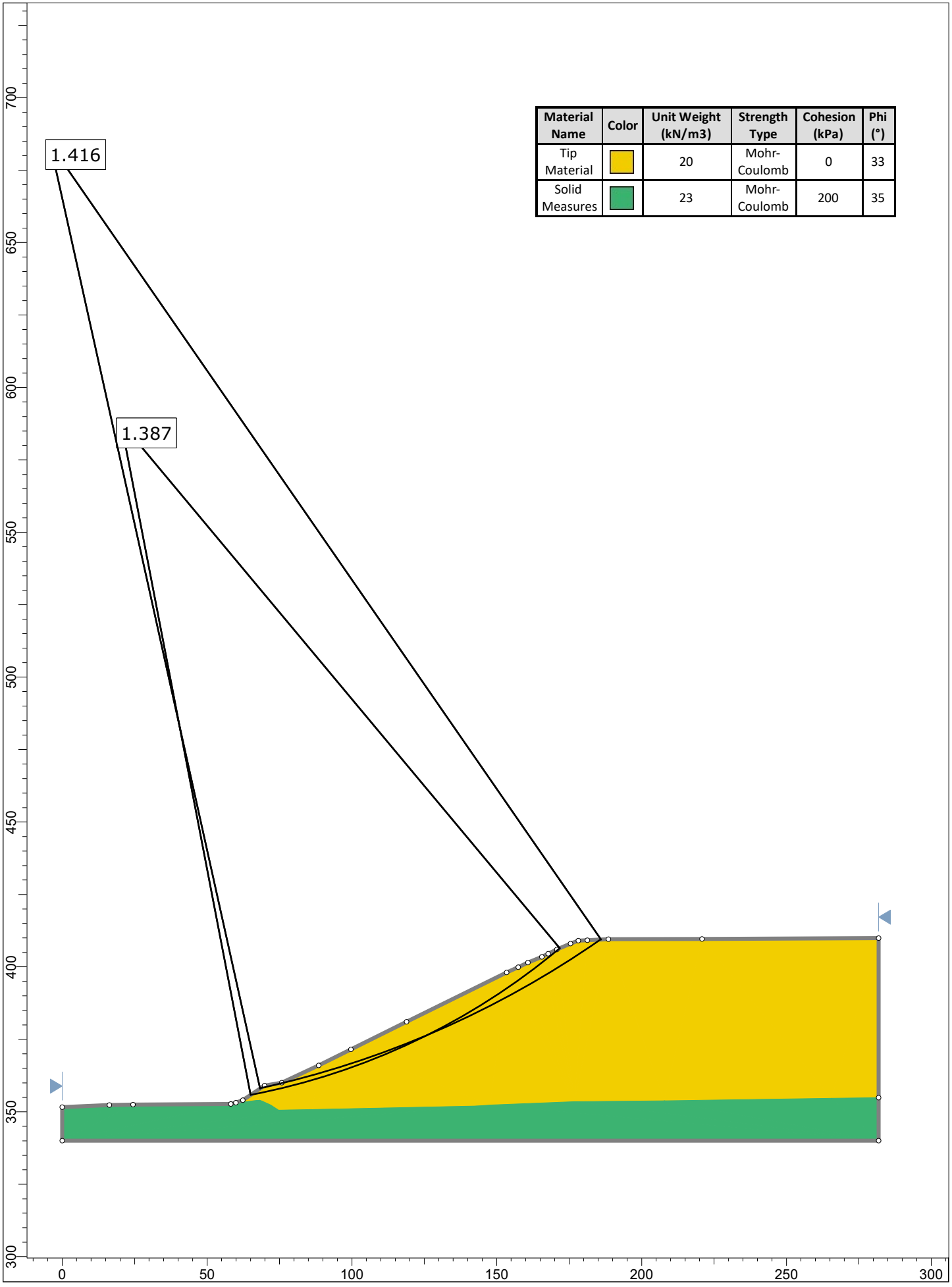

1.378
600
550
500
450
400
350
-50
0
50
100
150
200
250
300
350



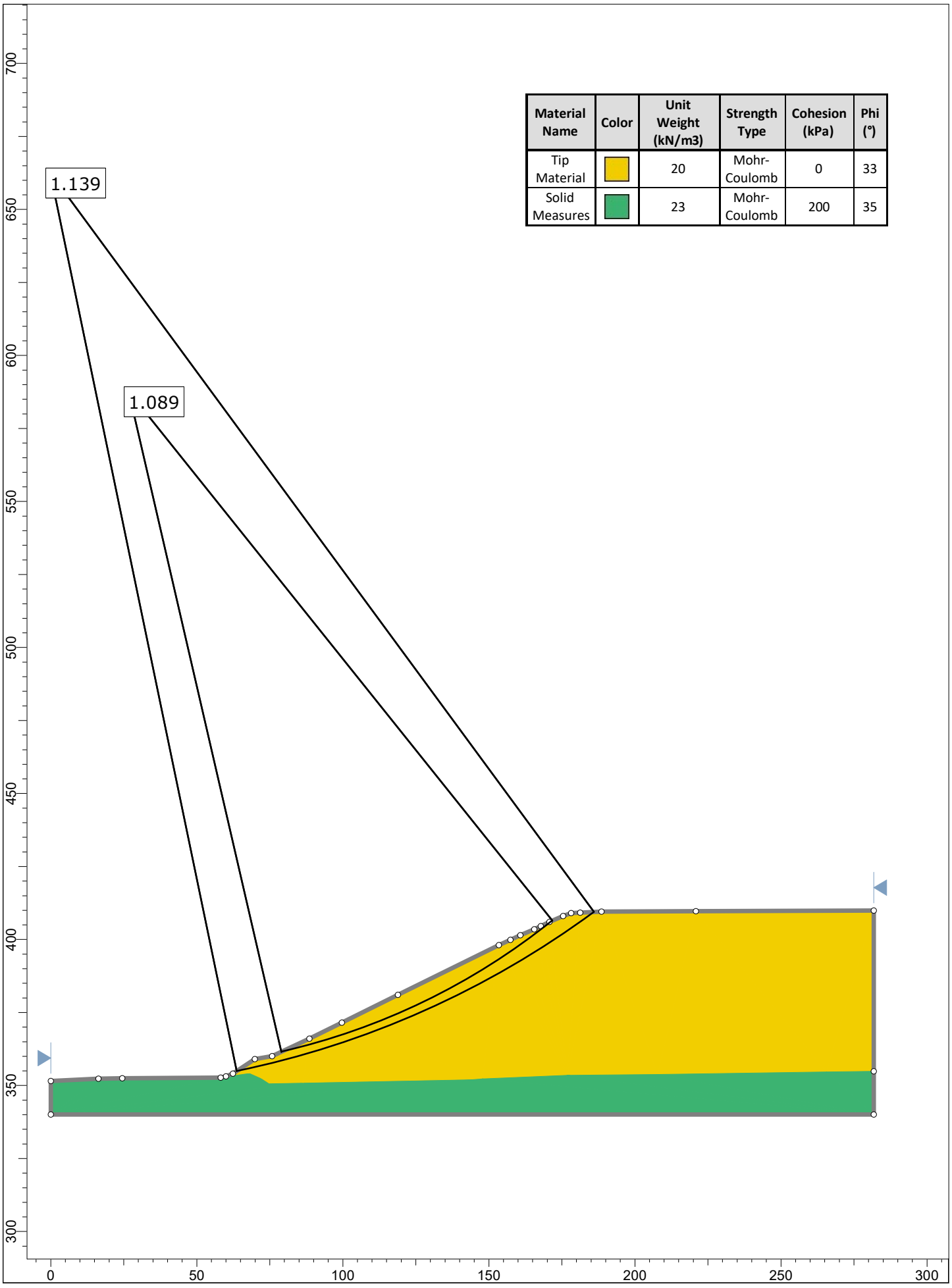

| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (°) |
|---|---|---|---|---|---|
| Tip Material | | 20 | Mohr-Coulomb | 0 | 33 |
| Solid Measures | | 23 | Mohr-Coulomb | 200 | 35 |


1.264
1.178
Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (°)
Tip Material | 20 | Mohr-Coulomb | 0 | 33
Solid Measures | 23 | Mohr-Coulomb | 200 | 35
1000
900
800
700
600
500
400
300
-100
0
100
200
300

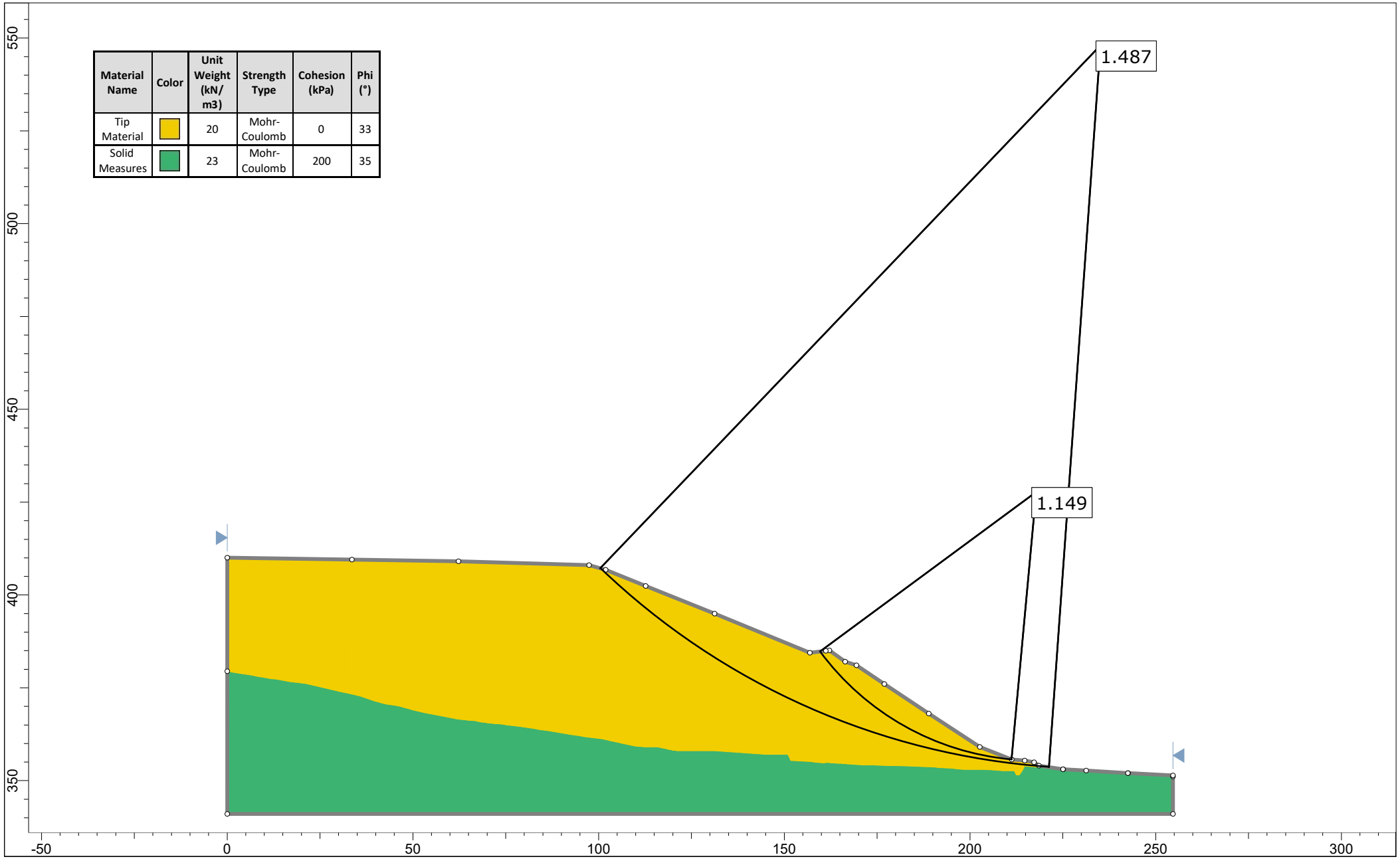
| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (°) |
|---|---|---|---|---|---|
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| Solid Measures | | 23 | Mohr-Coulomb | 200 | 35 |

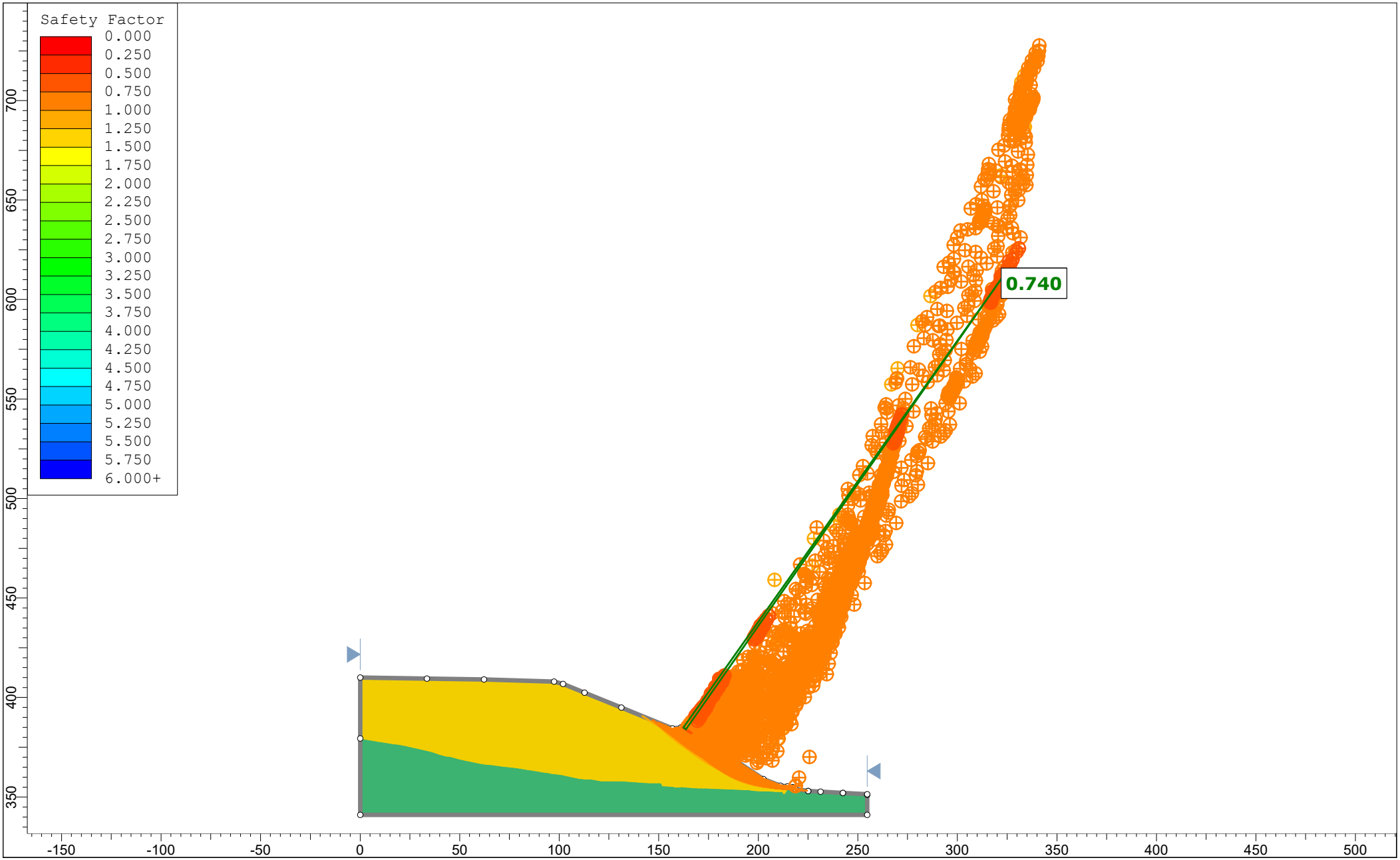


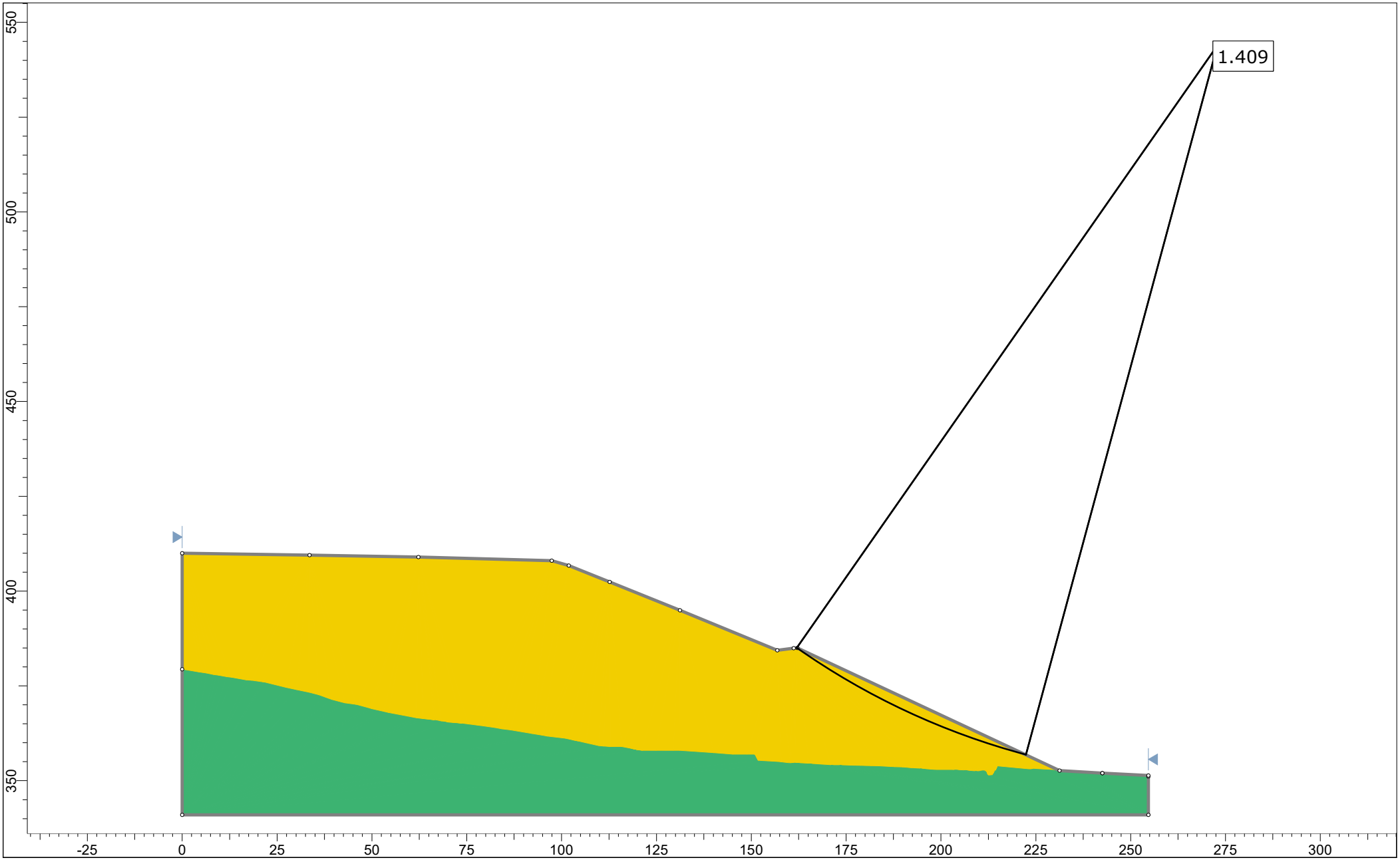
| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (°) |
|---|---|---|---|---|---|
| Tip Material | | 20 | Mohr-Coulomb | 0 | 33 |
| Solid Measures | | 23 | Mohr-Coulomb | 200 | 35 |



| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (°) |
|---|---|---|---|---|---|
| Tip Material | | 20 | Mohr-Coulomb | 0 | 33 |
| Solid Measures | | 23 | Mohr-Coulomb | 200 | 35 |



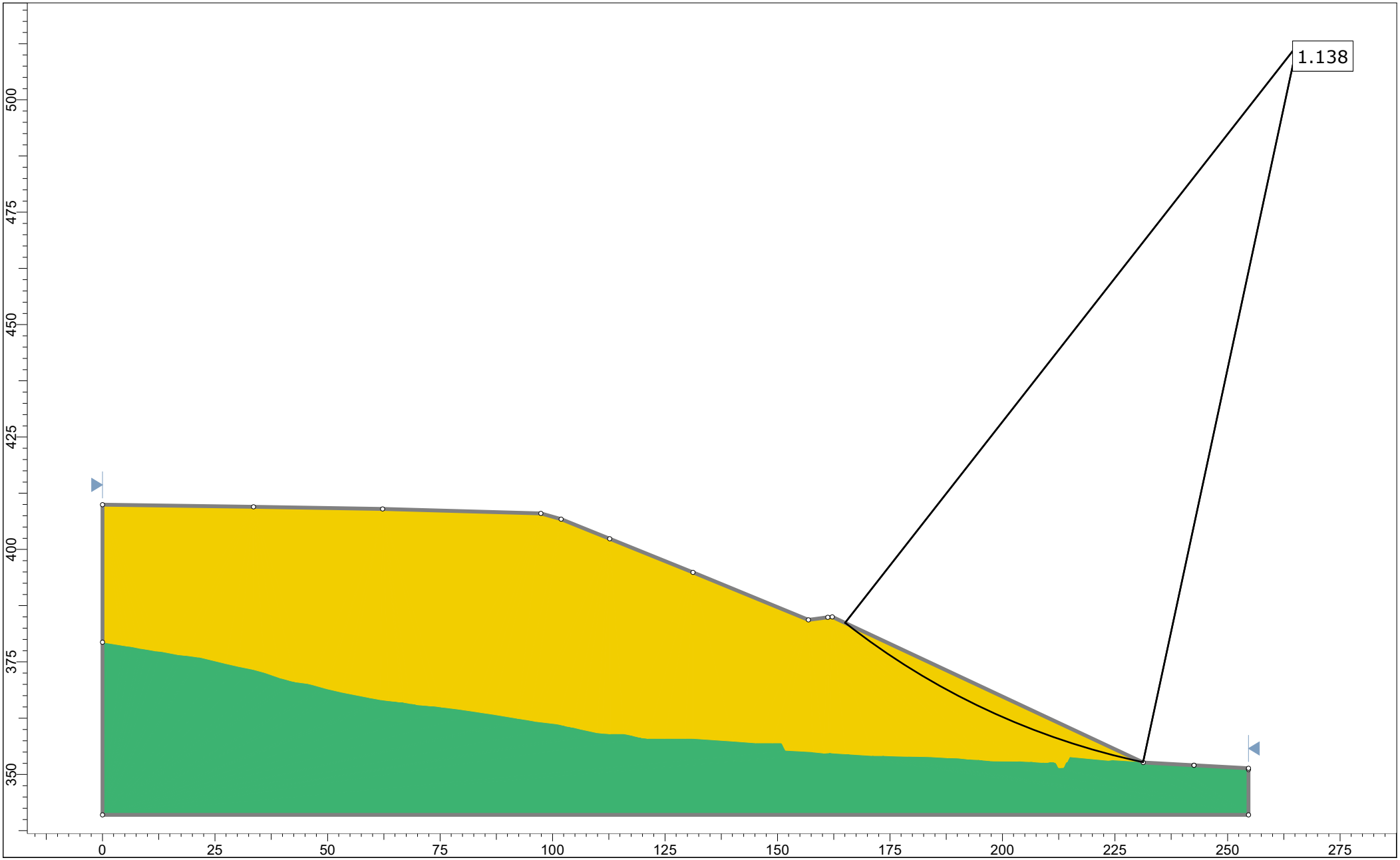

Safety Factor
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0.500
0.750
1.000
1.250
1.500
1.750
2.000
2.250
2.500
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3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
0.740
700
650
600
550
500
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100
150
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450
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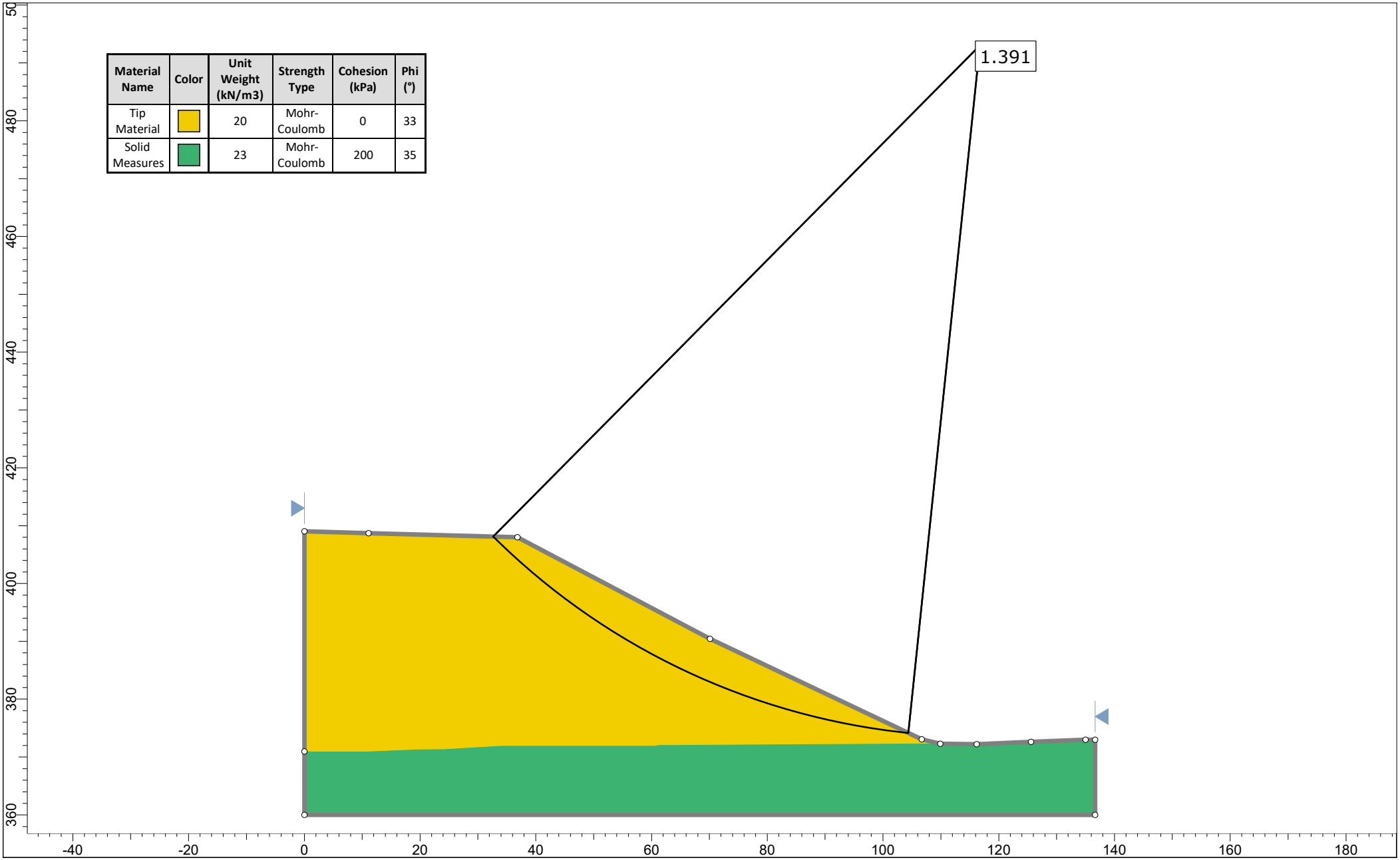

XS 4 Regraded - Eurocode 1

OVERBURDEN MOUND 3

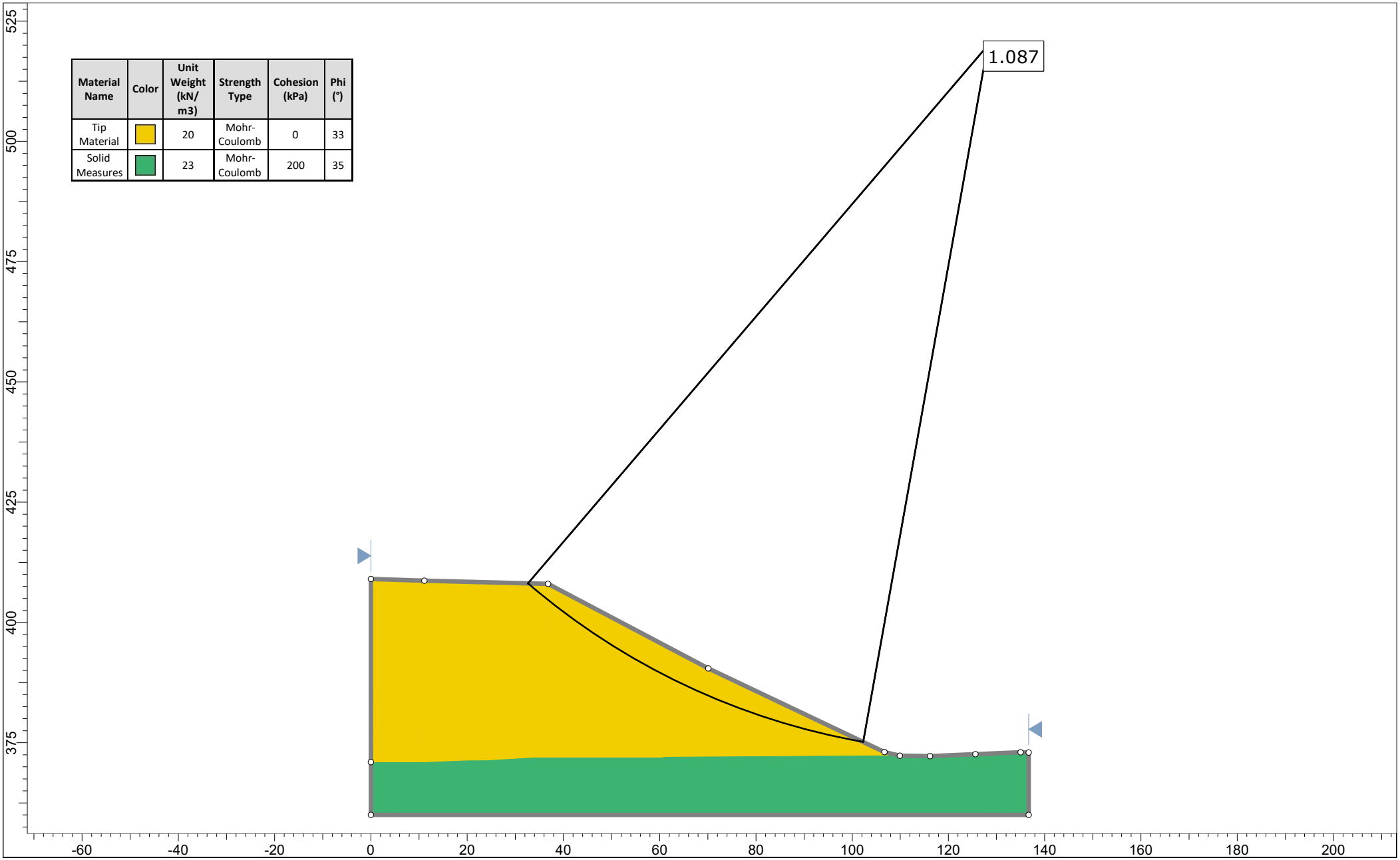
23/01/2026, 10:44:52


1.138
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425
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350
0
25
50
75
100
125
150
175
200
225
250
275

| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (°) |
|---|---|---|---|---|---|
| Tip Material | | 20 | Mohr-Coulomb | 0 | 33 |
| Solid Measures | | 23 | Mohr-Coulomb | 200 | 35 |



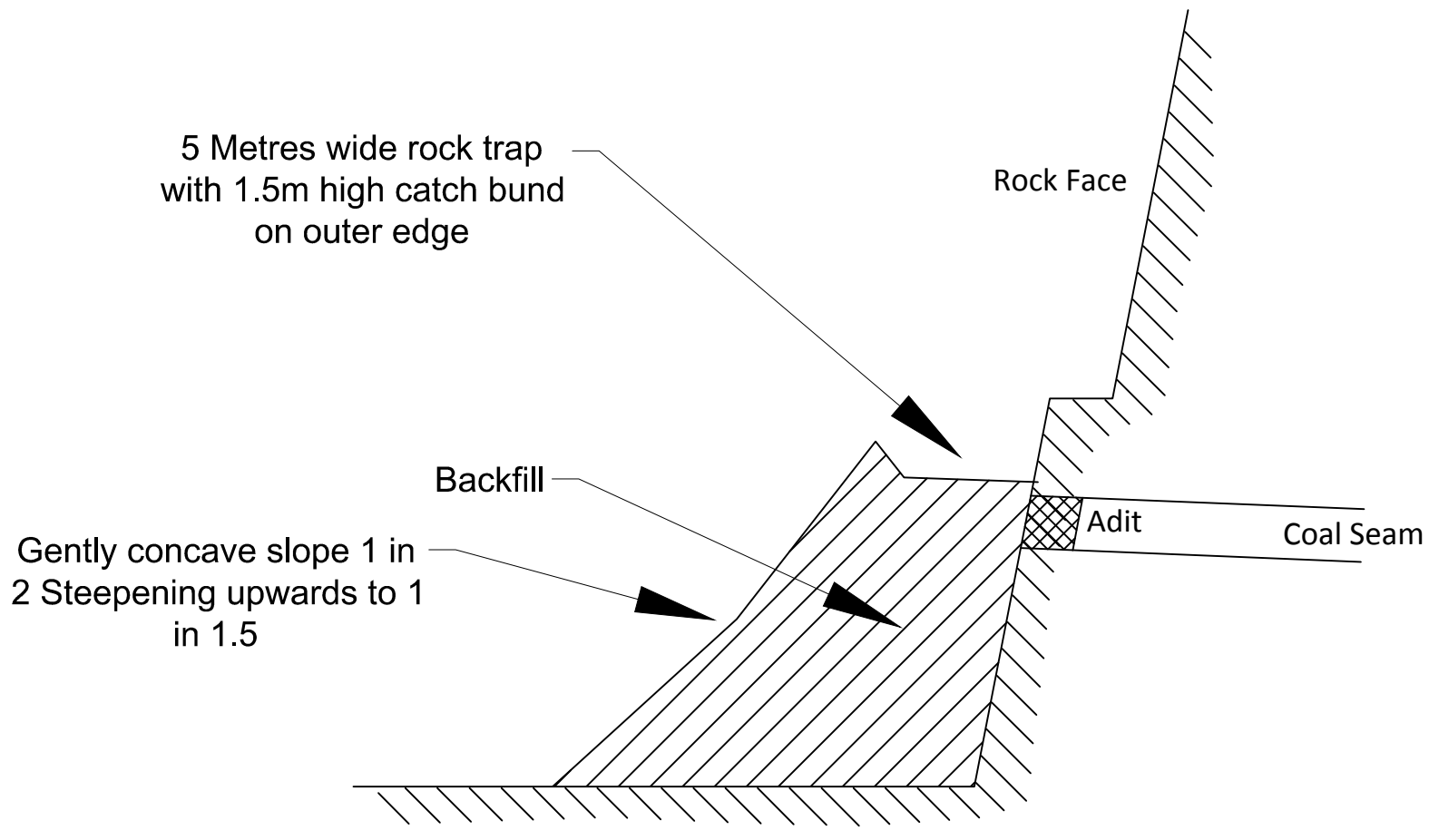
| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (°) |
|---|---|---|---|---|---|
| Tip Material | | 20 | Mohr-Coulomb | 0 | 33 |
| Solid Measures | | 23 | Mohr-Coulomb | 200 | 35 |



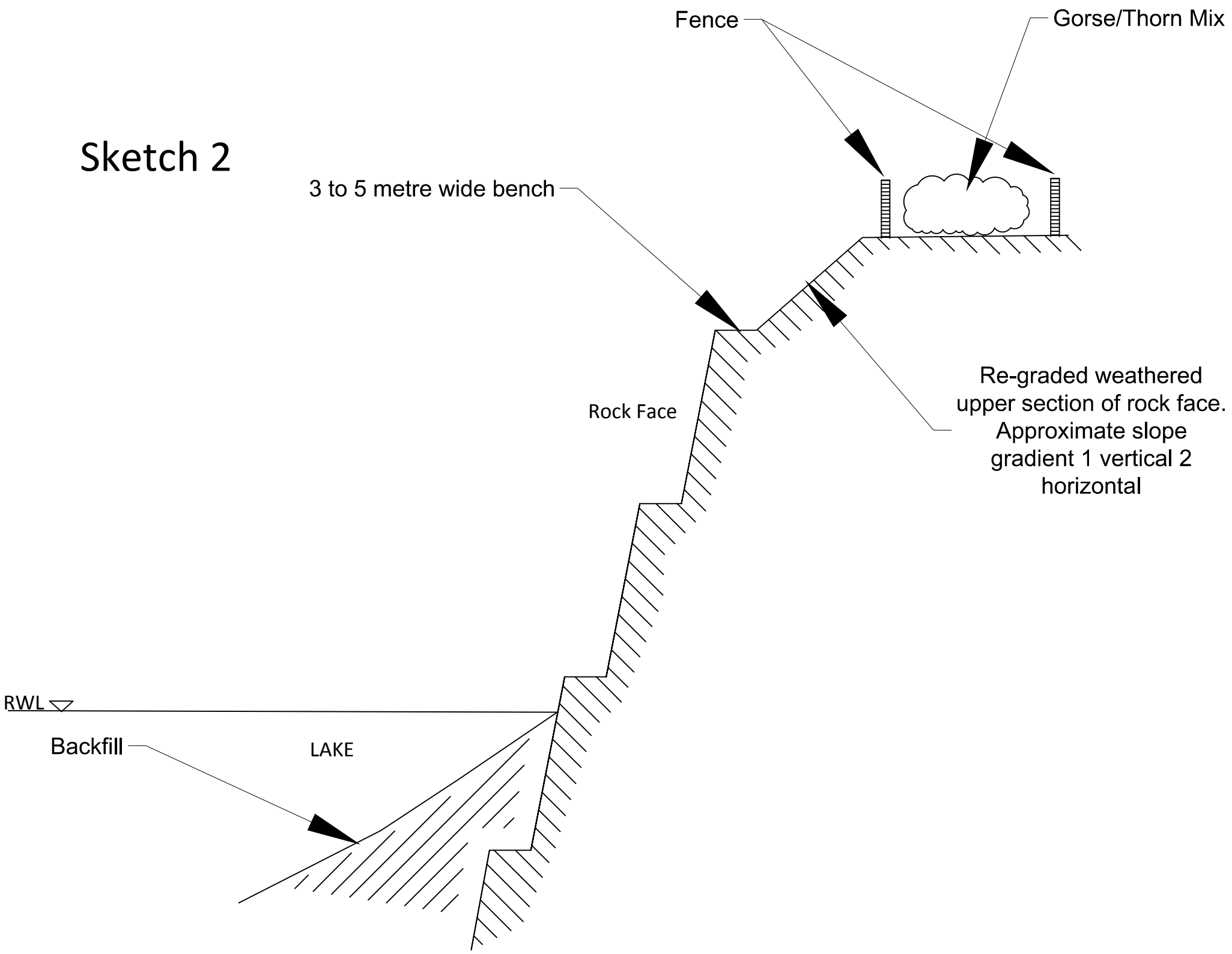
# APPENDIX 5

## Restoration Schematic Sections

## Sketch 1

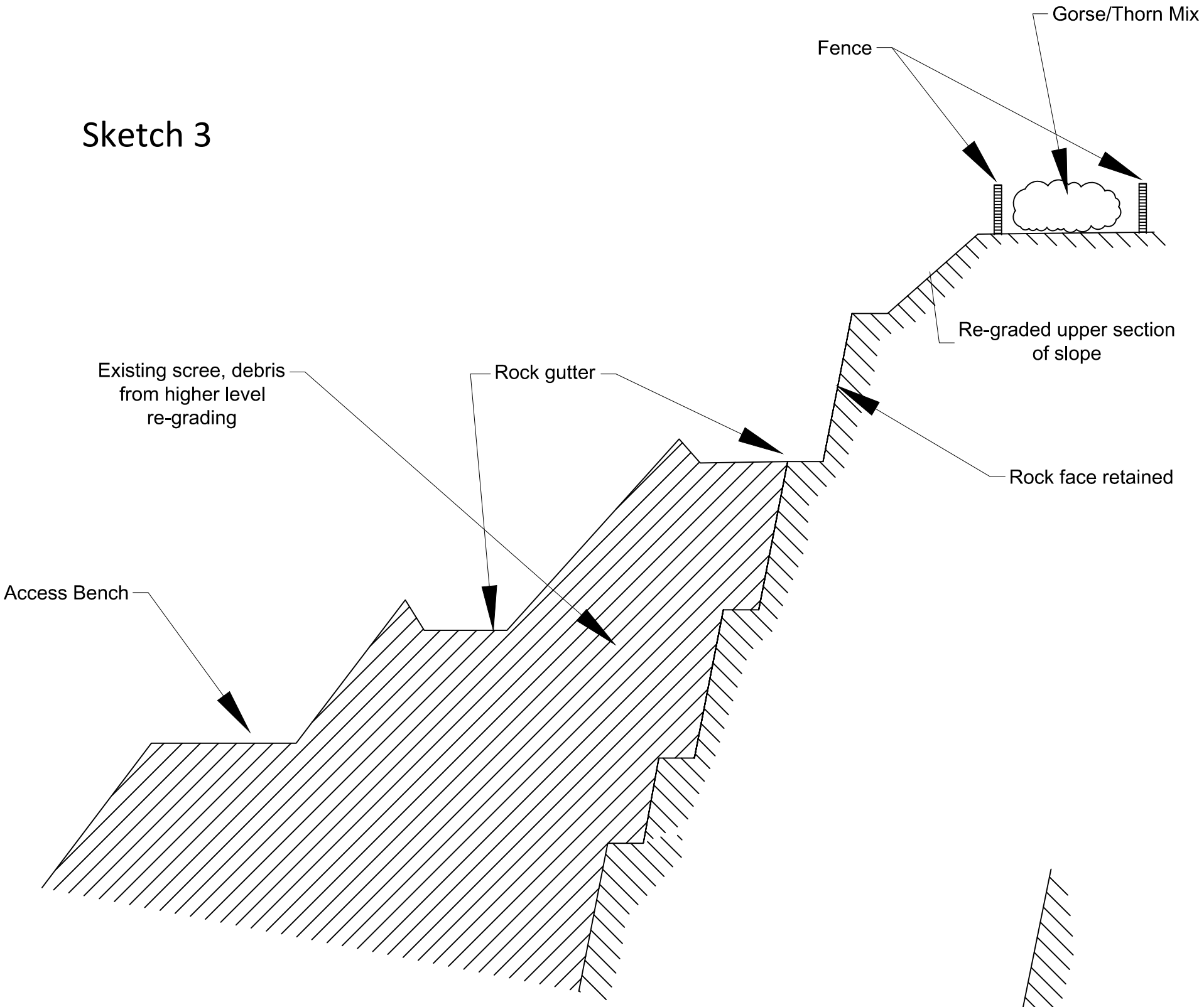



## Sketch 2

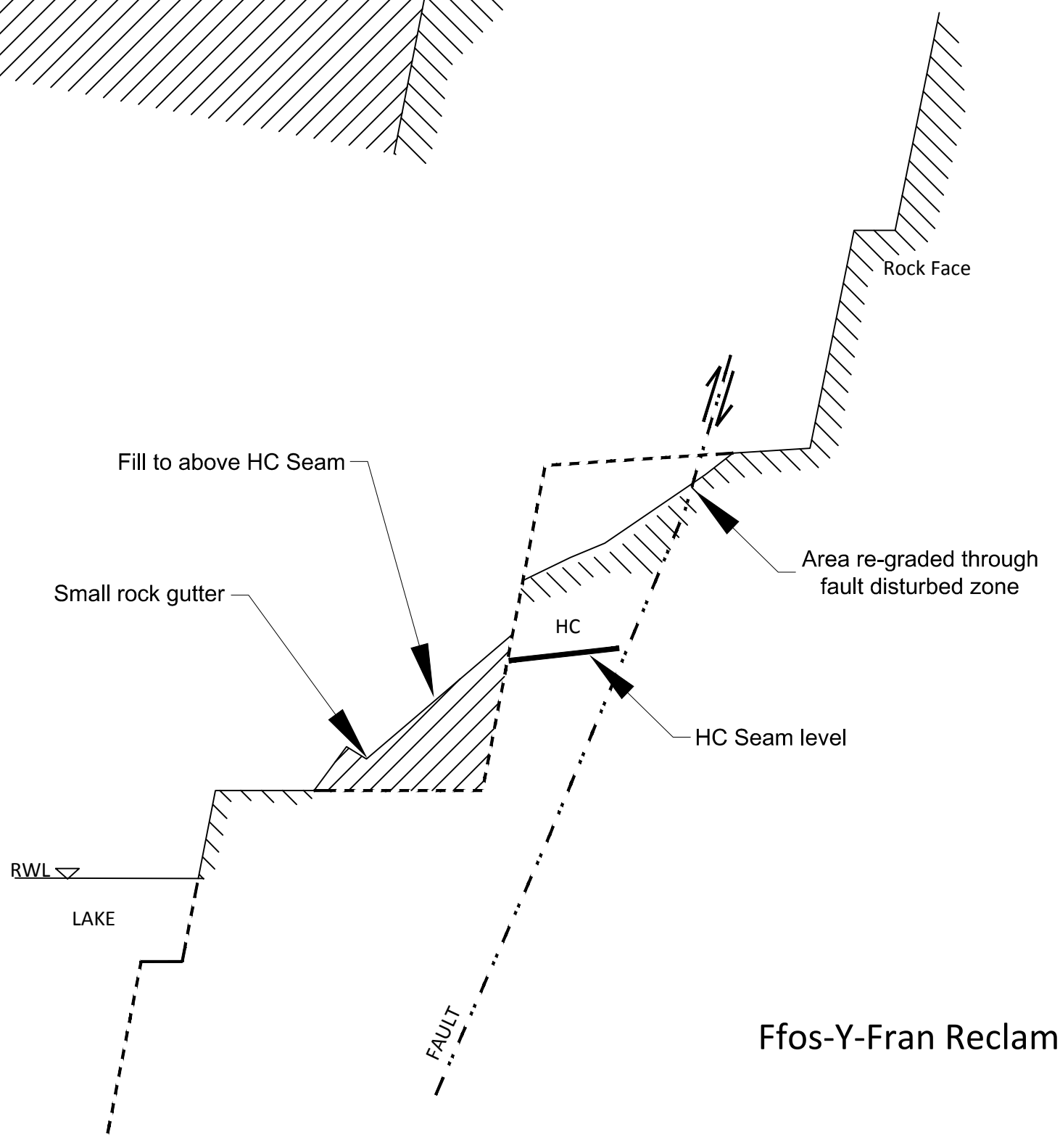



Ffos-Y-Fran Reclamation
Drawing 1 - Schematic cross-sections of the east wall
illustrating proposed remedial works adjacent to rock faces

## Sketch 3



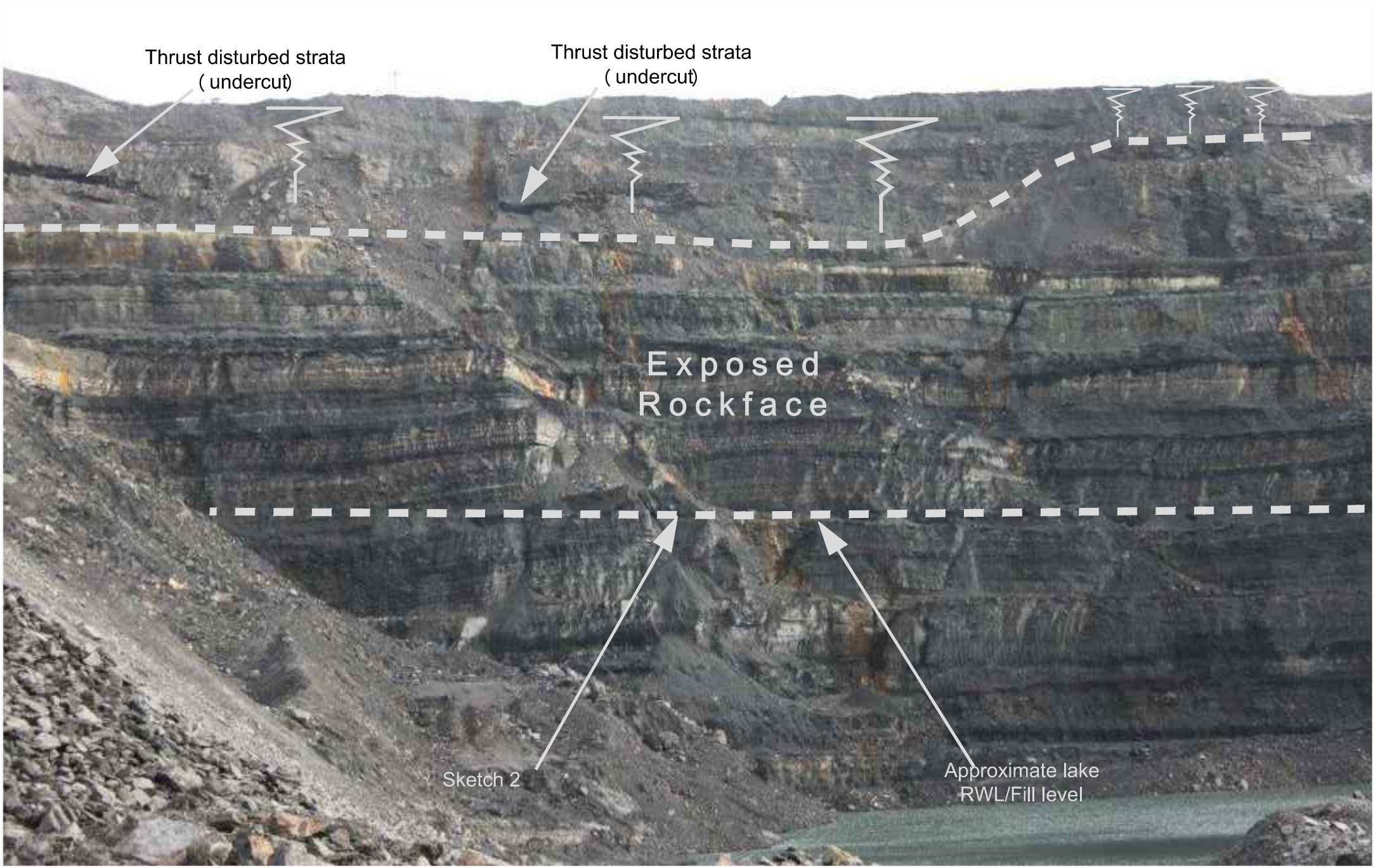

## Sketch 4




Ffos-Y-Fran Reclamation

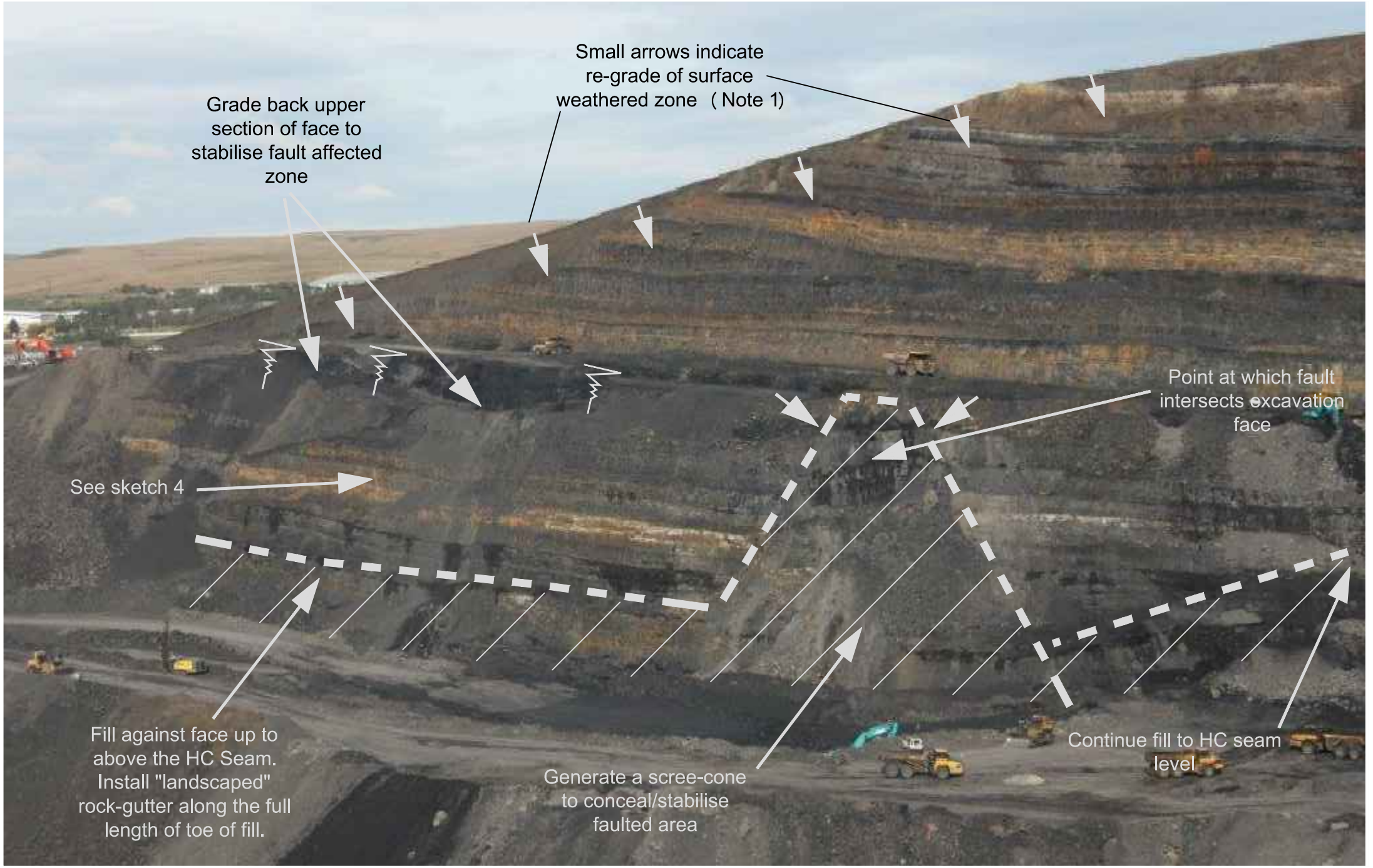
# PHOTOGRAPHS

(to follow)




Drawing No 1 - South Wall

JAMES
associates
Geological, Mining and Development Consultants




Drawing No 2 - East Wall - Northern End ( Rhaslas Level)

JAMES associates
Geological, Mining and Development Consultants




Drawing No 3 - East Wall - Southern End

JAMES
associates
Geological, Mining and Development Consultants




Drawing No 4 - Backfill ( Looking North)

JAMES associates
Geological, Mining and Development Consultants




Drawing No 5 - East wall

JAMES associates
Geological, Mining and Development Consultants




Drawing No 6 - Corner point - East wall

JAMES associates
Geological, Mining and Development Consultants