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Geological & Geotechnical Consultants

Bromsberrow Quarry

Stability Risk Assessment Report (October 2023)

Prepared for: Bromsberrow Sand and Gravel Limited

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Bromsberrow Sand and Gravel Limited

Bromsberrow Quarry

Stability Risk Assessment Report

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1.0 INTRODUCTION

1.1 Report Context

Key GeoSolutions Limited (KGS) have been commissioned by Bromsberrow Sand and Gravel Limited to undertake a Stability Risk Assessment in order to assess the stability of the proposed restoration at Bromsberrow Quarry. This report has been compiled in accordance with the template issued by the EA (Ref: SRA Version 2 – November 2003), with reference to R&D Technical Reports P1-385/TR1 and TR2 where applicable.

The report provides an overview of the available data and a review of the existing ground conditions.

1.2 Conceptual Stability Site Model

This report deals with the proposed mineral extraction and the restoration with inert waste at Bromsberrow Quarry. The extent of the proposed development area of the mineral extraction and inert waste infill is shown in Drawing No. 7873-005-D-002.

Bromsberrow Quarry is located on the east side of the village of Bromsberrow Heath, Ledbury and directly to the north of the M50 motorway.

The National Grid Reference of Bromsberrow Quarry is 373900mE 233100mN.

The site is covered by Geological Sheet No. 216 (Tewkesbury), which shows the site to be extracting the Bridgnorth Sandstone Formation of the New Red Sandstone Supergroup. The Bridgnorth Sandstone Formation strata are described as red, medium grained, cross bedded aeolian sandstones, which are poorly cemented.

Groundwater is not encountered in the quarry, with surface water that enters the quarry being able to infiltrate to ground through the quarry floor. A borehole held on the BGS database and located 600m to the north of the site encountered water at an elevation of c. 31mAOD. The groundwater monitoring data recorded at 8 boreholes by Geotechnical Engineering Ltd between September 2021 and March 2022 (see Appendix SRA 3) confirms that the groundwater level (c. 32 mAOD) at the site is 20-27.32m below ground surface. A maximum groundwater level of 35mAOD has been adopted for the current assessment.

The quarry is extracting sand for the production of various construction aggregates. The mineral extraction is proposed to be undertaken to a floor level of 36mAOD with a maximum slope angle of 60° from the horizontal. The excavation area will subsequently be filled with inert waste to achieve the proposed restoration profile.

The mineral extraction and restoration will be carried out progressively in phases in accordance with the quarry development plan. Drawing No. 7873-005-D-002 shows the phased details for mineral extraction and restoration.

It is proposed that a 1m thick geological barrier (liner) will be constructed over the base and the sides of the excavation prior to the placement of inert waste. The geological barrier will be formed from engineered clay fill with a maximum permeability coefficient of 1×10^{-9} m/s.

1.2.1 Basal Subgrade Model

The basal subgrade will be formed by in-situ strata of the Bridgnorth Formation (New Red Sandstone Supergroup) at an elevation of 36 mAOD.

1.2.2 Side Slope Subgrade Model

The side slopes will be formed of in-situ strata of the Bridgnorth Sandstone Formation.

The Bridgnorth Formation faces will be excavated at a slope angle of 60°.

1.2.3 Basal Lining Model

It is proposed to install a minimum 1m thick basal geological barrier within the proposed restoration area, which will be compacted to achieve a maximum permeability of 1×10^{-9} m/s.

1.2.4 Side Slope Lining Model

The side slope lining will consist of a minimum 1m thick layer of clay, which will be compacted to achieve a maximum permeability of 1×10^{-9} m/s. It is proposed that the lining will be placed in lifts of a maximum height of 2m, subsequent lifts will only be constructed once the inert waste has been placed to the crest of the previous lift.

1.2.5 Waste Mass Model

The waste mass will consist of materials described as inert waste comprising construction waste, demolition and building waste.

Due to the inert nature of the waste material, leachate and gas abstraction measures are not proposed. It is planned that restoration will be undertaken progressively as each phase is completed although this will depend on the availability of suitable materials.

The waste materials will be placed in compacted layers of thickness appropriate for the material being deposited; the maximum anticipated layer thickness is 1m with maximum lift heights of 2m and with temporary slopes in the waste no steeper than a 1v in 2h gradient.

The restoration design indicates that the inert waste infill will be wholly contained within the excavation void and the final restoration profile has no significant outer slope. However, given the restoration will be undertaken progressively in several phases, intermediate/temporary outer backfill slopes will be formed at a slope gradient of maximum 1(v) : 2(h) with slope height of maximum 20m (see drawing no. 7873-005-D-004).

1.2.6 Capping System Model

It is proposed that due to the inert nature of the waste materials accepted at the site and the fact there is no requirement to collect leachate or gas, there is no proposed engineered capping system.

2.0 STABILITY RISK ASSESSMENT

Each of the six principal components of the conceptual stability site model has been considered and the various elements of the component have been assessed with regard to stability (see Drawing No. 7873-006-001).

The principal components considered are:

- the basal subgrade;
- the side slope subgrade;
- the basal lining system;
- the side slope lining system;
- the waste, and
- the capping system.

2.1 Risk Screening

Issues relating to stability and integrity for each principal component of the development have been subject to a preliminary review to determine the need to undertake further detailed geotechnical analyses. The following sections present the results of this screening exercise.

2.1.1 Basal Subgrade Screening

The stability and deformability of the basal subgrade will be ensured during the construction and in the long term by appropriate design of the components in Table SRA 2/1, below.

Table SRA 2/1

Stability Components for Basal Subgrade

Excessive Deformation	Compressible Subgrade	The basal subgrade will comprise in-situ Bridgnorth Sandstone Formation. The sandstone will be of low compressibility.
	Basal Heave	Ground water is not encountered within the quarry at subgrade level and the maximum water level recorded at the site is c. 3m below the quarry floor, hence basal heave within sandstone strata is not considered to be a problem and therefore this aspect is not considered further.
	Cavities in Subgrade	No evidence of cavities was identified during the site inspection. Natural cavities are not known to exist in the Bridgnorth Sandstone strata, therefore this aspect is not considered further.

Given the foregoing, it is not considered that the basal subgrade system requires further assessment.

2.1.2 Side Slope Subgrade Screening

The controlling factors that will affect the stability and deformability of the side slope subgrade are detailed in Table SRA 2/2 below.

Table SRA 2/2

Stability Components for Side Slope Subgrade

Cut Slope	**Bridgnorth Sandstone Formation**	Stability	The side slope subgrade will be formed by in-situ Bridgnorth Sandstone Formation. These slopes will be formed at a maximum slope angle of 60° and a maximum height of 25m. The stability of the unconfined slopes will be considered further.
		Deformability	The in-situ Bridgnorth Sandstone Formation is considered to be essentially incompressible. Therefore, this issue does not require further consideration.
		Groundwater	No groundwater is encountered within the excavation area.

Given the foregoing, it is considered that the side slope subgrade system requires further assessment.

2.1.3 Basal Lining Screening

The basal lining system consists of 1m thick engineered geological barrier that will be placed and compacted in layers prior to the placement of inert waste. No ground water is encountered within the excavation area and the engineered basal lining system is considered to be essentially incompressible. The basal lining system will be considered as the part of the waste mass and the stability of it is considered in Section 2.1.5 below.

2.1.4 Side Slope Lining Screening

The side slope lining system will be progressively built up in maximum 2m lifts; shortly after, inert waste will be backfilled against it to a similar elevation. The controlling factors that will affect the stability and deformability of the side slope liner are detailed in Table SRA 2/3 below.

Table SRA 2/3

Stability Components for Side Slope Liner

Failure involving slope liner	Stability	The exposed clay slope at any time will be maximum 2m high, formed as a wedge of clay against the sandstone slope. Given the limited height and temporary nature of the liner slope these are not considered further.
Failure involving subgrade and waste	Stability	Phased restoration will result in the generation of partially backfilled slopes. Instability within the waste and the subgrade could potentially occur and this will be considered further.

Given the foregoing, it is considered that the side slope lining system requires further assessment.

2.1.5 Waste Mass Screening

The controlling factors that will affect the stability and deformability of the waste mass are detailed in Table SRA 2/4 below.

Table SRA 2/4

Stability Components for Waste Slopes

Failure wholly in waste	Stability	The waste materials will be placed in compacted layers of thickness appropriate for the material being deposited. Given the nature of phased restoration, temporary intermediate waste slopes will be formed at a gradient of no steeper than 1(v) in 2(h). The stability of the unconfined slopes will be considered further.
Failure involving subgrade and waste	Stability	Phased restoration will result in temporary 20m high waste slopes. Instability within the waste and the basal subgrade could potentially occur and this will be considered further.
Failure in basal and/or slope lining system	Stability	The lining system form an interface between waste mass and subgrade formation. The potential instability of the temporary waste slopes may result in the movement of waste mass along the basal and/or slope liner interface and this will be considered further.

Given the foregoing, it is considered that the waste mass and lining system require further assessment.

2.1.6 Leachate Screening

No requirement for treatment of leachate has been proposed within the scheme and so this has not been considered further within this report.

2.1.7 Capping System Screening

As previously discussed in Section 1.2.6, there is no proposed engineered barrier / capping system; therefore, detailed geotechnical analysis is not required.

2.2 Lifecycle Phases

It is proposed that waste deposition will be progressive in as areas of the excavation are completed. The inert waste will be built up in layers, following the creation of each 2m high section of slope liner, inert waste will be immediately placed adjacent to the liner.

The waste will be placed in eight phases, beginning in the southwest of the excavation area, as a continuance of the existing infilling operation, then working towards the northwest following the phasing of the extraction process.

Given the ongoing infilling operations and progressive restoration of the site, temporary waste slope will be formed. The restoration area will be extended laterally and increased in height with progressive infilling and ultimately all tip slopes will be backfilled to achieve the approved restoration contours of the site.

2.3 Data Summary

The following data is required as input for the analyses undertaken for this Stability Risk

Assessment:

- material unit weight;
- drained and/or undrained shear strength of soil / rock and waste;
- hydrogeological conditions.

The geotechnical parameter values adopted are discussed in more detail in Section 2.6.

2.4 Selection of Appropriate Factors of Safety

The factor of safety is the numerical expression of the degree of confidence that exists, for a given set of conditions, against a particular failure mechanism occurring. It is expressed as the ratio of resisting forces against driving forces within a slope. This is readily determined by limit equilibrium slope stability analysis, which is the only type of analyses required for the current study.

Prior to determining appropriate factors of safety for the various elements of the model, it is necessary to identify key 'receptors' and evaluate the consequences in the event of failure. Consideration of the following receptors is required:

- Human beings (i.e. direct risk)
- Property – site infrastructure and third party property.

The factor of safety adopted for each component of the model would be related to the consequences of failure.

The scenario currently being analysed will represent short-term slope conditions; ultimately the temporary waste slope will be progressively backfilled with inert waste and the entire restoration area will be increased in height to comply with the approved restoration contours of the site.

The proposed backfill and excavation is contained wholly below the surrounding ground level and that no third party property or site infrastructure will be affected in the event of failure. it is considered that a factor of safety of 1.2 is appropriate for a temporary tip slope.

2.5 Justification for Modelling Approach and Software

In order to perform the Stability Risk Assessment, the components of the proposed development, as previously described in Section 1.2 of this document, have to be considered not only individually but in conjunction with one another where relevant.

It is considered that circular failure through the mass of the material (including the lining system) is the most likely form of instability. The failure of the lining system (slope and basal) may occur due to the movement of waste mass along the slope and basal lining system, this is assessed by considering non-circular wedge analysis.

With the proposed system being a simple construction, it is only necessary to employ limit equilibrium stability analyses for the derivation of factors of safety for potential failures. The limit equilibrium analyses have been undertaken using the software package SLIDE2 (Rocscience Ltd.).

2.6 Justification of Geotechnical Parameters Selected for Analysis

The stability analyses that have been undertaken as part of this assessment have assumed various geotechnical parameters for the in-situ strata, engineered geological barrier and inert waste materials.

The parameters that have been used are summarised below in Table SRA 2/5.

Table SRA 2/5
Geotechnical Parameters Used in Analyses

Material Type	Effective Cohesion, c' (kN/m^2)	Angle of Shearing Resistance, Ø' (°)	Bulk Density (kN/m^3)	Typical Description
Waste Backfill	1	28 (20 - 34)*	20	Imported Inert waste
Bridgnorth Sandstone	140	29	22	Weakly cemented sandstone
Geological barrier	4	25	20	Firm silty clay

* Used for sensitivity analysis for waste material, see Section 2.7.7

Groundwater has not been encountered at the restoration area at the site. A maximum groundwater level of 35mAOD (1m below the basal liner) has been adopted for the stability analysis.

2.6.1 Parameters Selected for Basal Subgrade Analysis

The parameters are given in Table SRA 2/5 for the Bridgnorth Sandstone Formation have been assumed by KGS, based upon the findings of site inspections as part of previous geotechnical assessments, knowledge of similar materials and ground conditions elsewhere.

2.6.2 Parameters Selected for Side Slope Subgrade Analysis

The parameters are given in Table SRA 2/5 for the Bridgnorth Sandstone Formation have been assumed by KGS, based upon the findings of site inspections as part of previous geotechnical assessments, knowledge of similar materials and ground conditions elsewhere.

2.6.3 Parameters Selected for Basal Liner Analysis

The parameters are given in Table SRA 2/5 for the basal liner (geological barrier) has been assumed by KGS, based upon knowledge of similar materials and ground conditions elsewhere.

2.6.4 Parameters Selected for Side Slope Liner Analysis

The parameters are given in Table SRA 2/5 for the clay side slope liner has been assumed by KGS, based upon knowledge of similar materials and ground conditions elsewhere.

2.6.5 Parameters Selected for Waste Analysis

The parameters are given in Table SRA 2/5 for inert waste has been selected based on experience of other sites. A sensitivity analysis will be conducted for the waste material considering a range of angles of shearing resistance between 20 and 34 degrees (see Section 2.7.7).

2.6.6 Parameter Selected for Capping Analysis

Not applicable.

2.7 Analyses

Details of the various Stability Risk Assessment analyses undertaken for the site are presented in the following sections. The schematic cross sections (see drawing no. 7873-005-D-002) have been produced to represent the general slope profile through the development area. The cross sections used for the stability analysis represent the maximum height of excavation slope of the proposed of mineral extraction and maximum thickness of the proposed backfill, and hence presents the worst scenario. Therefore, it is considered that the stability risk assessment results are applicable to the whole development area.

2.7.1 Basal Subgrade Analysis

The stability of the basal subgrade will be a function of the height of the unconfined side slopes and this aspect is considered as part of the side slope subgrade analysis (Section 2.7.2).

2.7.2 Side Slope Subgrade Analysis

The stability analysis program SLIDE2 has been used to analyse the rotational failure using limit equilibrium analysis.

Details for the analysis are summarised below in Table SRA 2/6 and analysis outputs are presented in Appendix SRA 1.

Table SRA 2/6

Summary of Stability Analysis for Side Slope and Basal Subgrade

Section	Failure Mechanism Analysed	FoS	Comments
SRA-01	Circular	2.03	Failure through entire slope

A minimum factor of safety (FoS) of 2.03 against global entire slope failure through the side slope and basal subgrade have been determined; this factor of safety is deemed acceptable for short term stability.

2.7.3 Basal Lining Analysis

The stability of the basal lining system will be a function of the waste height and the outer slope of the waste mass; therefore, the stability of the basal lining will be considered as part of the waste mass analysis (Section 2.7.5).

2.7.4 Side Slope Lining Analysis

The liner will be progressively built up in layers prior to the placement of inert waste, therefore, the stability of the side slope lining system will be considered as part of the waste mass analysis (Section 2.7.5).

2.7.5 Waste Mass Analysis

Both circular and non-circular failure mechanisms have been considered using the SLIDE2 program, with the stability of the relevant slip surfaces being analysed using vertical slice limit equilibrium methods.

Details for the analysis are summarised below in Table SRA 2/7 and analysis outputs are presented in Appendix SRA 1.

Table SRA 2/7

Summary of Stability Analysis for Waste Mass (including lining system)

Section	Failure Mechanism Analysed	FoS	Comments
SRA-02	Circular	1.18	Shallow failure through waste mass and basal liner – waste slope only, near slope surface
		1.27	Significant failure through waste mass and basal liner –waste mass and basal liner, 6m behind the top edge of the slope
		1.55	Global failure through entire slope, including subgrade, waste mass and lining system
SRA-02	Non-circular	1.23	Non-circular wedge failure through the lining system and waste mass – waste material movement along basal liner

A minimum factor of safety against any significant failure through the waste mass and lining system >1.25 has been determined; this value is deemed acceptable for short term stability.

Any slope failure with a FoS less than 1.2 is relatively shallow and should have limited impact on the overall slope stability. For a temporary tip slope, the shallow slope failure can be adequately managed on site.

2.7.6 Capping Analysis

Not applicable.

2.7.7 Sensitivity Analysis for Waste Material

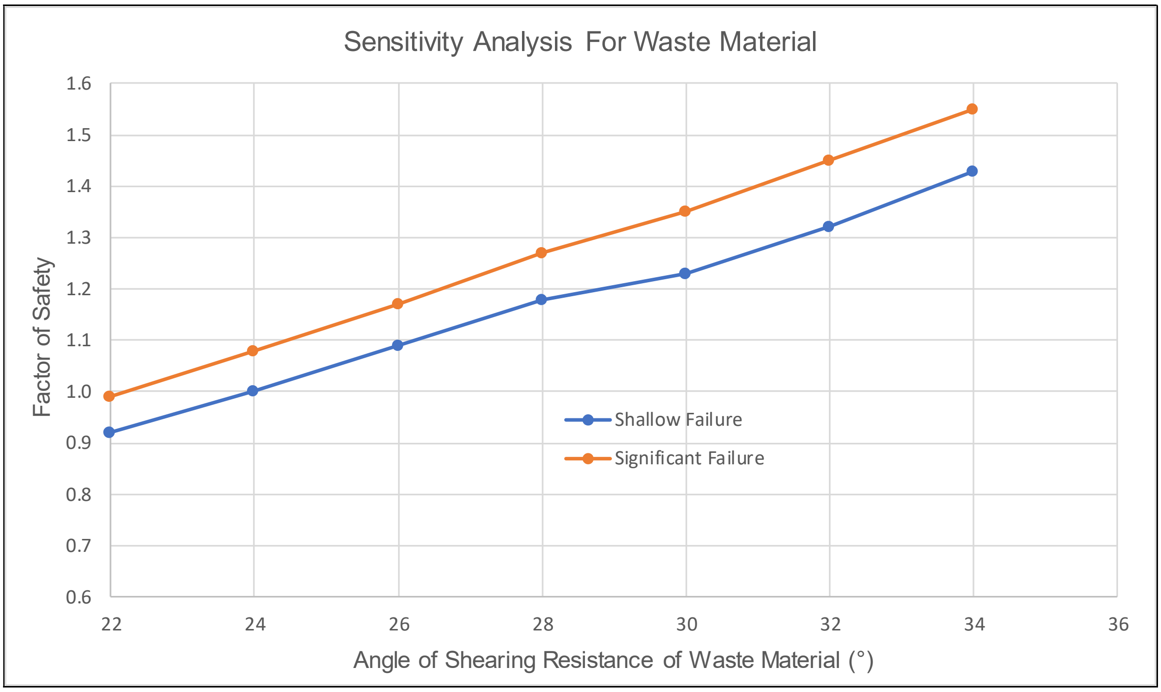
The stability analysis discussed in Sections 2.7.1 to 2.7.6 indicates the lowest FoS of 1.18 occurred within the waste material in the form of rotational/circular failure. A sensitivity analysis has been undertaken for the waste material in relation to rotational/circular failure mechanism. The Slide2 model with the lowest FoS of 1.18 has been adopted for the sensitivity analysis by varying the angle of shearing resistance between 20° and 34° to represent variable waste material.

The detailed results of the sensitivity analysis are included in Appendix SRA 2 and are summarised in Figure 1.

The results of the sensitivity analyses indicate that slope failure will likely occur within the waste backfill with an angle of shearing resistance less than 24°. The analysis indicates that the waste backfill should have a minimum angle of shearing resistance of 28° to have a FoS greater than 1.2 against any major slope failure.

KGS has been told that the proposed waste backfill will be formed from inert construction and demolition waste, which likely comprise a mixture of silt, clay, sand and gravels. It is considered that the placement of inert waste can be adequately managed on site to ensure a minimum angle of shearing resistance of 28 degrees.

Figure SRA 2/1 Sensitivity Analysis Results



2.8 Assessment

2.8.1 Basal Subgrade Assessment

Assessment of the basal subgrade has been undertaken as part of the assessment of the side slope subgrade.

2.8.2 Side Slope Subgrade Assessment

The assessment of this component indicates that the stability of the basal and side slope subgrade is acceptable in the short term. This is confirmed by inspection of the existing excavated slopes within the quarry. It is assumed that the restoration with inert waste will be carried out shortly (within 5 years) following extraction of the mineral within this area to prevent erosion / slumping and ensure long-term stability of the slopes.

The 2021 geotechnical assessment undertaken in accordance with the Quarries Regulations 1999 concluded that the sandstone rock faces have few discontinuities in the rock mass and therefore the stability of the rock faces is dictated by the rock mass shear strength with low risk of kinematic failure.

During the process of restoration or backfilling of inert waste, a rock trap containment should be maintained between the waste backfill and the rock faces to contain rockfall. The minimum requirements for rock trap containment in accordance with HSE guidance are:

Rock trap width:	¼ Height of Face above roadway or working area
Rock trap depth*:	⅛ Height of Face above roadway or working area

2.8.3 Basal Lining Assessment

The stability of the basal lining has been considered as part of the waste mass analysis (Section 2.8.5).

2.8.4 Side Slope Lining Assessment

The stability of the side slope lining has been considered as part of the waste mass analysis (Section 2.8.5).

2.8.5 Waste Mass Assessment

The waste mass analysis incorporates analyses of the lining system (basal and side slope) since these components will play a role in waste mass stability.

The assessment of this component indicates that the stability of the final restoration design is acceptable in the short term. Ultimately the whole excavation area will be backfilled with inert waste and the final restoration contours are almost flat across the site, which will in turn ensure the long-term stability at the site.

The typical sections been analysed have considered the maximum slope height and outer slope gradient of the inert waste backfill and thus represent the worst scenario.

It is noted that any potential backfill slopes formed during the restoration process are only temporary slopes and the whole site will ultimately be backfilled. It is considered that it will be possible for the temporary slopes to be managed through appropriate site operating procedures with any minor instabilities reprofiled as necessary.

Given the ongoing and progressing backfilling operations, the slope height of the inert waste backfill will most likely be less than the maximum height considered in the stability analysis and thus be more stable.

2.8.6 Capping Assessment

Not applicable.

2.9 MONITORING

2.9.1 The Risk Based Monitoring Scheme

Based upon the foregoing Stability Risk Assessment, a simple risk-based monitoring scheme is considered appropriate for the continued development of the site.

2.9.2 Basal Subgrade Monitoring

See Section 2.9.3 below.

2.9.3 Side Slope Subgrade Monitoring

The quarry excavation is subject to the inspection requirements of the Quarries Regulations 1999, it is considered that these will be adequate to monitor the stability of the excavation slopes.

It is recommended that the proposed regrading works be surveyed following completion to ensure compliance with proposed design. Monitoring during construction will comprise construction quality assurance to ensure compliance with the construction specification.

During the process of restoration or backfilling of inert waste, a rock trap containment should be maintained between the waste backfill and the rock faces to contain rockfall.

No additional instrumentation is deemed as being required during construction or post closure.

2.9.4 Basal Lining Monitoring

It is recommended that the basal lining be surveyed following completion to ensure compliance with the proposed design. Monitoring during construction will comprise construction quality assurance to ensure compliance with the construction specification.

No additional instrumentation is deemed as being required during construction or post closure

2.9.5 Side Slope Lining Monitoring

Monitoring during construction will comprise construction quality assurance to ensure compliance with the construction specification.

No additional instrumentation is deemed as being required during construction or post closure.

2.9.6 Waste Mass Monitoring

Monitoring during construction will comprise construction quality assurance to ensure compliance with the construction specification.

Prior to placement of any waste / restoration fills the suitability of the waste mass (upper surface) will be confirmed by a competent person. Any soft or wet areas will need to be removed and replaced with suitable fill.

Bromsberrow site personnel to undertake daily inspections of the waste mass to confirm its stability, a written record of all inspections to be maintained. They will ensure that the waste is placed and compacted adequately to achieve a suitable shear strength.

2.9.7 Capping System Monitoring

Not applicable.

APPENDIX SRA 1

Output of Stability Analysis

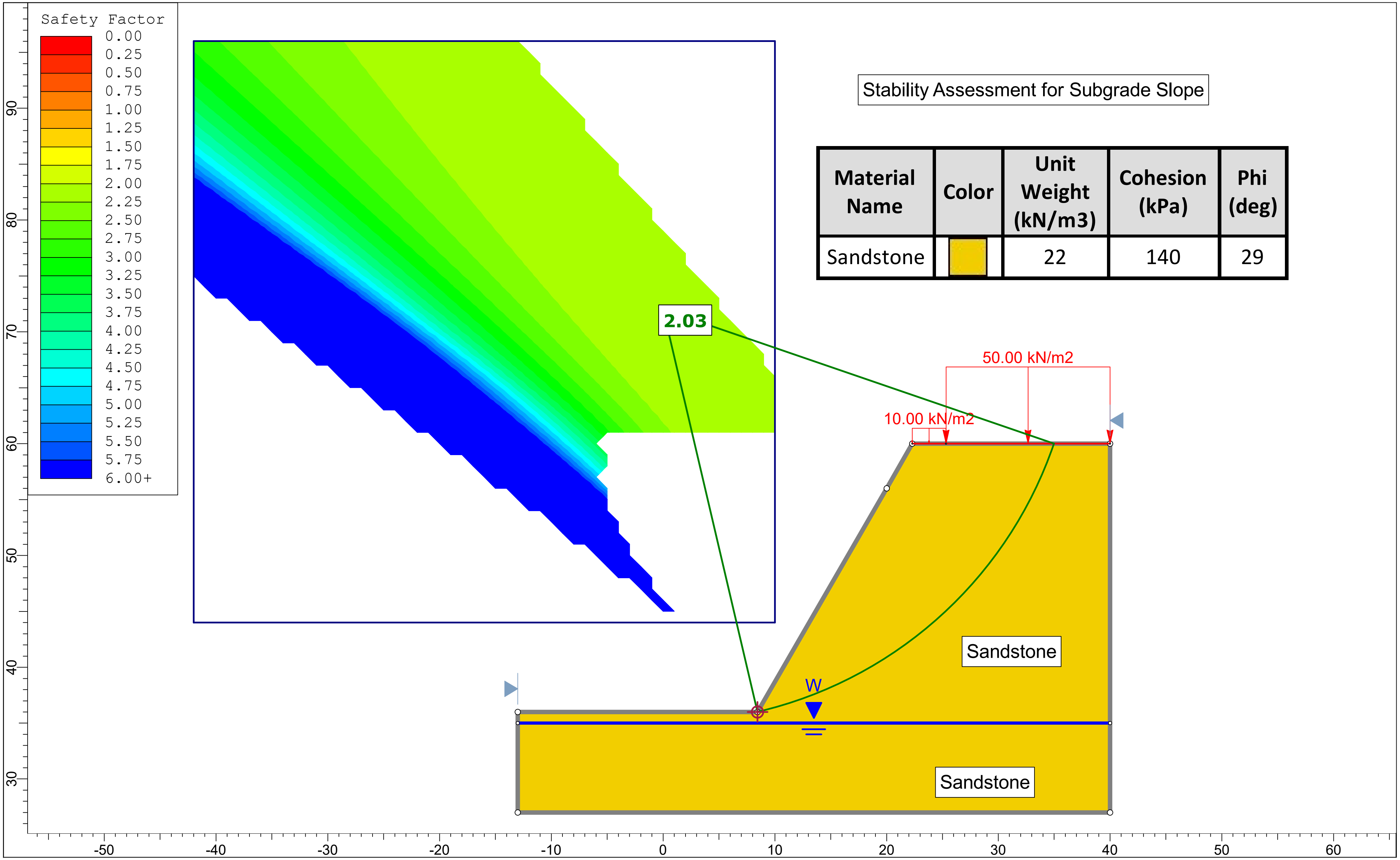
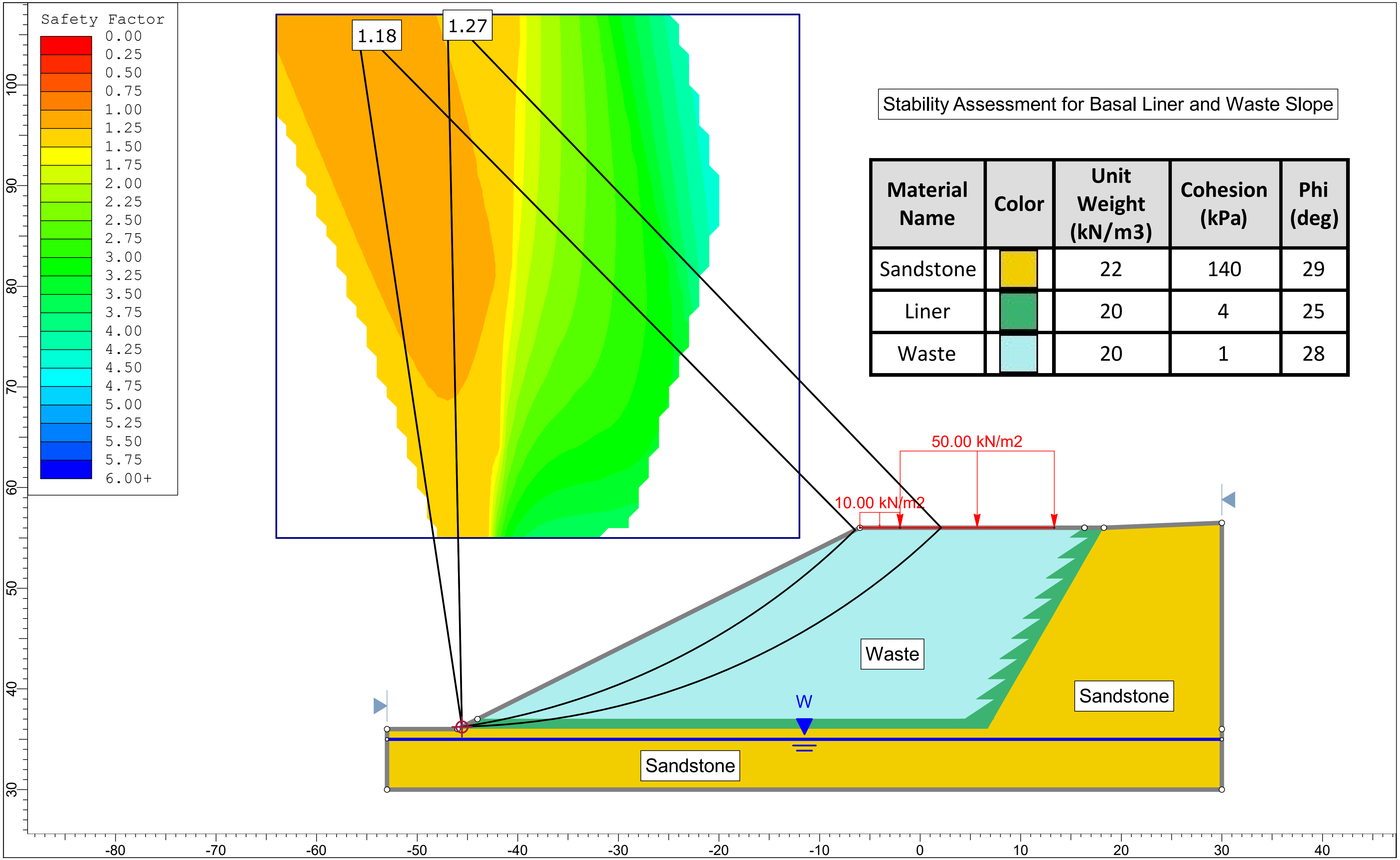


Figure 1 - SRA-01, failure through basal and slope subgrade



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sandstone		22	140	29
Liner		20	4	25
Waste		20	1	28

Figure 2 - SRA-02, failure through basal liner and waste mass

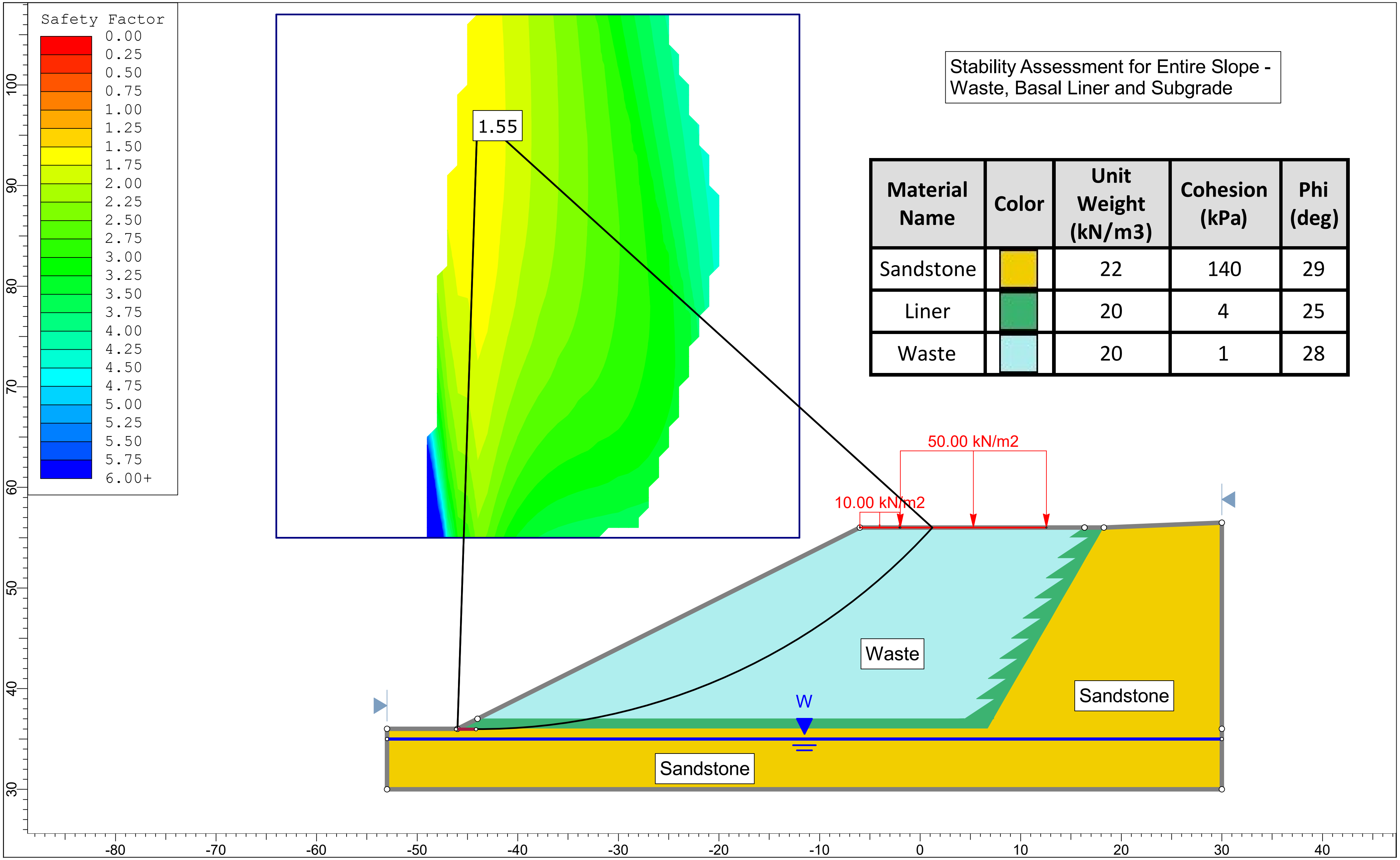
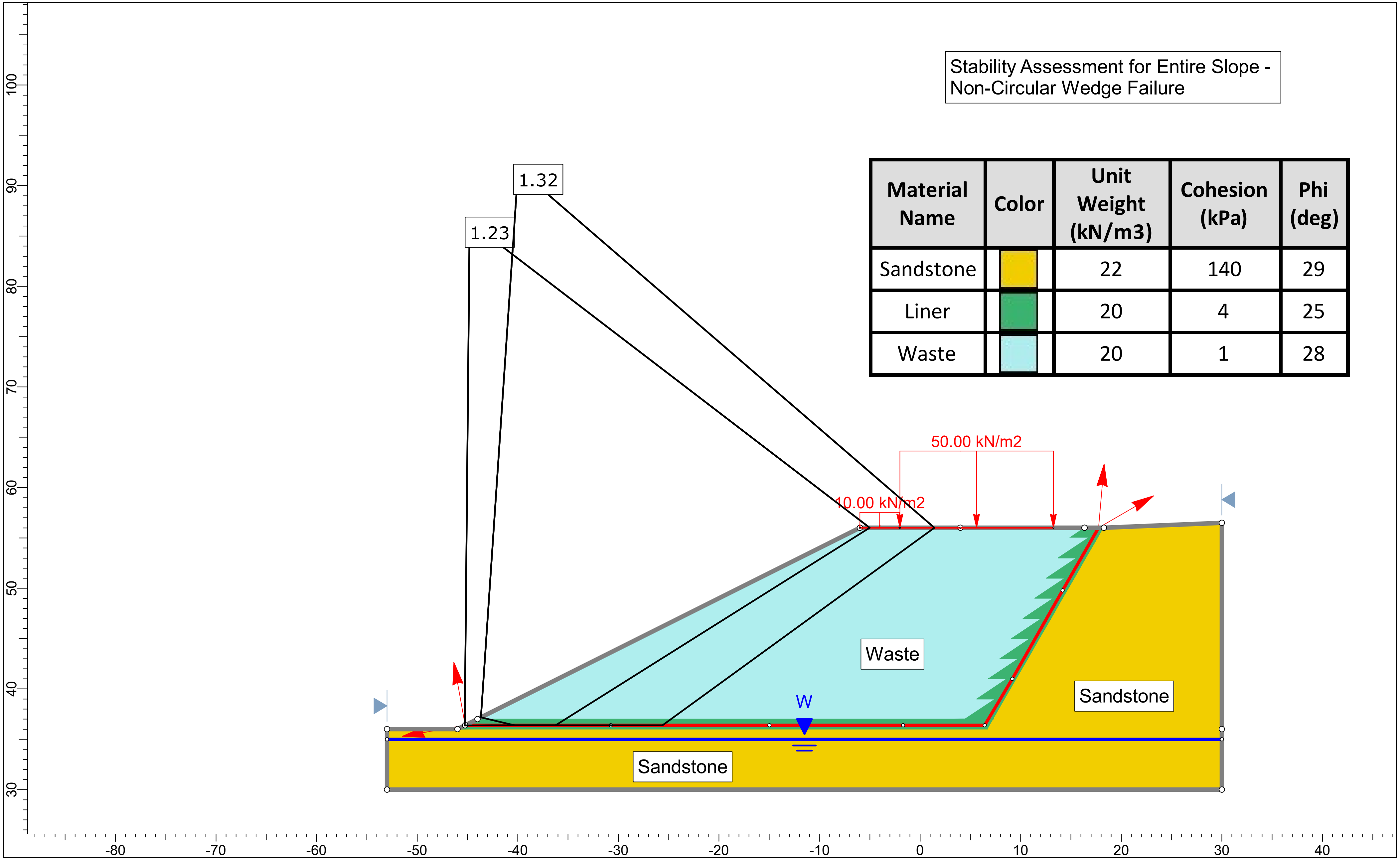


Figure 3 - SRA-02, failure through subgrade, basal liner and waste mass

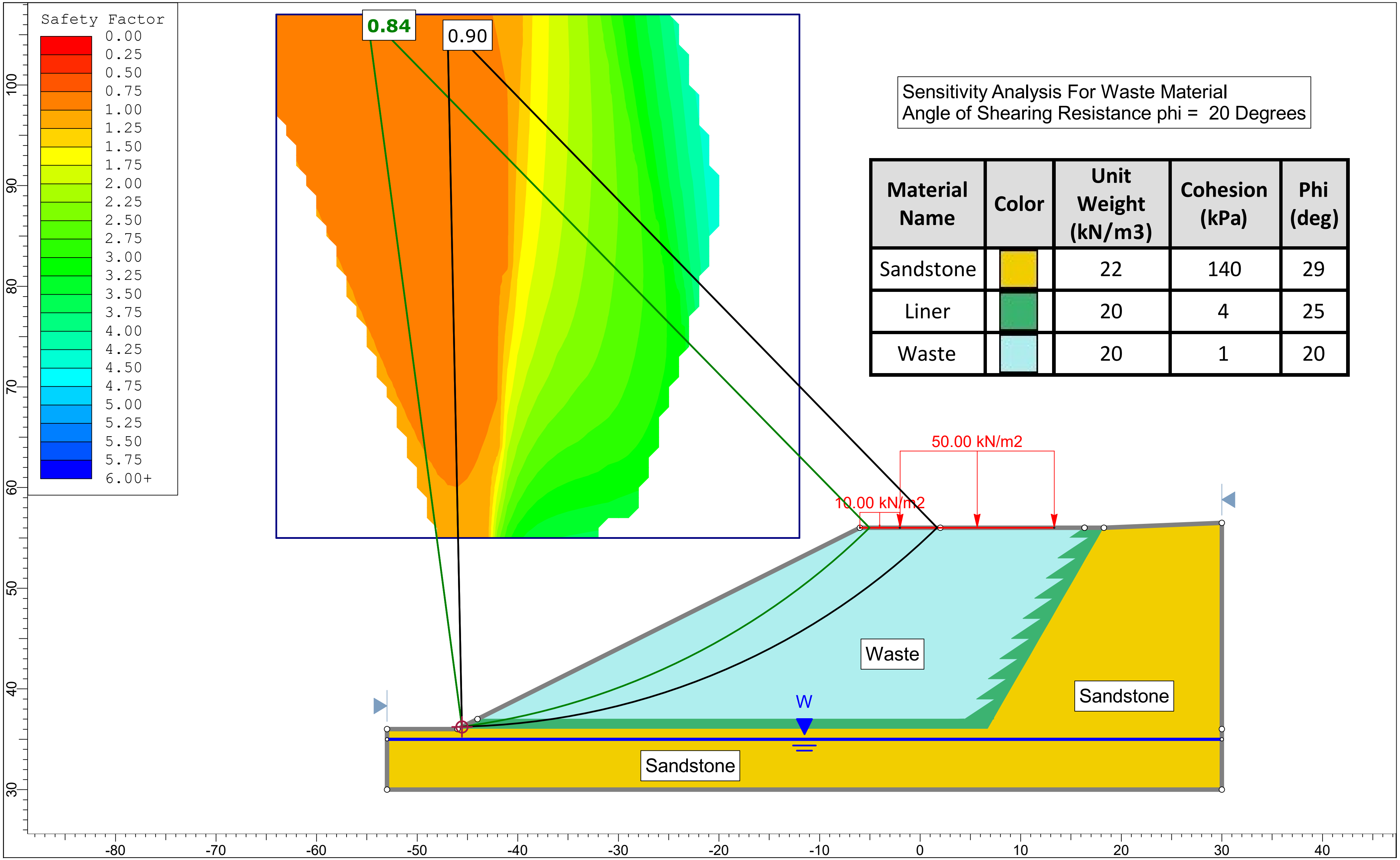


Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sandstone		22	140	29
Liner		20	4	25
Waste		20	1	28

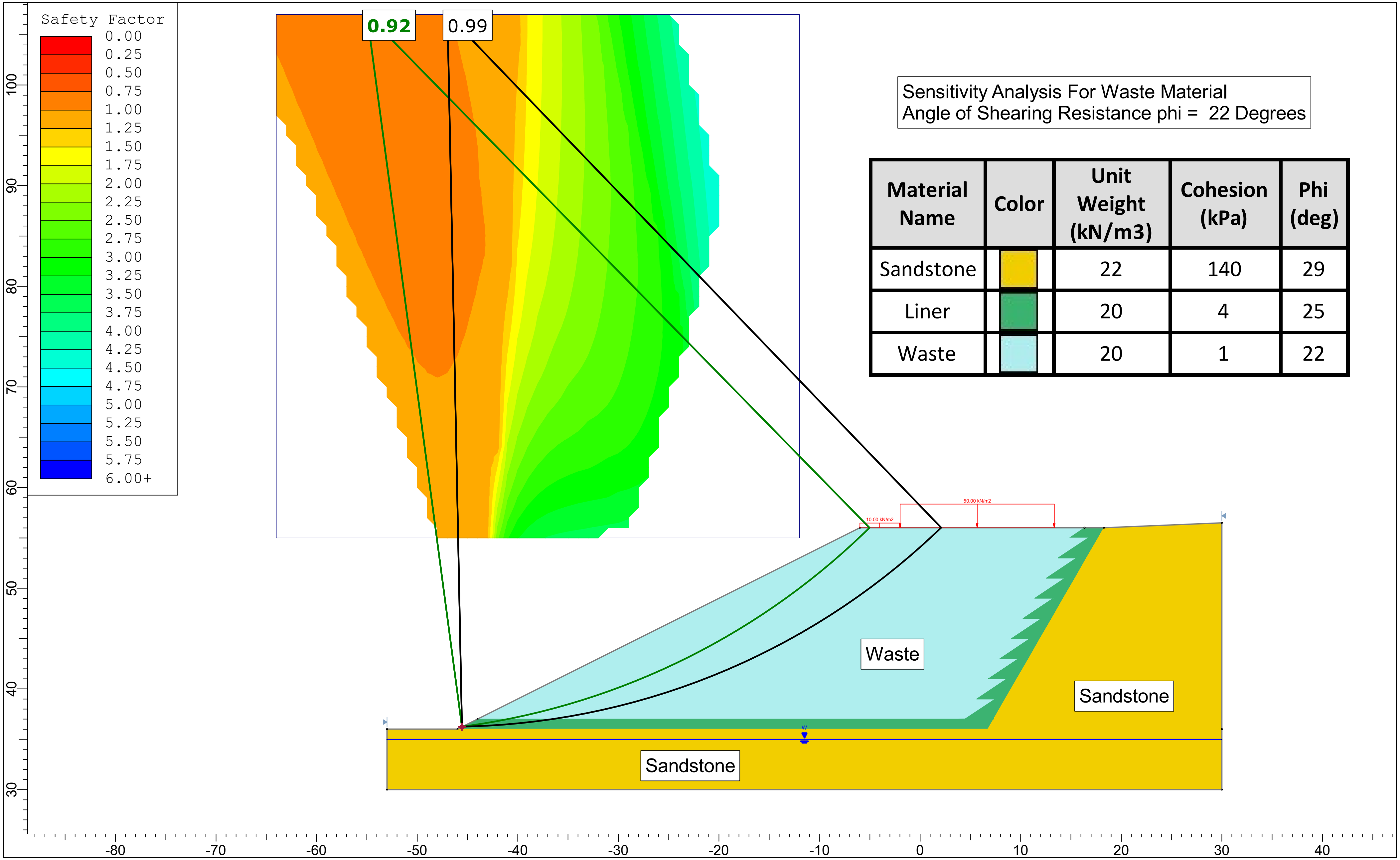
Figure 4 - SRA-02, non-circular failure through basal liner and waste mass

APPENDIX SRA 2

Output of Sensitivity Analysis

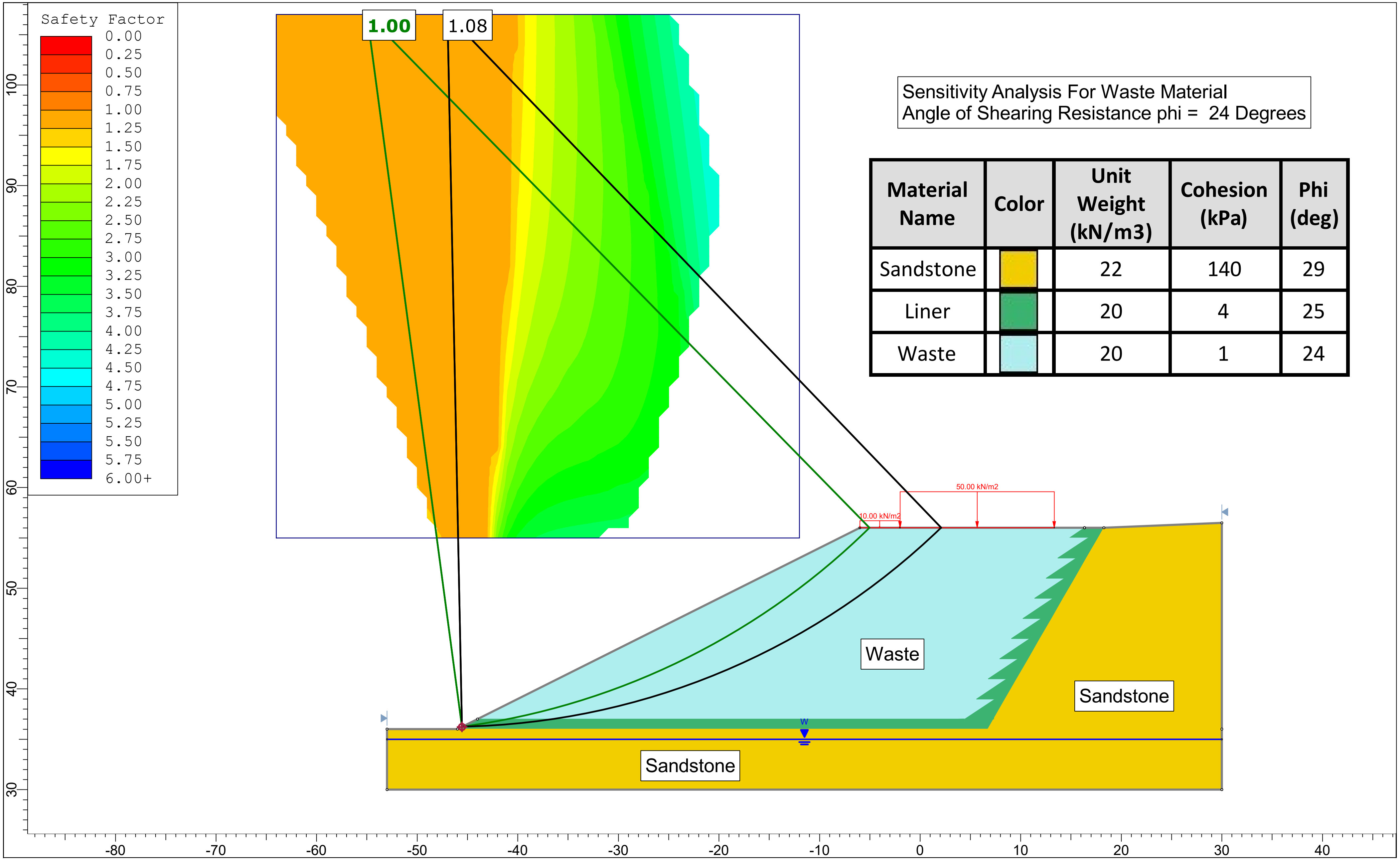


Plot 1 - angle of shearing resistance of 20 degrees



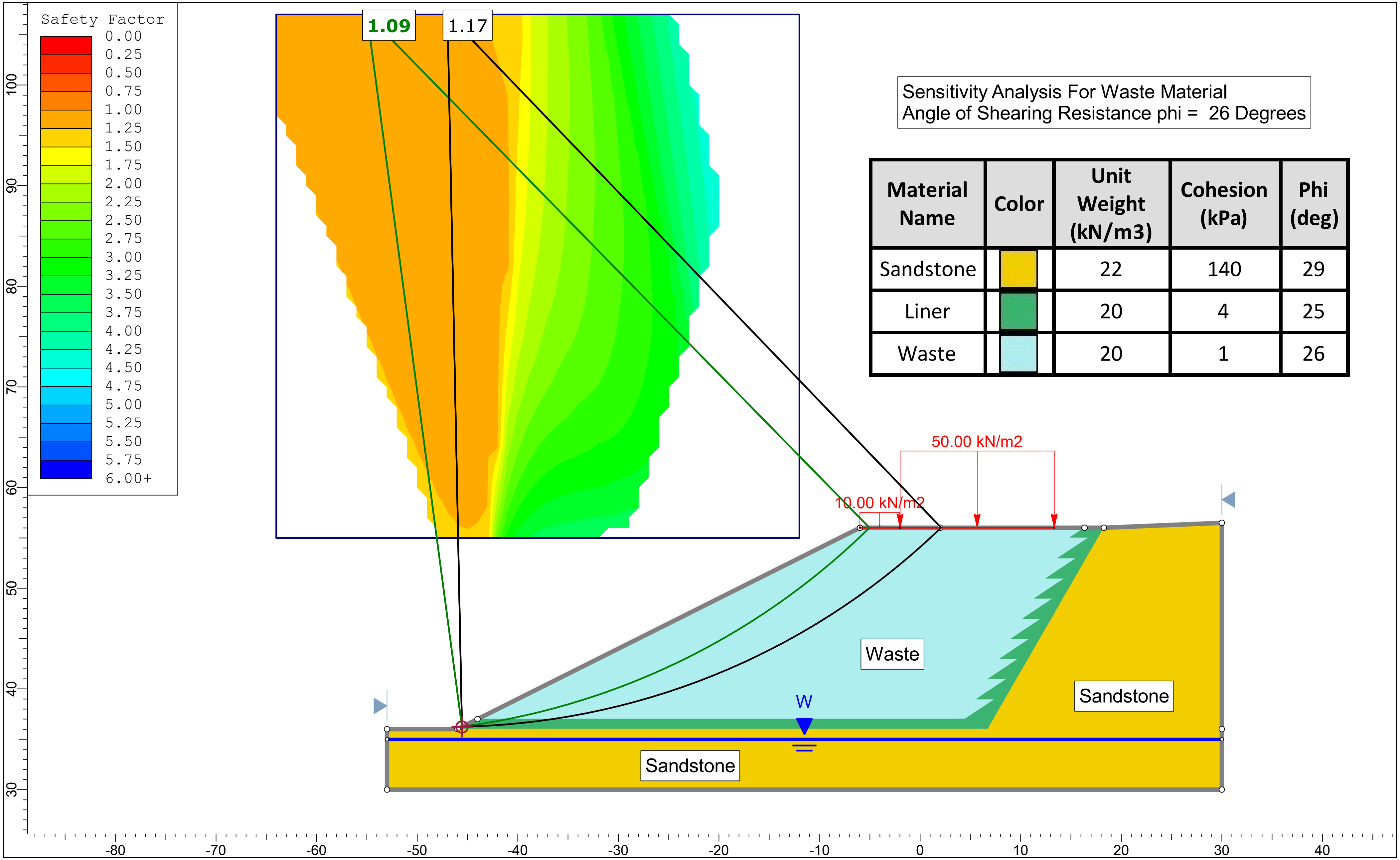
Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sandstone		22	140	29
Liner		20	4	25
Waste		20	1	22

Plot 2 - angle of shearing resistance of 22 degrees



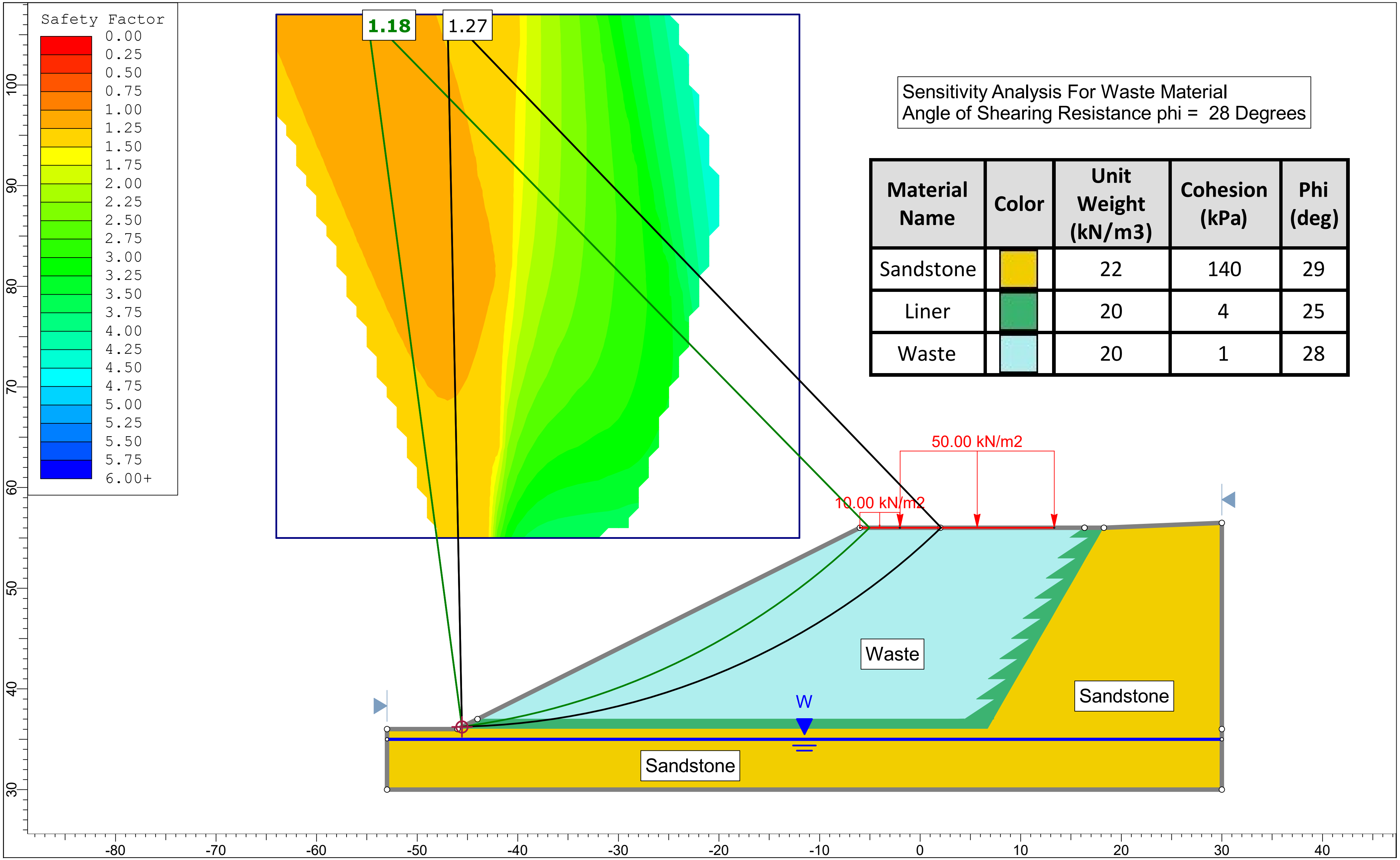
Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sandstone		22	140	29
Liner		20	4	25
Waste		20	1	24

Plot 3 - angle of shearing resistance of 24 degrees



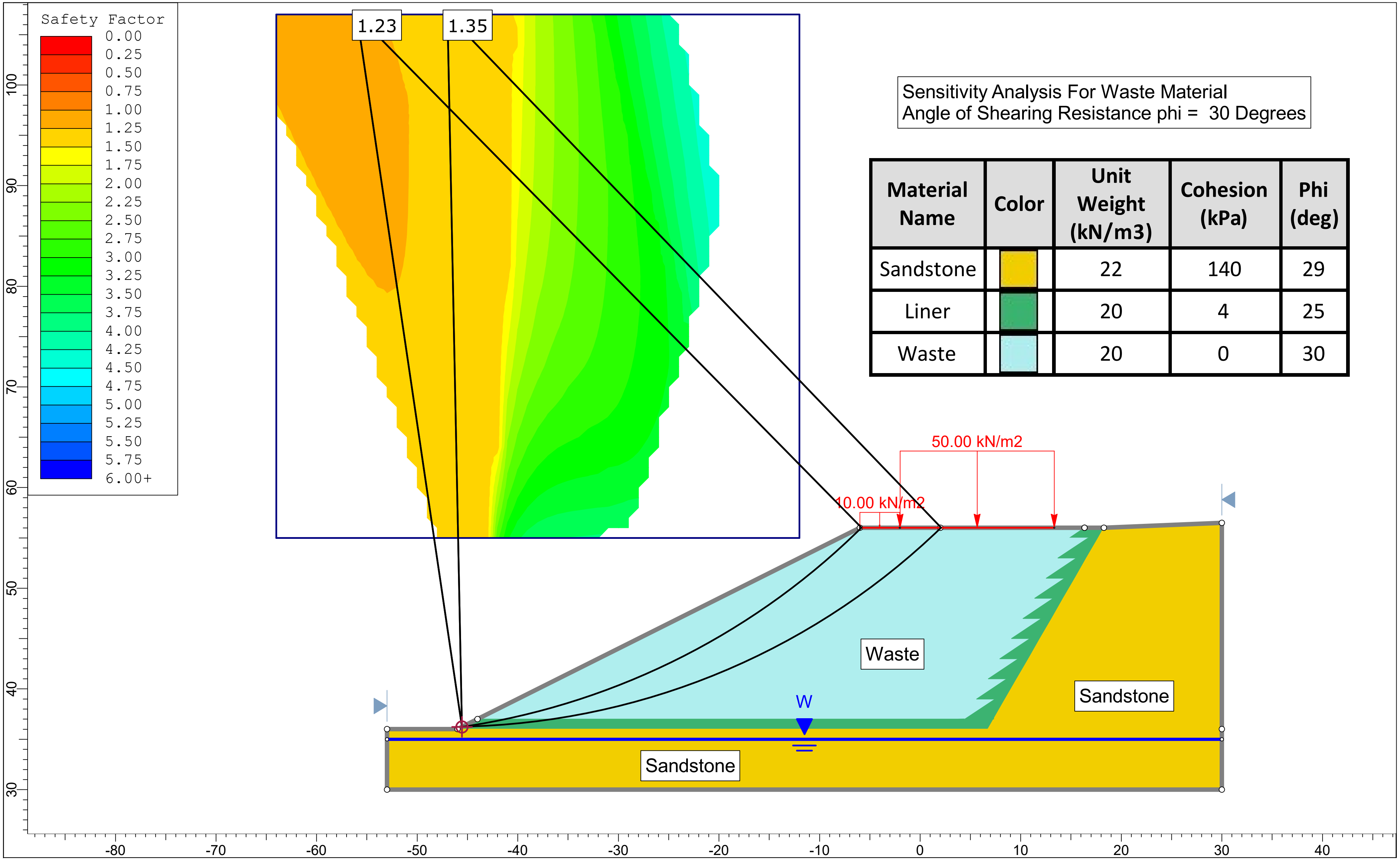
Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sandstone		22	140	29
Liner		20	4	25
Waste		20	1	26

Plot 4 - angle of shearing resistance of 26 degrees



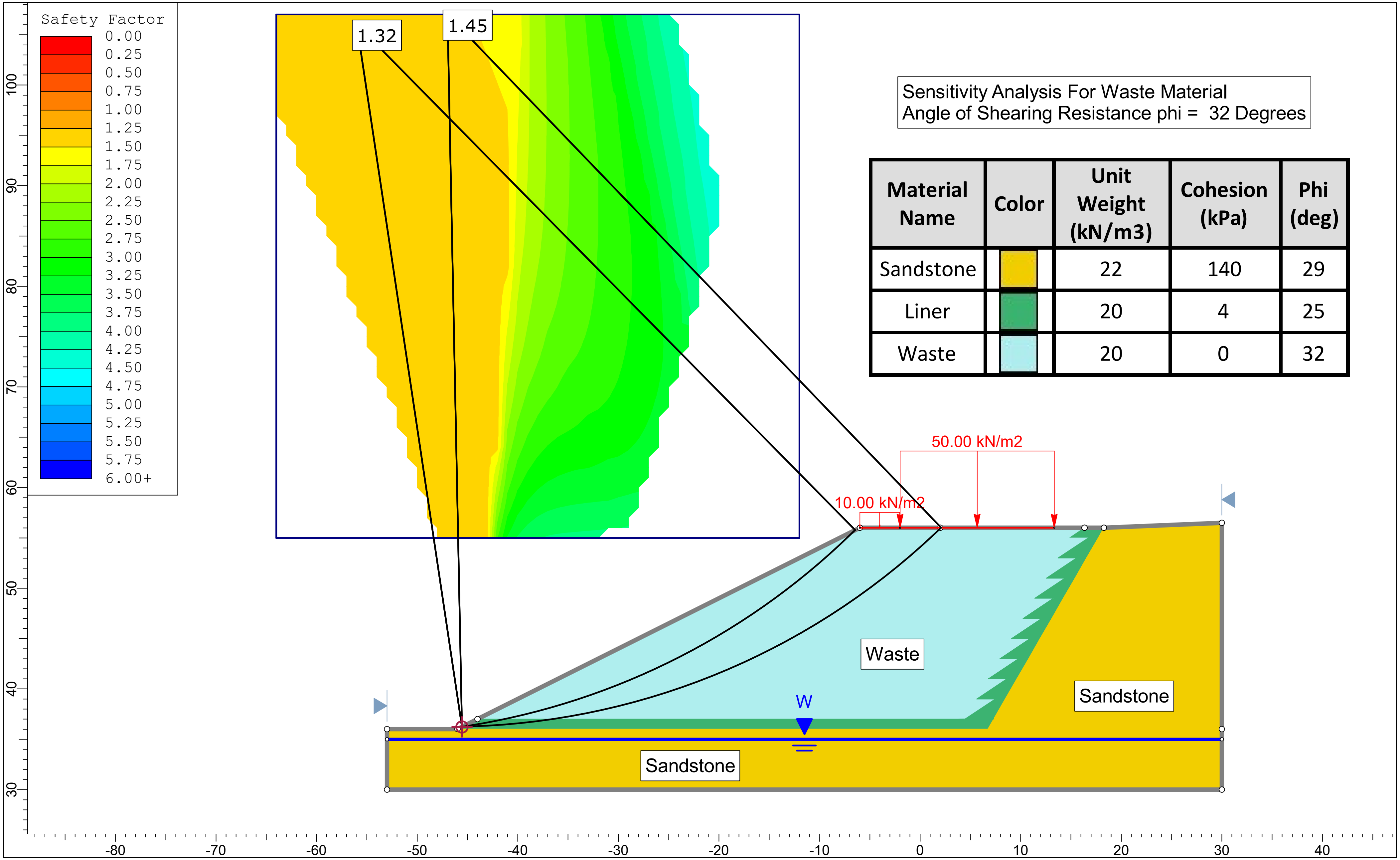
Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sandstone		22	140	29
Liner		20	4	25
Waste		20	1	28

Plot 5 - angle of shearing resistance of 28 degrees



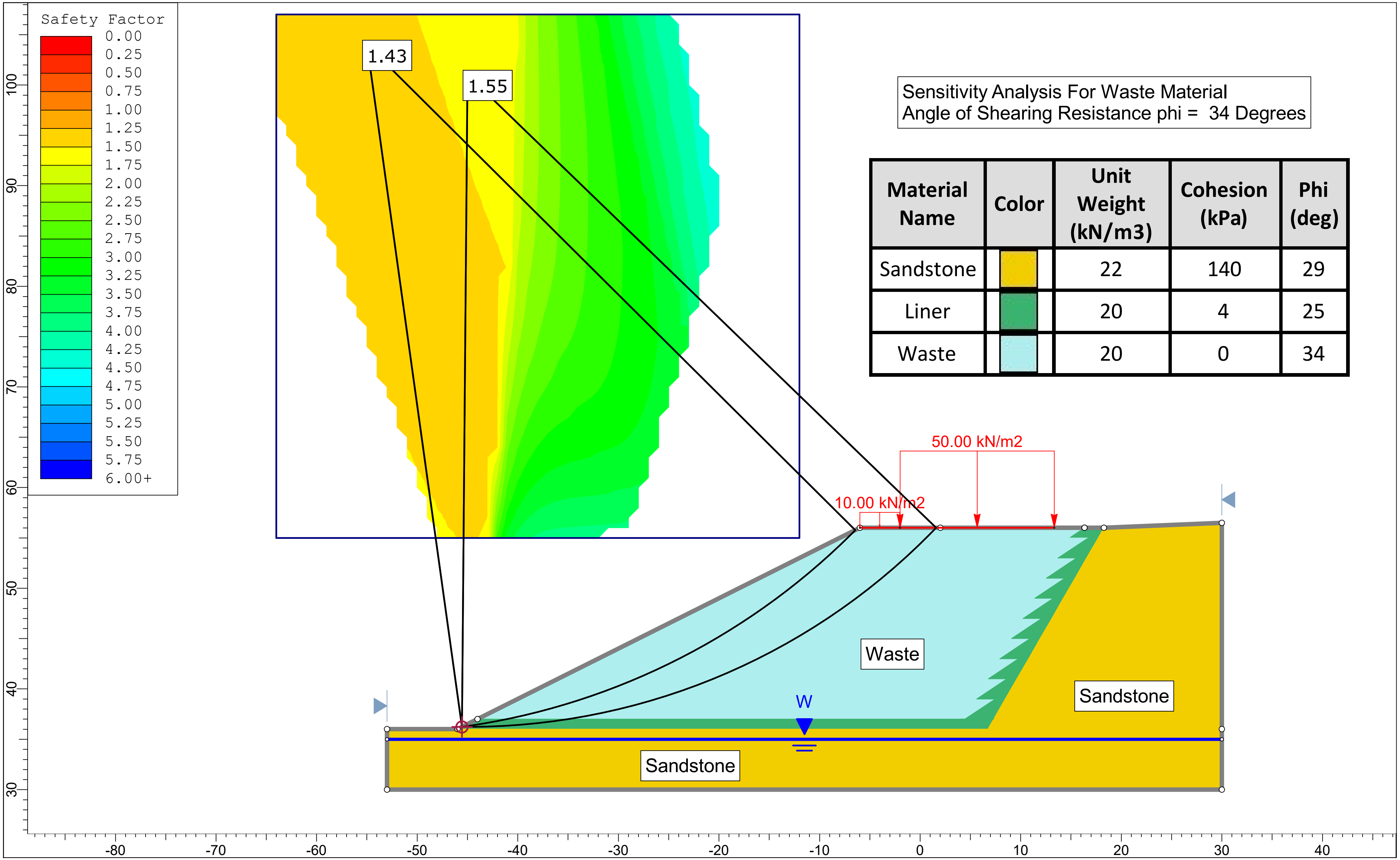
Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sandstone		22	140	29
Liner		20	4	25
Waste		20	0	30

Plot 6 - angle of shearing resistance of 30 degrees



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sandstone		22	140	29
Liner		20	4	25
Waste		20	0	32

Plot 7 - angle of shearing resistance of 32 degrees



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sandstone		22	140	29
Liner		20	4	25
Waste		20	0	34

Plot 8 - angle of shearing resistance of 34 degrees

APPENDIX SRA 3

Groundwater Monitoring Data from Geotechnical Engineering Limited

BROMSBERROW SAND AND GRAVEL QUARRY

FACTUAL REPORT ON WELL INSTALLATION

Prepared for ALLSTONE SAND AND GRAVEL AGGREGATES TRADING COMPANY LTD

Report Ref: 36646

Geotechnical Engineering Ltd
Centurion House, Olympus Park
Quedgeley, Gloucester. GL2 4NF

01452 527743
www.geoeng.co.uk

BROMSBERROW SAND AND GRAVEL QUARRY

FACTUAL REPORT ON WELL INSTALLATION

Prepared for ALLSTONE SAND AND GRAVEL AGGREGATES TRADING COMPANY LTD

Report Ref: 36646

PROJECT: Proposed Quarry Infilling

CONSULTANT: P. E. Duncliffe Limited

VOLUME - VERSION	STATUS	ORIGINATOR	CHECKER	APPROVED	DATE
1 of 1 – A	FINAL	JH	CT	CT	23/09/2021

ORIGINATOR	APPROVER
JOHN HANSON Director	COLIN THOMAS Consultant

The report is not to be used for contractual or engineering purposes unless this sheet is signed and the report designated “Final”.
The report has been prepared for the sole use and reliance by Allstone Sand and Gravel Aggregates Trading Company Limited. GEL accepts no liability as a result of the use or reliance of this report by any other parties.

CONTENTS

REPORT **PAGE**

FIGURES **Nos.**

APPENDICES

1. INTRODUCTION

It is proposed to backfill a quarry at Bromsberrow Heath, Ledbury. Geotechnical Engineering Limited (GEL) was instructed by P. E. Duncliffe Limited acting on behalf of Allstone Sand and Gravel Aggregates Trading Company Limited to install a number of monitoring wells to facilitate groundwater and gas monitoring.

The scope of works and terms and conditions of appointment were specified by the Consultant and GEL correspondence reference T32011-2 dated 4th August 2021. The investigation was carried out under supervision of the Client.

This report describes the investigation and presents the findings.

2. SITE LOCATION

The site is situated off Bell Lane, Bromsberrow Heath, near Ledbury HR8 1NX and may be located by its National Grid co-ordinates SO 7383 3304.

3. WELL INSTALLATION

3.1 Fieldwork

The monitoring wells were installed during the period 31st August to the ** September 2021 and comprised seven boreholes/installations. The borehole locations were selected by the Consultant and set out by this Company and are shown on Figure 1.

Statutory service plans were obtained and the location of the highlighted services identified in the field, prior to commencement of the boreholes. The statutory service plans are provide separately.

The boreholes, referenced BH01, BH01A, BH02, BH02A, BH03, BH04 and BH04A, were formed using a track-mounted Geotechnical P601 Rig. Initially, an inspection pit was hand excavated at each borehole location to a maximum depth of 1.20m to check for buried services.

Open hole drilling techniques were employed from the base of the inspection pit utilising a polycrystalline diamond full face bit with compressed air flush to form a 120mm diameter borehole. Temporary casing was installed to a maximum depth of 3.00m to ensure hole stability.

Boreholes were monitored for groundwater ingress as the borehole was formed. Water levels were also recorded on completion of the borehole and prior to the installation of the monitoring well. The water levels are tabulated below and presented on the installation records, Appendix A.

Borehole	Response Zone (m – bgl)*	Water level (m bgl)*
BH01	20.00-35.00	27.32
BH01A	1.00-20.00	Dry
BH02	20.00 – 35.00	25.84
BH02A	1.00 – 20.00	Dry
BH03	3.00 – 35.00	26.89
BH04	20.00 – 35.00	20.00 – recorded strike
BH04A	1.00 – 20.00	Dry

* m bgl – m below ground level

On completion, gas/water monitoring standpipes were installed in each borehole. The installation consisted of a 50mm ID HDPE slotted tube set in a filter response zone of non-calcareous pea gravel. The installation was sealed above with a bentonite plug and accessed via a valve assembly. As instructed by the Client, the installations were protected at the surface by a lockable stopcock cover set in concrete. Installation details are in Appendix A.

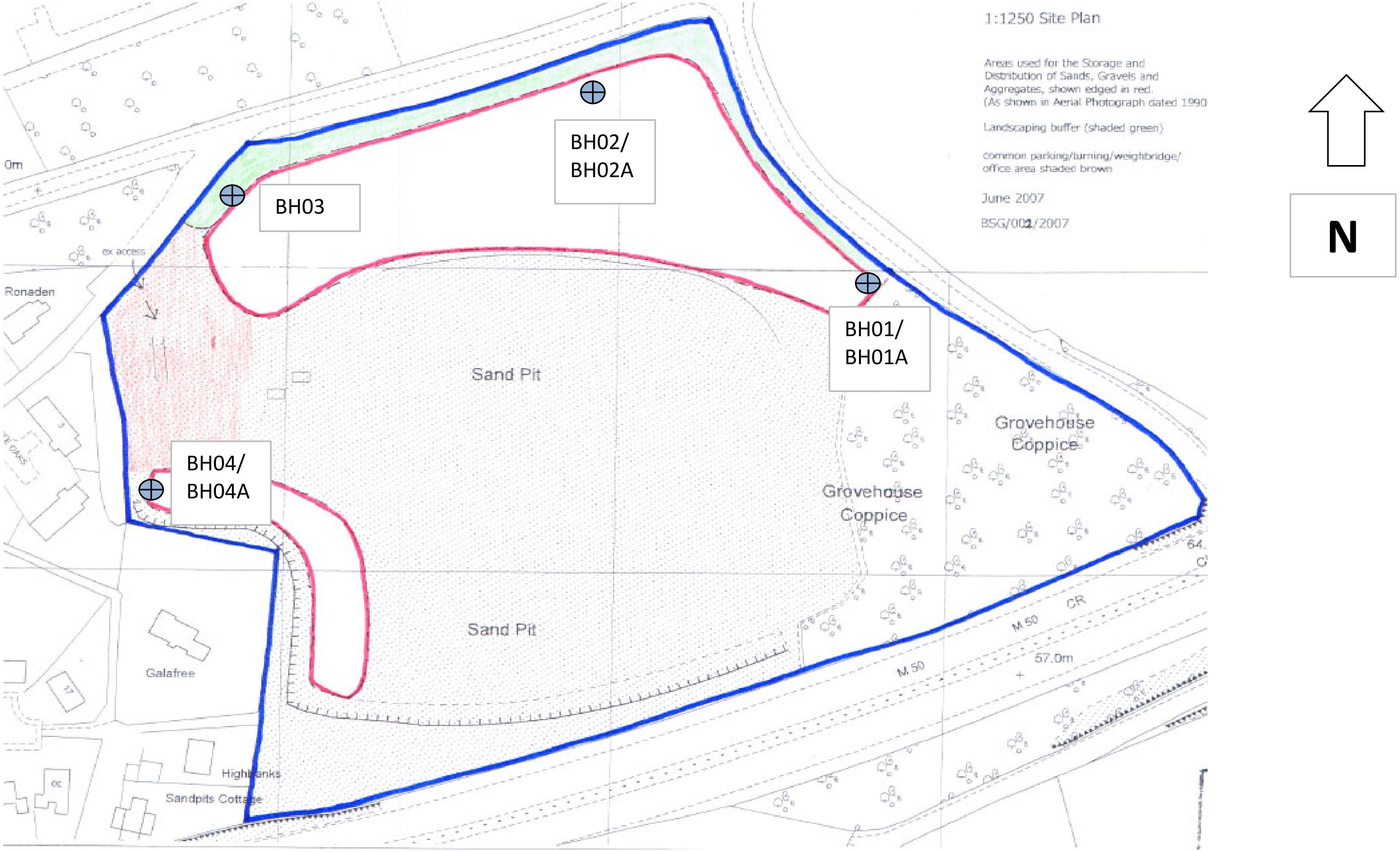
GEOTECHNICAL ENGINEERING LIMITED

Geotechnical Engineering Limited

EXPLORATORY HOLE LOCATION PLAN

CLIENT ALLSTONE SAND AND GRAVEL AGGREGATES TRADING COMPANY LTD

SITE BROMSBERROW SAND AND GRAVEL QUARRY



Plan provided by Consultant
Scale unknown

⊕ Approximate Exploratory hole location

CONTRACT	FIGURE
36646	**1**

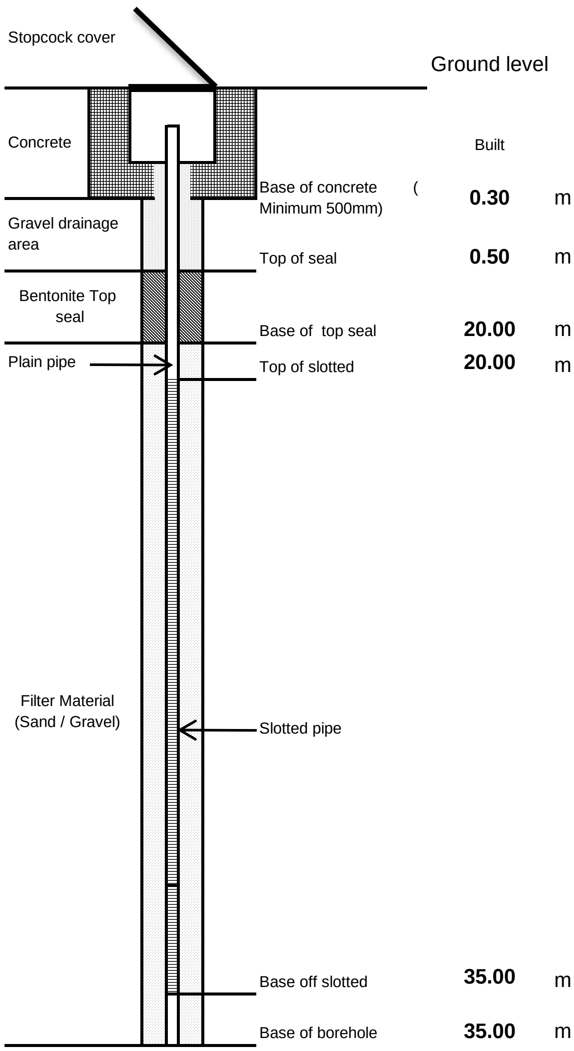
APPENDIX A

INSTALLATION DETAILS

GEOTECHNICAL ENGINEERING LTD

Summary of Standpipe Installation

Schematic Diagram (not to scale)



Installation Details

Standpipe diameter (id)	50	mm
Borehole diameter	120	mm
Slot size	1	mm
Geosock	Yes	
Gas tap	Single	
Filter type	Gravel	
Type of cover	Flush (cast)	
Initial reading	27.32	m
Time of Initial reading	1000	hhmm

	Base (m)	Top (m)
Concrete	0.30	GL
Gravel drainage	0.50	0.30
Borehole seal top	20.00	0.50
Filter zone	35.00	20.00
Plain pipe	20.00	GL
Slotted zone	35.00	20.00
Base of borehole	35.00	

Remarks

11 bags of gravel 13 bags of bentonite pellets 1 balast 1/4 cement

Rig type	Commachio 601	Project Title			
Drilling Crew Details		Bromesberrow Quarry			
Support Operative	Kieran Bryant				
Lead Driller	Nick Lewis-Watkins	Project No	36646		
Site category	Green	Day	Wednesday	Date	September 1, 2021
Engineer	Allstone			Borehole Number	
				BH01	

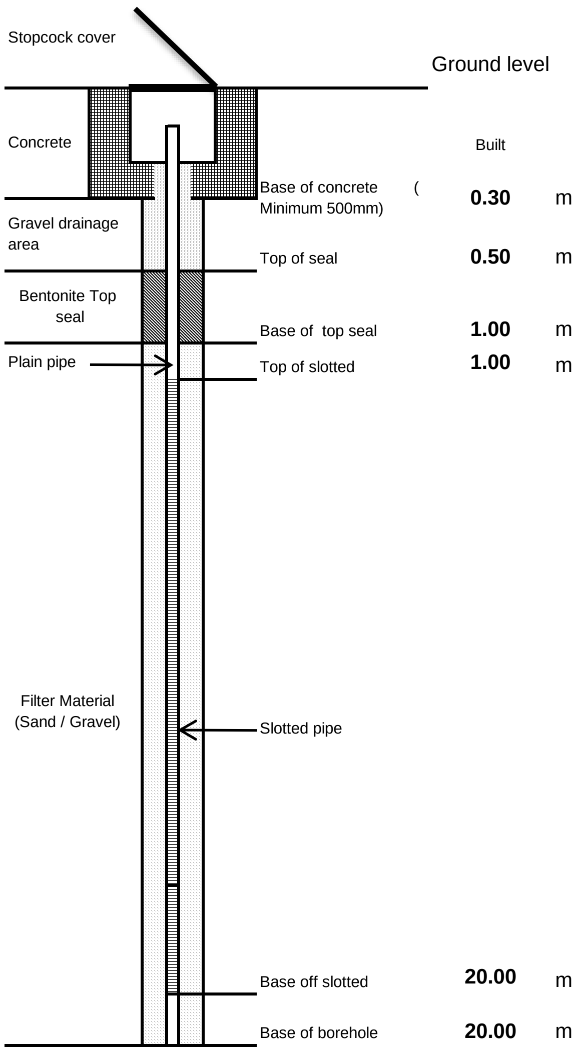
AGS

Produced by KeyLogbook

GEOTECHNICAL ENGINEERING LTD

Summary of Standpipe Installation

Schematic Diagram
(not to scale)



Installation Details

Standpipe diameter (id)	50	mm
Borehole diameter	120	mm
Slot size	1	mm
Geosock	Yes	
Gas tap	Single	
Filter type	Gravel	
Type of cover	Flush (cast)	
Initial reading	Dry	m
Time of Initial reading	1230	hhmm

	Base (m)	Top (m)
Concrete	0.30	GL
Gravel drainage	0.50	0.30
Borehole seal top	1.00	0.50
Filter zone	20.00	1.00
Plain pipe	1.00	GL
Slotted zone	20.00	1.00
Base of borehole	20.00	

Remarks

16 bags of gravel 1 bentonite 1 balast 1/4 cement

Rig type	Commachio 601	**Project Title**			
Drilling Crew Details		Bromesberrow Quarry			
Support Operative	Kieran Bryant				
Lead Driller	Nick Lewis-Watkins	**Project No**		36646	
Site category	Green	**Day**	Monday	**Date**	September 6, 2021
Engineer	Allstone			**Borehole Number**	
				BH01A	

AGS

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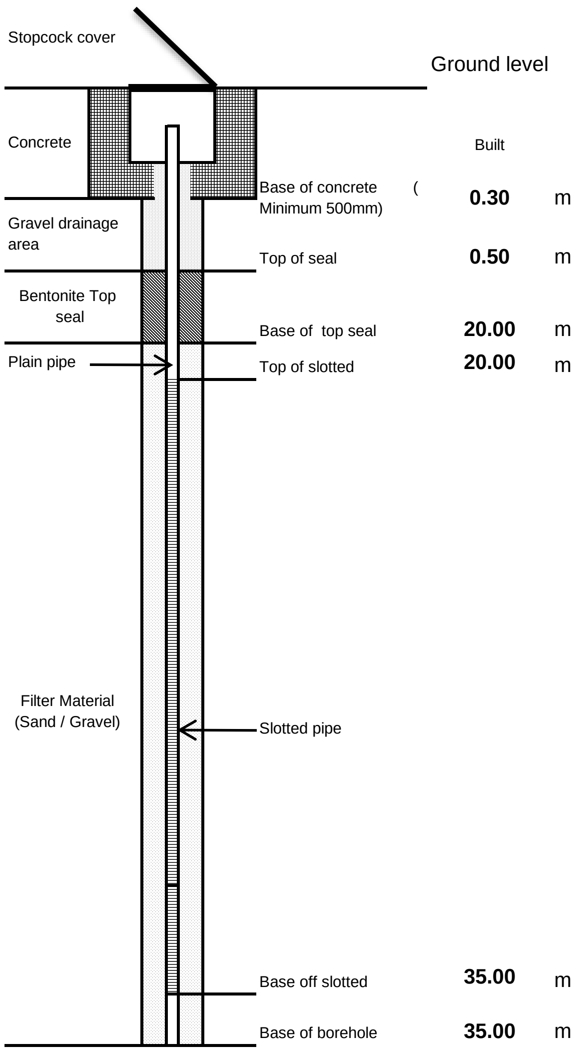
GEOTECHNICAL ENGINEERING LTD

Summary of Standpipe Installation

Schematic Diagram
(not to scale)



Installation Details

Standpipe diameter (id)	50	mm
Borehole diameter	120	mm
Slot size	1	mm
Geosock	Yes	
Gas tap	Single	
Filter type	Gravel	
Type of cover	Flush (cast)	
Initial reading	25.84	m
Time of Initial reading	1700	hhmm

	Base (m)	Top (m)
Concrete	0.30	GL
Gravel drainage	0.50	0.30
Borehole seal top	20.00	0.50
Filter zone	35.00	20.00
Plain pipe	20.00	GL
Slotted zone	35.00	20.00
Base of borehole	35.00	

Remarks

gravel 11 bags 14 bags bentonite 1 balast 1/4 cement

Rig type	Commachio 601	**Project Title**			
Drilling Crew Details		Bromesberrow Quarry			
Support Operative	Kieran Bryant				
Lead Driller	Nick Lewis-Watkins	**Project No**	36646		
Site category	Green	**Day**	Wednesday	**Date**	September 1, 2021
Engineer	Allstone		**Borehole Number**		
			BH02		

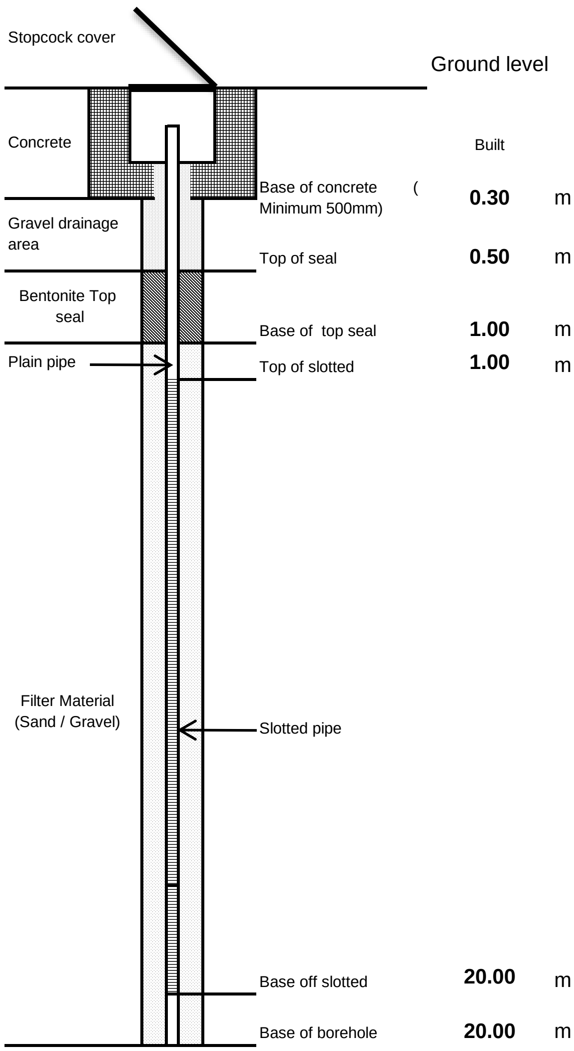
AGS

Produced by KeyLogbook

GEOTECHNICAL ENGINEERING LTD

Summary of Standpipe Installation

Schematic Diagram
(not to scale)



Installation Details

Standpipe diameter (id)	50	mm
Borehole diameter	120	mm
Slot size	1	mm
Geosock	Yes	
Gas tap	Single	
Filter type	Gravel	
Type of cover	Flush (cast)	
Initial reading	Dry	m
Time of Initial reading	1015	hhmm

	Base (m)	**Top (m)**
Concrete	0.30	GL
Gravel drainage	0.50	0.30
Borehole seal top	1.00	0.50
Filter zone	20.00	1.00
Plain pipe	1.00	GL
Slotted zone	20.00	1.00
Base of borehole	20.00	

Remarks

17 bags gravel 1 bentonite pellets 1 balast 1/4 cement

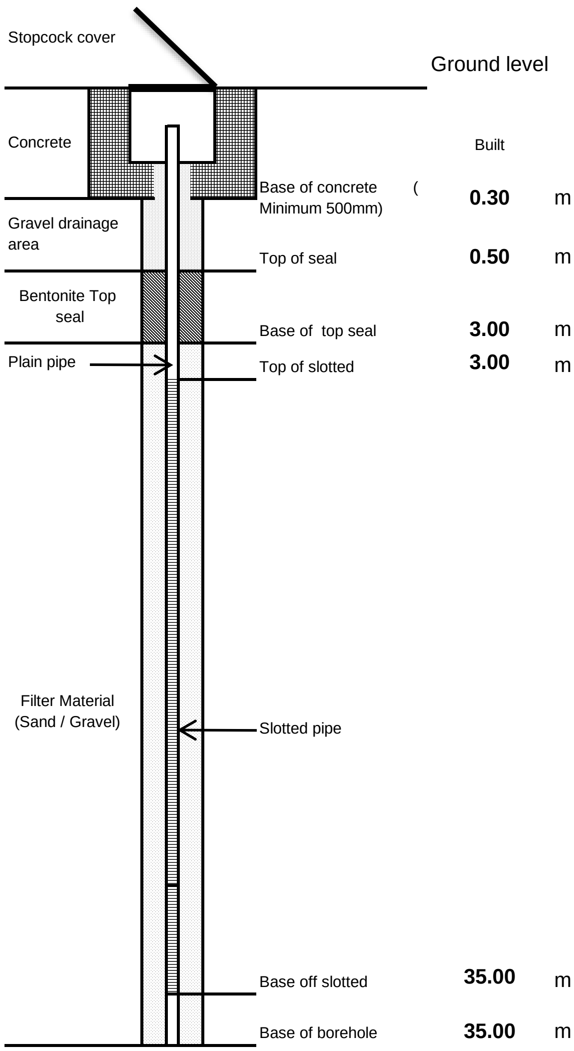
Rig type	Commachio 601	**Project Title**			
Drilling Crew Details		Bromesberrow Quarry			
Support Operative	Kieran Bryant				
Lead Driller	Nick Lewis-Watkins	**Project No**		36646	
Site category	Green	**Day**	Monday	**Date**	September 6, 2021
Engineer	Allstone			**Borehole Number**	
				BH02A	

AGS

GEOTECHNICAL ENGINEERING LTD

Summary of Standpipe Installation

Schematic Diagram
(not to scale)



Installation Details

Standpipe diameter (id)	50	mm
Borehole diameter	120	mm
Slot size	1	mm
Geosock	Yes	
Gas tap	Single	
Filter type	Gravel	
Type of cover	Flush (cast)	
Initial reading	26.89	m
Time of Initial reading	1530	hhmm

	Base (m)	Top (m)
Concrete	0.30	GL
Gravel drainage	0.50	0.30
Borehole seal top	3.00	0.50
Filter zone	35.00	3.00
Plain pipe	3.00	GL
Slotted zone	35.00	3.00
Base of borehole	35.00	

Remarks

27 bags of gravel 3 bentonite pellets 1 balast 1/4 cement

Rig type	Commachio 601	**Project Title**			
Drilling Crew Details		Bromesberrow Quarry			
Support Operative	Kieran Bryant				
Lead Driller	Nick Lewis-Watkins	**Project No**		36646	
Site category	Green	**Day**	Friday	**Date**	September 3, 2021
Engineer	Allstone			**Borehole Number**	
				BH03	

AGS

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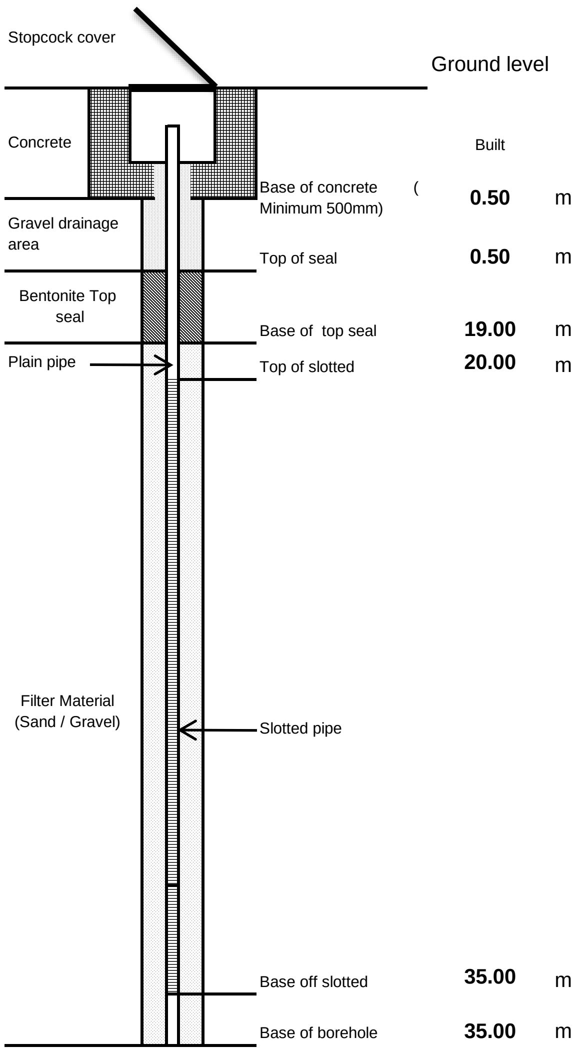
GEOTECHNICAL ENGINEERING LTD

Summary of Standpipe Installation

Schematic Diagram
(not to scale)



Installation Details

Standpipe diameter (id)	50	mm
Borehole diameter	154	mm
Slot size	1	mm
Geosock	Yes	
Gas tap	Single	
Filter type	Gravel	
Type of cover	None	
Initial reading	-	m
Time of Initial reading	1450	hhmm

	Base (m)	Top (m)
Concrete	0.50	GL
Gravel drainage	0.50	0.50
Borehole seal top	19.00	0.50
Filter zone	35.00	19.00
Plain pipe	20.00	GL
Slotted zone	35.00	20.00
Base of borehole	35.00	

Remarks

x18 gravel x16 bentonite

Rig type	Comacchio 601
Drilling Crew Details	
Support Operative	Tom Bowen
Lead Driller	Chris Jones
Site category	Yellow
Engineer	Allstone

Project Title

Bromesberrow Quarry

Project No	36646		
Day	Thursday	**Date**	September 2, 2021
Borehole Number	BH04		

AGS

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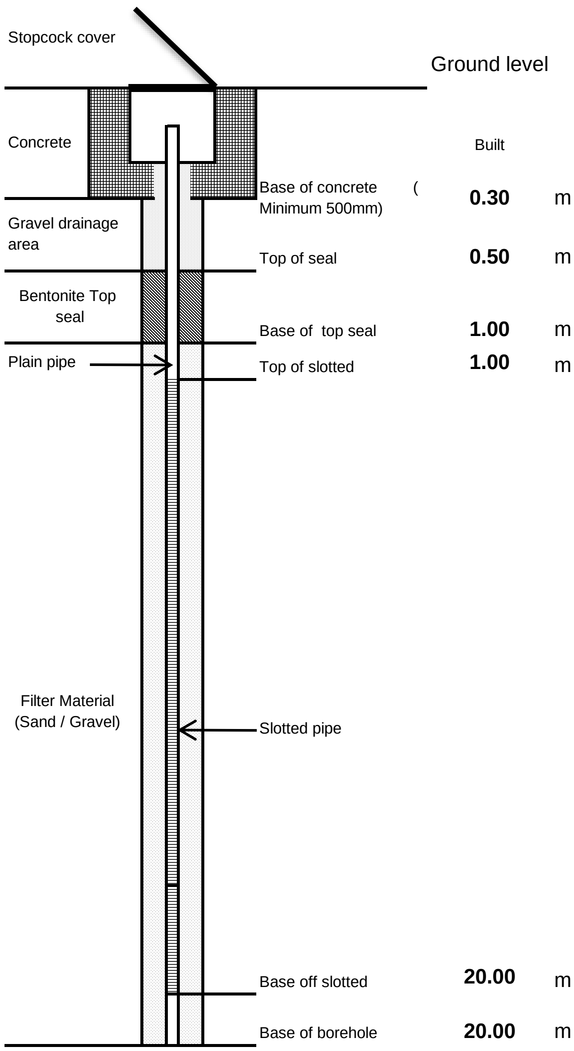
GEOTECHNICAL ENGINEERING LTD

Summary of Standpipe Installation

Schematic Diagram
(not to scale)



Installation Details

Standpipe diameter (id)	50	mm
Borehole diameter	120	mm
Slot size	1	mm
Geosock	Yes	
Gas tap	Single	
Filter type	Gravel	
Type of cover	Flush (cast)	
Initial reading	Dry	m
Time of Initial reading	1650	hhmm

	Base (m)	Top (m)
Concrete	0.30	GL
Gravel drainage	0.50	0.30
Borehole seal top	1.00	0.50
Filter zone	20.00	1.00
Plain pipe	1.00	GL
Slotted zone	20.00	1.00
Base of borehole	20.00	

Remarks

16 bags of gravel 1 bag of bentonite 1 balast 1/4 cement

Rig type	Commachio 601	**Project Title**			
Drilling Crew Details		Bromesberrow Quarry			
Support Operative	Kieran Bryant				
Lead Driller	Nick Lewis-Watkins	**Project No**		36646	
Site category	Green	**Day**	Monday	**Date**	September 6, 2021
Engineer	Allstone			**Borehole Number**	
				BH04A	

AGS

Produced by KeyLogbook

Geotechnical Engineering Limited

GAS AND GROUNDWATER LEVELS

CLIENT ALLSTONE SAND AND GRAVEL

SITE BROMSBERROW QUARRY - NORTH

borehole /trial pit no.	date & time	barometric pressure (mb)	carbon dioxide (%)	methane (%)	oxygen (%)	LEL (%)	hydrogen sulphide (ppm)	gas flow (ltr/hr)	temperature (°C)	water level (m - bgl)
BH01	15/03/22 12:15:00									26.74
BH01A	15/03/22 11:30:00	1015						4.7	11	
BH01A	15/03/22 11:31:00							4.7		
BH01A	15/03/22 11:32:00							4.8		
BH01A	15/03/22 11:33:00							4.8		
BH01A	15/03/22 11:34:00							4.8		
BH01A	15/03/22 11:35:00		2.1	0.0	18.9	0.0	0			
BH01A	15/03/22 11:36:00		2.1	0.0	18.9	0.0	0			
BH01A	15/03/22 11:37:00		2.1	0.0	18.9	0.0	0			
BH01A	15/03/22 11:38:00		2.1	0.0	18.9	0.0	0			
BH01A	15/03/22 11:39:00		2.2	0.0	18.8	0.0	0			
BH01A	15/03/22 11:40:00		2.2	0.0	18.8	0.0	0			
BH01A	15/03/22 11:41:00		2.2	0.0	18.8	0.0	0			
BH01A	15/03/22 11:42:00		2.2	0.0	18.8	0.0	0			
BH01A	15/03/22 11:43:00		2.2	0.0	18.8	0.0	0			
BH01A	15/03/22 11:44:00		2.2	0.0	18.8	0.0	0			
BH01A	15/03/22 11:45:00									DRY
BH02	15/03/22 11:15:00									25.25
BH02A	15/03/22 10:30:00	1014						12.0	9	
BH02A	15/03/22 10:31:00							12.0		
BH02A	15/03/22 10:32:00							11.8		
BH02A	15/03/22 10:33:00							11.8		
BH02A	15/03/22 10:34:00							11.7		
BH02A	15/03/22 10:35:00		4.4	0.0	17.0	0.0	0			
BH02A	15/03/22 10:36:00		4.4	0.0	17.0	0.0	0			
BH02A	15/03/22 10:37:00		4.4	0.0	17.0	0.0	0			

general remarks:

# denotes result exceeding capacity of gas monitoring equipment

50MM Piezo installed with Gas Tap

CONTRACT	CHECKED
36710	**JH**

Geotechnical Engineering Limited

GAS AND GROUNDWATER LEVELS

CLIENT ALLSTONE SAND AND GRAVEL

SITE BROMSBERROW QUARRY - NORTH

borehole /trial pit no.	date & time	barometric pressure (mb)	carbon dioxide (%)	methane (%)	oxygen (%)	LEL (%)	hydrogen sulphide (ppm)	gas flow (ltr/hr)	temperature (°C)	water level (m - bgl)
BH02A	15/03/22 10:38:00		4.4	0.0	17.0	0.0	0			
BH02A	15/03/22 10:39:00		4.4	0.0	17.0	0.0	0			
BH02A	15/03/22 10:40:00		4.4	0.0	17.0	0.0	0			
BH02A	15/03/22 10:41:00		4.4	0.0	17.0	0.0	0			
BH02A	15/03/22 10:42:00		4.4	0.0	17.0	0.0	0			
BH02A	15/03/22 10:43:00		4.4	0.0	17.0	0.0	0			
BH02A	15/03/22 10:44:00		4.4	0.0	17.0	0.0	0			
BH02A	15/03/22 10:45:00									DRY
BH03	15/03/22 09:30:00	1016						12.3	7	
BH03	15/03/22 09:31:00							12.3		
BH03	15/03/22 09:32:00							12.2		
BH03	15/03/22 09:33:00							12.4		
BH03	15/03/22 09:34:00							12.4		
BH03	15/03/22 09:35:00		0.0	0.0	19.9	0.0	0			
BH03	15/03/22 09:36:00		0.0	0.0	19.9	0.0	0			
BH03	15/03/22 09:37:00		0.1	0.0	19.9	0.0	0			
BH03	15/03/22 09:38:00		0.1	0.0	19.9	0.0	0			
BH03	15/03/22 09:39:00		0.2	0.0	19.8	0.0	0			
BH03	15/03/22 09:40:00		0.2	0.0	19.8	0.0	0			
BH03	15/03/22 09:41:00		0.2	0.0	19.8	0.0	0			
BH03	15/03/22 09:42:00		0.3	0.0	19.7	0.0	0			
BH03	15/03/22 09:43:00		0.3	0.0	19.7	0.0	0			
BH03	15/03/22 09:44:00		0.3	0.0	19.7	0.0	0			
BH03	15/03/22 09:45:00									21.55
BH04	15/03/22 09:20:00									18.02
BH04A	15/03/22 08:30:00	1017						0.0	6	

general remarks:

# denotes result exceeding capacity of gas monitoring equipment

50MM Piezo installed with Gas Tap

CONTRACT	CHECKED
36710	**JH**

Geotechnical Engineering Limited

GAS AND GROUNDWATER LEVELS

CLIENT ALLSTONE SAND AND GRAVEL

SITE BROMSBERROW QUARRY - NORTH

borehole /trial pit no.	date & time	barometric pressure (mb)	carbon dioxide (%)	methane (%)	oxygen (%)	LEL (%)	hydrogen sulphide (ppm)	gas flow (ltr/hr)	temperature (°C)	water level (m - bgl)
BH04A	15/03/22 08:31:00							0.0		
BH04A	15/03/22 08:32:00							0.0		
BH04A	15/03/22 08:33:00							0.0		
BH04A	15/03/22 08:34:00							0.0		
BH04A	15/03/22 08:35:00		4.5	0.0	16.0	0.0	0			
BH04A	15/03/22 08:36:00		4.5	0.0	15.9	0.0	0			
BH04A	15/03/22 08:37:00		4.5	0.0	15.9	0.0	0			
BH04A	15/03/22 08:38:00		4.5	0.0	15.9	0.0	0			
BH04A	15/03/22 08:39:00		4.5	0.0	15.9	0.0	0			
BH04A	15/03/22 08:40:00		4.5	0.0	15.9	0.0	0			
BH04A	15/03/22 08:41:00		4.5	0.0	15.9	0.0	0			
BH04A	15/03/22 08:42:00		4.5	0.0	15.9	0.0	0			
BH04A	15/03/22 08:43:00		4.5	0.0	15.9	0.0	0			
BH04A	15/03/22 08:44:00		4.5	0.0	15.9	0.0	0			
BH04A	15/03/22 08:45:00									DRY

general remarks:

# denotes result exceeding capacity of gas monitoring equipment

50MM Piezo installed with Gas Tap

CONTRACT	CHECKED
36710	**JH**

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Watford,
Herts,
WD18 8YS

t: 01923 225404
f: 01923 237404
e: reception@i2analytical.com

Analytical Report Number : 22-46009

Project / Site name:	Bromsberrow Quarry	**Samples received on:**	16/03/2022
Your job number:	36710	**Samples instructed on/ Analysis started on:**	16/03/2022
Your order number:		**Analysis completed by:**	23/03/2022
Report Issue Number:	1	**Report issued on:**	23/03/2022
Samples Analysed:	4 water samples		

Signed: Izabela Wójcik

Izabela Wójcik
Technical Reviewer (Reporting Team)
For & on behalf of i2 Analytical Ltd.

Standard Geotechnical, Asbestos and Chemical Testing Laboratory located at: ul. Pionierów 39, 41 -711 Ruda Śląska, Poland.

Accredited tests are defined within the report, opinions and interpretations expressed herein are outside the scope of accreditation.

Standard sample disposal times, unless otherwise agreed with the laboratory, are :

soils - 4 weeks from reporting
leachates - 2 weeks from reporting
waters - 2 weeks from reporting
asbestos - 6 months from reporting

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Any assessments of compliance with specifications are based on actual analytical results with no contribution from uncertainty of measurement.
Application of uncertainty of measurement would provide a range within which the true result lies.
An estimate of measurement uncertainty can be provided on request.

UKAS TESTING 4041

Analytical Environmental Science

Analytical Report Number: 22-46009
Project / Site name: Bromsberrow Quarry

Lab Sample Number				2207320	2207321	2207322	2207323
Sample Reference				BH01	BH02	BH03	BH04
Sample Number				None Supplied	None Supplied	None Supplied	None Supplied
Depth (m)				26.74	25.25	21.55	18.02
Date Sampled				15/03/2022	15/03/2022	15/03/2022	15/03/2022
Time Taken				1215	1115	1015	0920
Analytical Parameter (Water Analysis)	**Units**	**Limit of detection**	**Accreditation Status**				
General Inorganics							
pH	pH Units	N/A	ISO 17025	7.6	7.5	7.3	7
Electrical Conductivity at 20 °C	µS/cm	10	ISO 17025	500	500	610	370
Sulphate as SO4	mg/l	0.045	ISO 17025	27.1	39.6	51.2	34.9
Chloride	mg/l	0.15	ISO 17025	110	91	140	72
Ammoniacal Nitrogen as N	µg/l	15	ISO 17025	< 15	< 15	< 15	< 15
Total Organic Carbon (TOC)	mg/l	0.1	ISO 17025	4.59	4.4	4.5	4.09
Nitrate as N	mg/l	0.01	ISO 17025	11.6	13.3	6.72	7.29
Nitrate as NO3	mg/l	0.05	ISO 17025	51.3	58.8	29.8	32.3
Nitrite as N	µg/l	1	ISO 17025	< 1.0	< 1.0	< 1.0	3.4
Nitrite as NO2	µg/l	5	ISO 17025	< 5.0	< 5.0	< 5.0	11
Alkalinity as CaCO3	mg/l	3	ISO 17025	32	21	18	4
Heavy Metals / Metalloids							
Iron (dissolved)	mg/l	0.004	ISO 17025	0.014	0.035	0.005	0.01
Calcium (total)	mg/l	0.012	ISO 17025	49	56	53	38
Magnesium (total)	mg/l	0.005	ISO 17025	7.2	8.9	8.4	6.3
Potassium (total)	mg/l	0.025	ISO 17025	5	7.6	8.1	10
Sodium (total)	mg/l	0.01	ISO 17025	36	33	60	20
Cadmium (dissolved)	µg/l	0.02	ISO 17025	0.03	0.03	0.04	< 0.02
Chromium (dissolved)	µg/l	0.2	ISO 17025	1.3	1.3	1.5	1.1
Copper (dissolved)	µg/l	0.5	ISO 17025	2.6	2.1	3.4	2.7
Lead (dissolved)	µg/l	0.2	ISO 17025	< 0.2	< 0.2	< 0.2	0.2
Manganese (dissolved)	µg/l	0.05	ISO 17025	4.2	13	23	170
Nickel (dissolved)	µg/l	0.5	ISO 17025	5.1	7.2	13	11
Zinc (dissolved)	µg/l	0.5	ISO 17025	20	14	52	8

U/S = Unsuitable Sample   I/S = Insufficient Sample

Analytical Report Number : 22-46009
Project / Site name: Bromsberrow Quarry

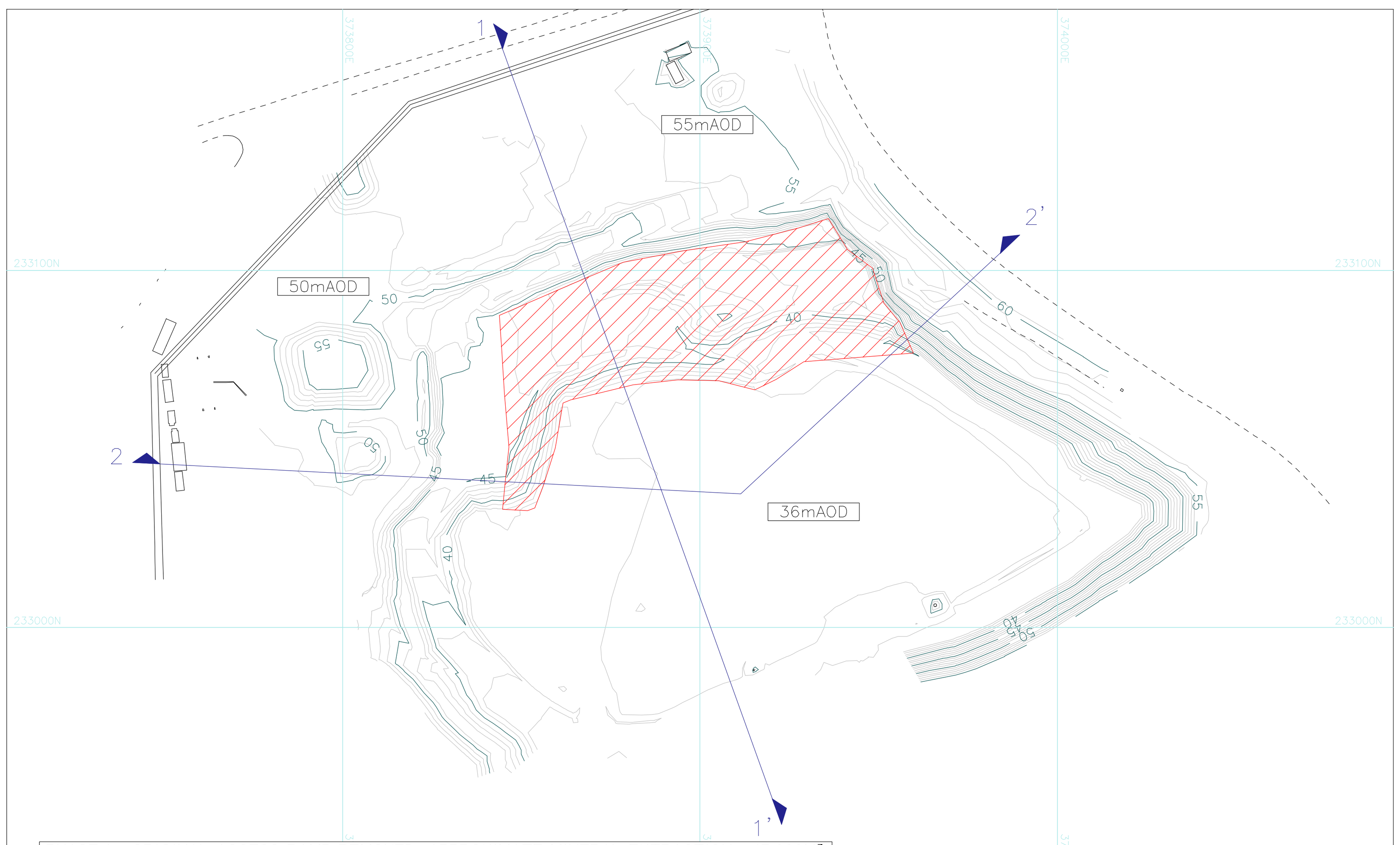
Water matrix abbreviations:
Surface Water (SW) Potable Water (PW) Ground Water (GW) Process Waters (PrW) Final Sewage Effluent (FSE) Landfill Leachate (LL)

Analytical Test Name	Analytical Method Description	Analytical Method Reference	Method number	Wet / Dry Analysis	Accreditation Status
Metals in water by ICP-OES (total)	Determination of metals in water by acidification followed by ICP-OES. Accredited matrices: SW PW GW, PrW (Al, Fe, Cu, Zn).	In-house method based on MEWAM 2006 Methods for the Determination of Metals in Soil.	L039-PL	W	ISO 17025
Metals in water by ICP-OES (dissolved)	Determination of metals in water by acidification followed by ICP-OES. Accredited Matrices SW, GW, PW, PrW.(Al, Cu,Fe,Zn).	In-house method based on MEWAM 2006 Methods for the Determination of Metals in Soil.	L039-PL	W	ISO 17025
Metals in water by ICP-MS (dissolved)	Determination of metals in water by acidification followed by ICP-MS. Accredited Matrices: SW, GW, PW except B=SW,GW, Hg=SW,PW, Al=SW,PW.	In-house method based on USEPA Method 6020 & 200.8 "for the determination of trace elements in water by ICP-MS.	L012-PL	W	ISO 17025
Electrical conductivity at 20oC of water	Determination of electrical conductivity in water by electrometric measurement. Accredited Matrices SW, GW, PW	In-house method	L031-PL	W	ISO 17025
Nitrite in water	Determination of nitrite in water by addition of sulphanilamide and NED followed by discrete analyser (colorimetry).Accredited matrices SW, GW, PW.	In-house method based on Examination of Water and Wastewater 20th Edition: Clesceri, Greenberg & Eaton	L082-PL	W	ISO 17025
Nitrate in water	Determination of nitrate by reaction with sodium salicylate and colorimetry. Accredited matrices SW, GW, PW	In-house method based on Examination of Water and Wastewatern & Polish Standard Method PN-82/C-04579.08,	L078-PL	W	ISO 17025
Sulphate in water	Determination of sulphate in water after filtration by acidification followed by ICP-OES. Accredited Matrices SW, GW, PW.	In-house method based on MEWAM 2006 Methods for the Determination of Metals in Soil.	L039-PL	W	ISO 17025
Total organic carbon in water	Determination of dissolved organic carbon in water by TOC/DOC NDIR analyser. Accredited matrices: SW PW GW.	In-house method based on Examination of Water and Wastewater 20th Edition: Clesceri, Greenberg & Eaton	L037-PL	W	ISO 17025
Ammoniacal Nitrogen as N in water	Determination of Ammonium/Ammonia/ Ammoniacal Nitrogen by the discrete analyser (colorimetric) salicylate/nitroprusside method. Accredited matrices SW, GW, PW.	In-house method based on Examination of Water and Wastewater 20th Edition: Clesceri, Greenberg & Eaton	L082-PL	W	ISO 17025
Nitrite as N in water	Determination of nitrite in water by addition of sulphanilamide and NED followed by discrete analyser (colorimetry). Accredited matrices SW, GW, PW.	In-house method based on Examination of Water and Wastewater 20th Edition: Clesceri, Greenberg & Eaton	L082-PL	W	ISO 17025
Nitrate as N in water	Determination of nitrate by reaction with sodium salicylate and colorimetry. Accredited matrices SW, GW, PW.	In-house method based on Examination of Water and Wastewatern & Polish Standard Method PN-82/C-04579.08,	L078-PL	W	ISO 17025
pH at 20oC in water (automated)	Determination of pH in water by electrometric measurement. Accredited matrices: SW PW GW	In house method.	L099-PL	W	ISO 17025
Chloride in water	Determination of Chloride (diissolved) colorimetrically by discrete analyser.	In house based on MEWAM Method ISBN 0117516260. Accredited matrices: SW, PW, GW.	L082-PL	W	ISO 17025
Alkalinity in Water (by discreet analyser)	Determination of Alkalinity by discreet analyser (colorimetry). Accredited matrices: SW, PW, GW.	In house method based on MEWAM & USEPA Method 310.2.	L082-PL	W	ISO 17025

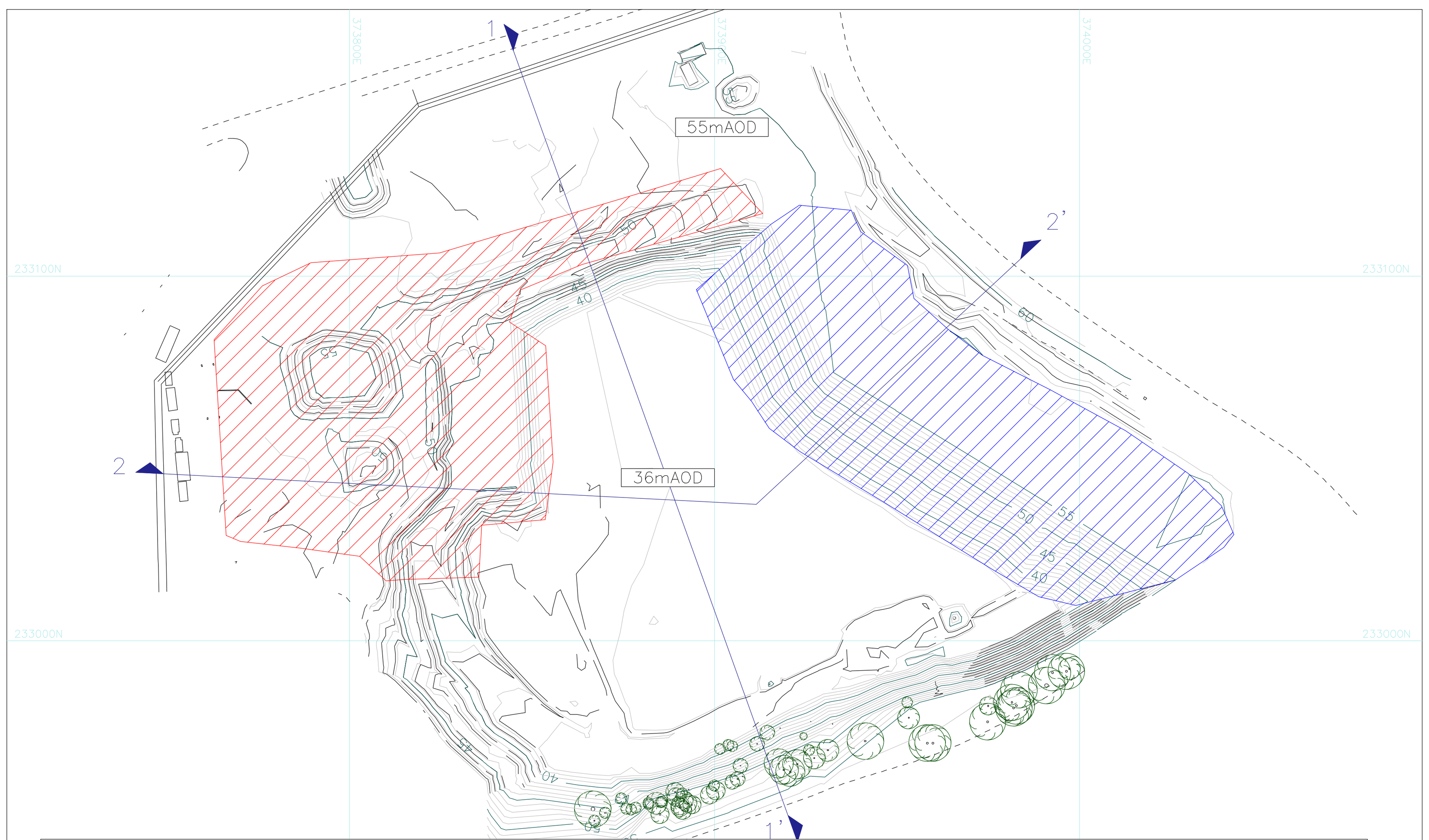
For method numbers ending in 'UK' analysis have been carried out in our laboratory in the United Kingdom.
For method numbers ending in 'PL' analysis have been carried out in our laboratory in Poland.
Soil analytical results are expressed on a dry weight basis. Where analysis is carried out on as-received the results obtained are multiplied by a moisture correction factor that is determined gravimetrically using the moisture content which is carried out at a maximum of 30oC.

Unless otherwise indicated, site information, order number, project number, sampling date, time, sample reference and depth are provided by the client. The instructed on date indicates the date on which this information was provided to the laboratory.

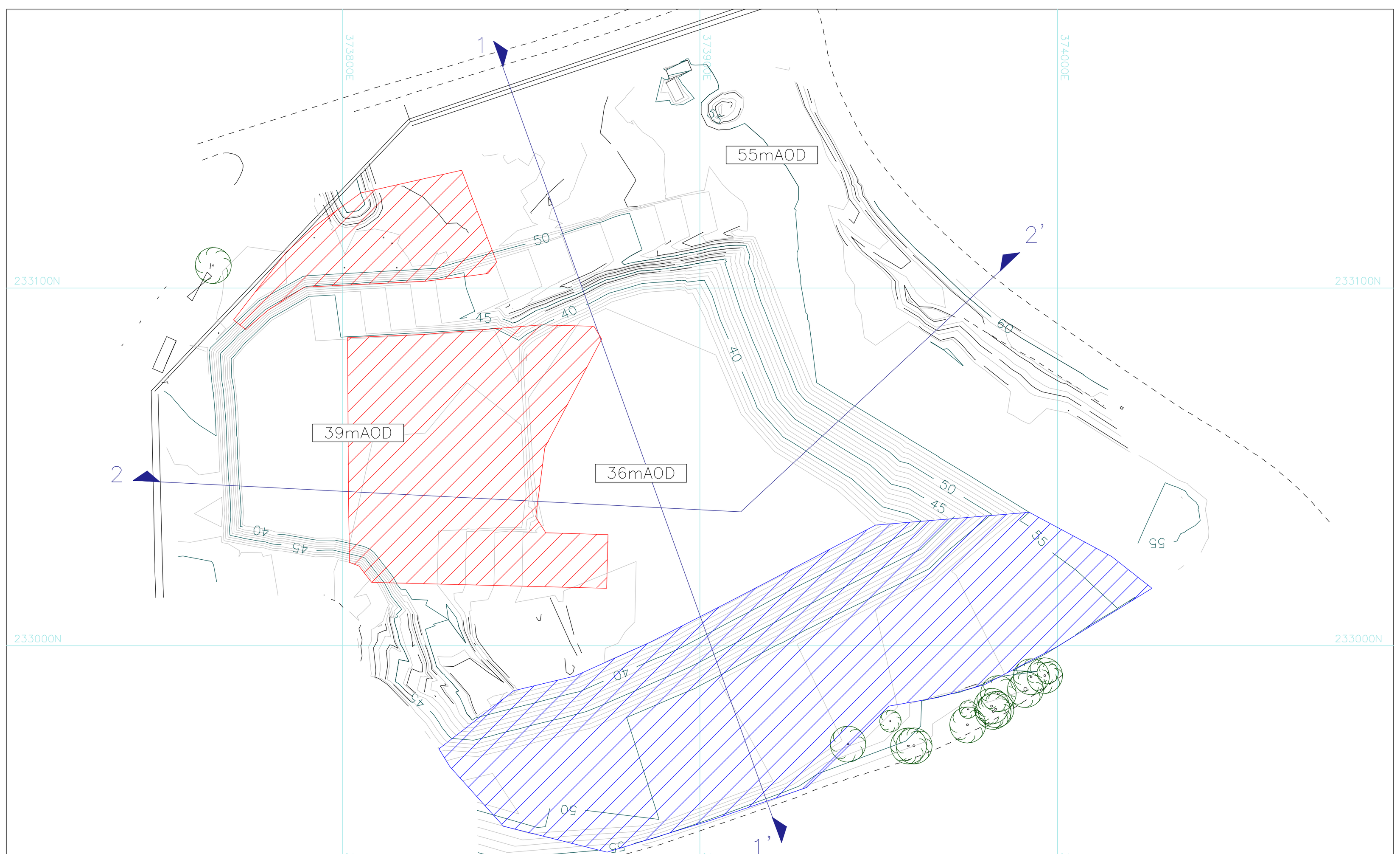
DRAWINGS



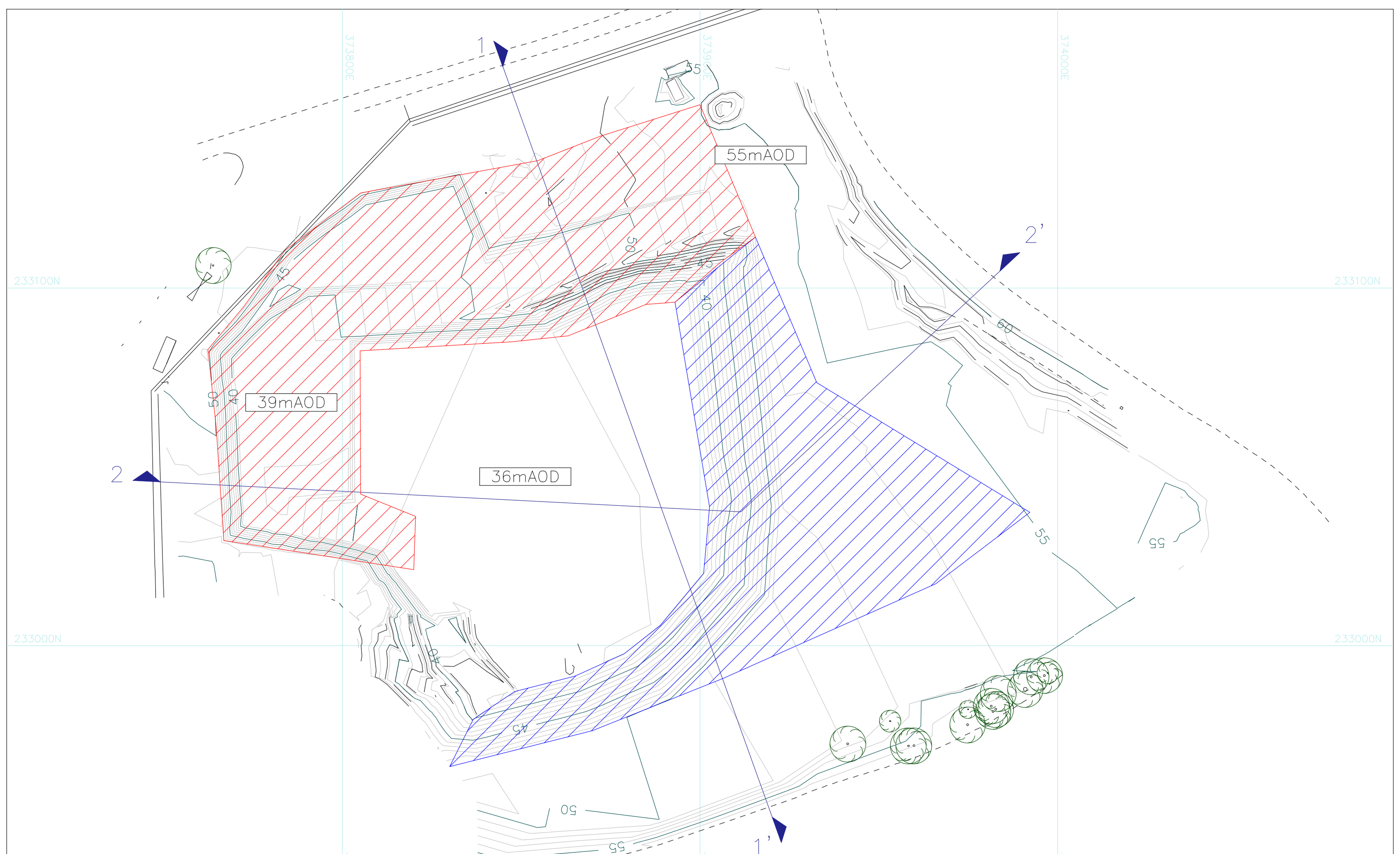
PHASE 1 - ORIGINAL ACCESS RAMP REMOVED. APPROXIMATE MINERAL EXTRACTION = 17,000M³.



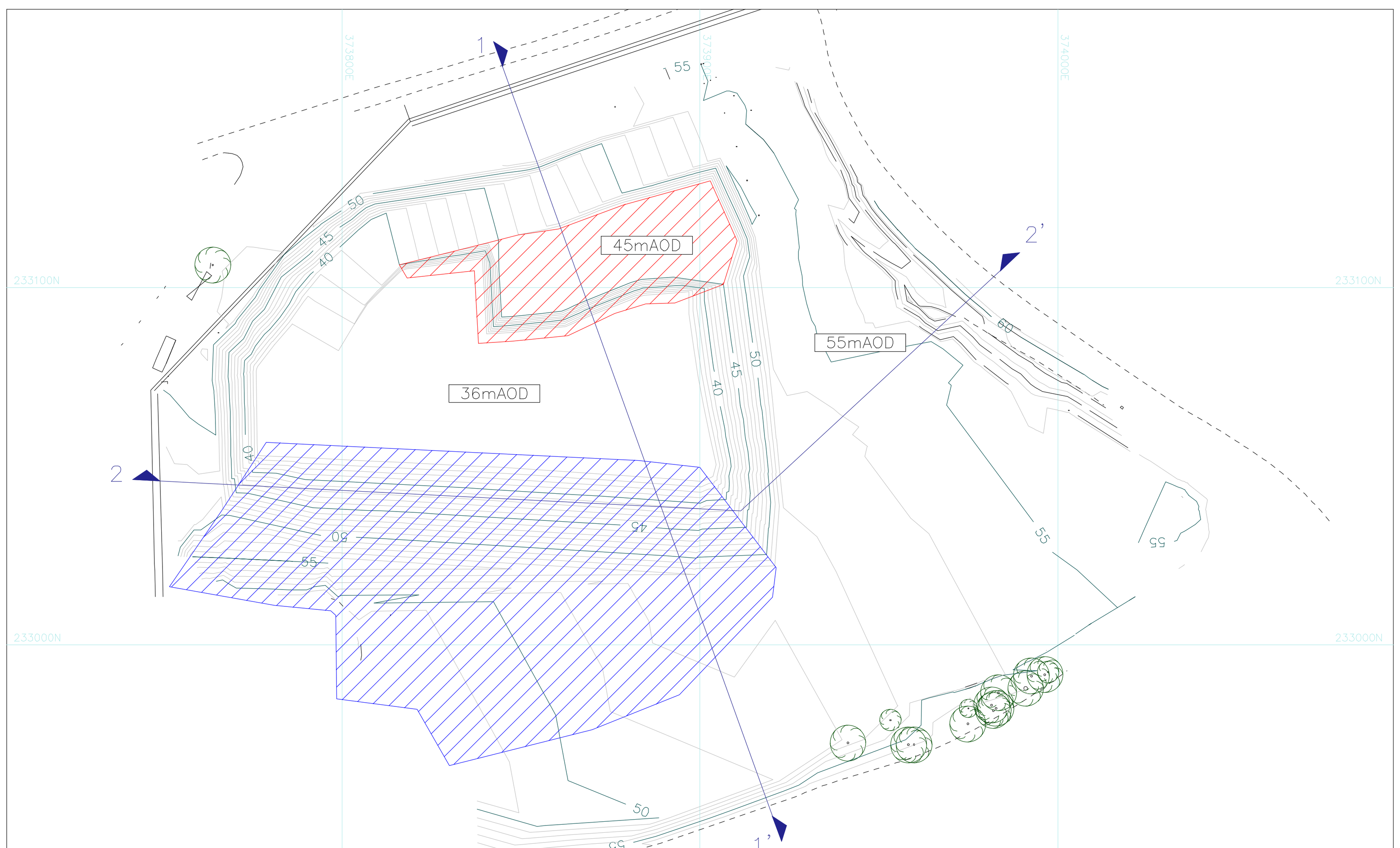
PHASE 2 - WESTERN AREA EXTRACTED TO 39MAOD AND NEW ACCESS RAMP CUT IN. RESTORATION IN EASTERN AREA OF SITE. NEW SITE ACCESS PUT IN.
APPROXIMATE MINERAL EXTRACTION = 52,000M³. APPROXIMATE RESTORATION VOLUME = 88,000M³.



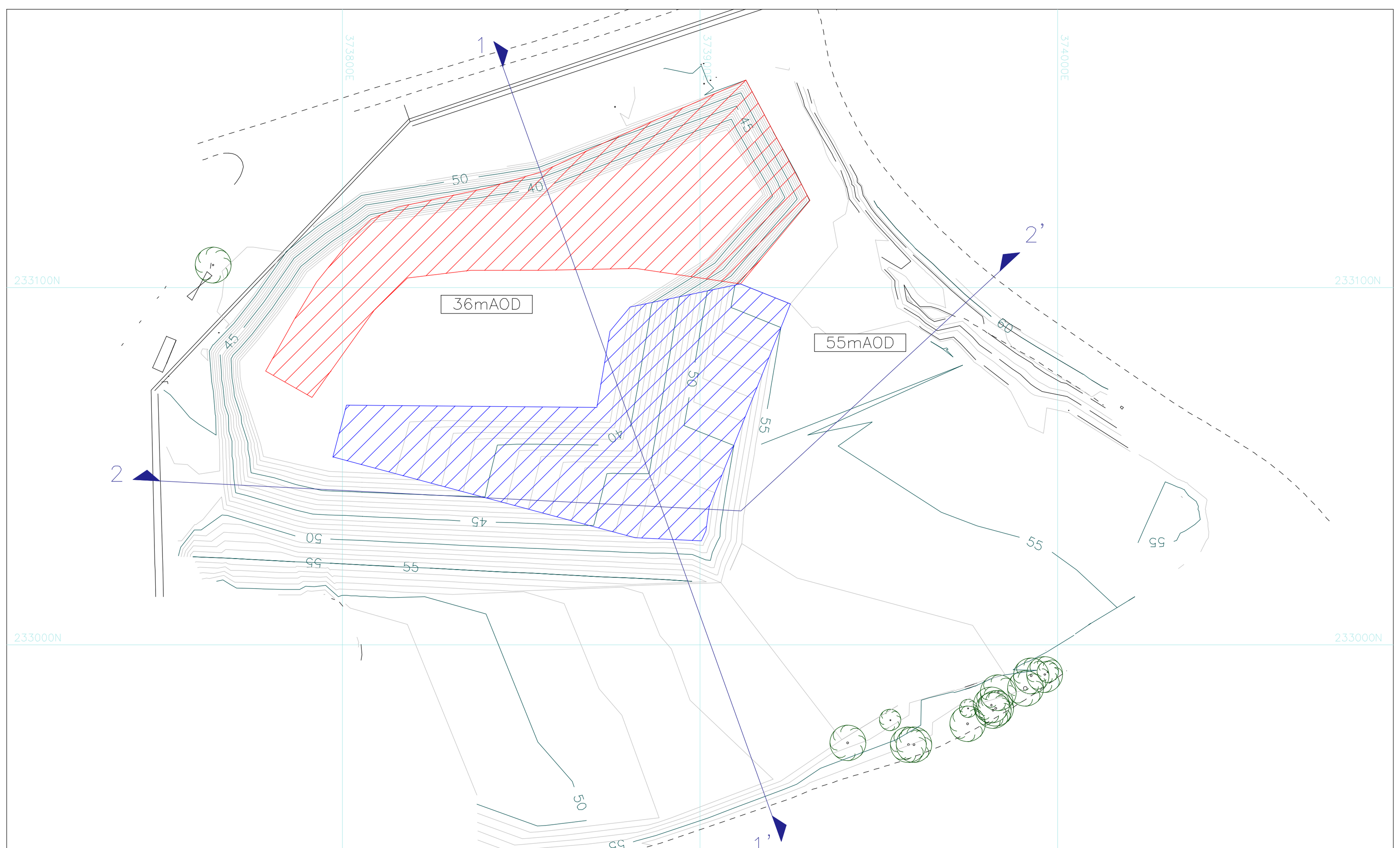
PHASE 3 - 39MAOD BENCH CONTINUES WEST. NEW BENCH CREATED AT 45MAOD, HEADING EAST. RESTORATION IN SOUTHERN AREA OF SITE.
APPROXIMATE MINERAL EXTRACTION = 18,000M³. APPROXIMATE RESTORATION VOLUME = 76,000M³.



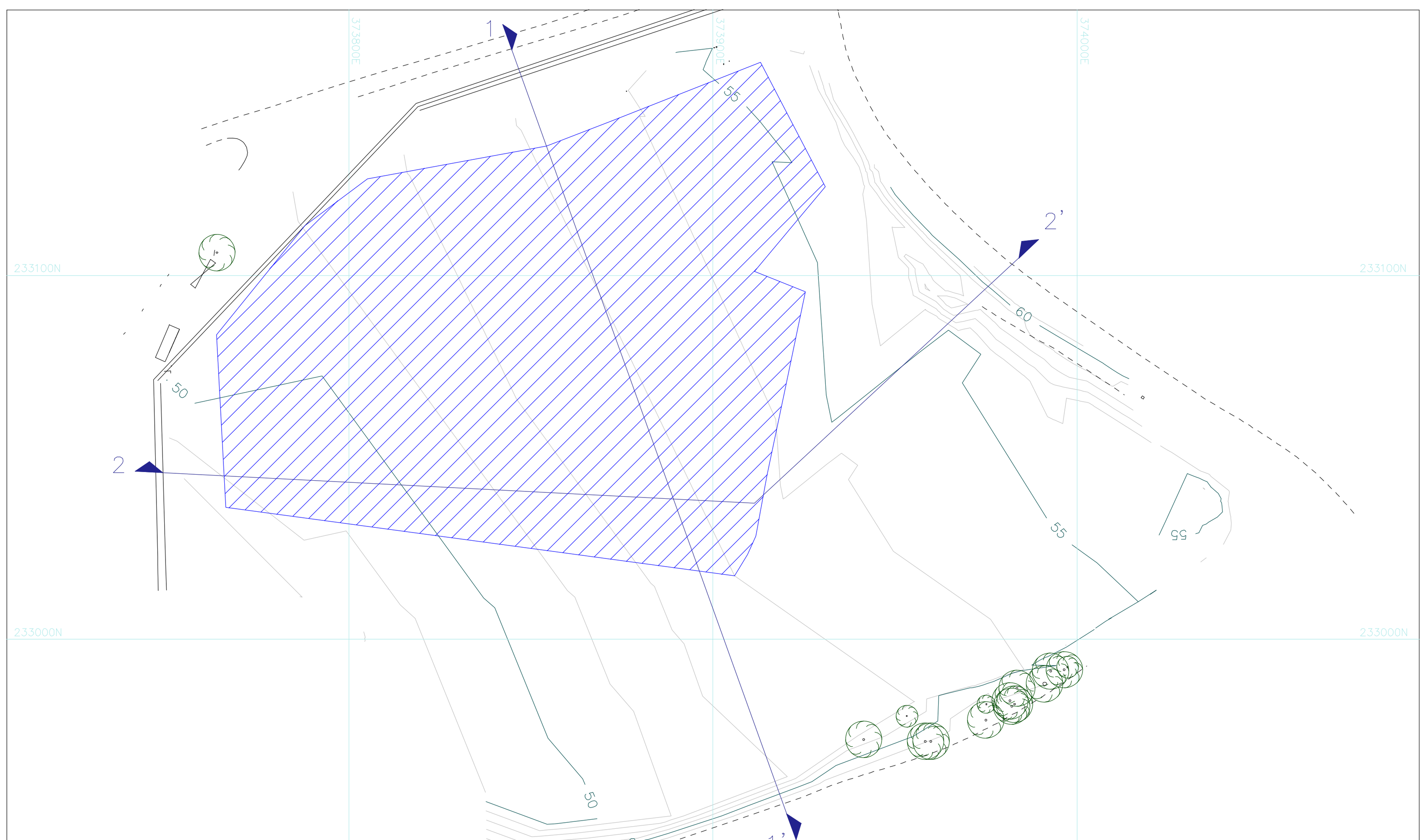
PHASE 4 - PREVIOUS RAMP REMOVED AND NEW ACCESS RAMP AT THE NORTHERN EXTENT OF SITE. BENCHES HEADING EAST. RESTORATION IN EAST OF SITE.
APPROXIMATE MINERAL EXTRACTION = 24,000M³. APPROXIMATE RESTORATION VOLUME = 43,000M³.



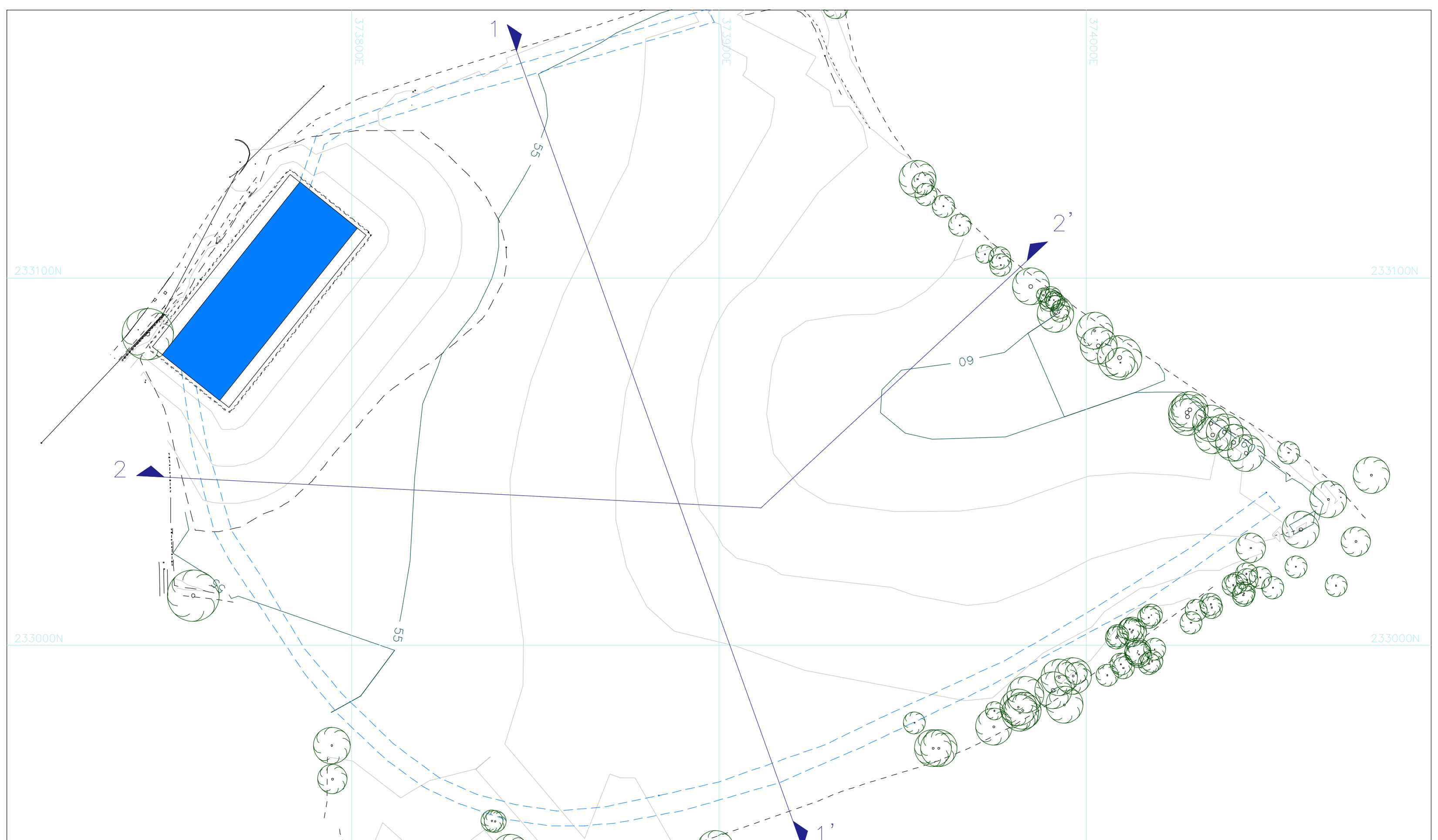
PHASE 5 - REMAINING BENCHES EXTRACTED. AREA IN NORTHEAST OF SITE TO BE EXTRACTED TO 36MAOD. RESTORATION IN SOUTH OF SITE.
APPROXIMATE MINERAL EXTRACTION = 17,000M³. APPROXIMATE RESTORATION VOLUME = 80,000M³.



PHASE 6 - NEW ACCESS RAMP CREATED ALONG THE EDGE OF RESTORATION AREA IN ORDER TO REMOVE MINREAL FROM AREA OF PREVIOUS ACCESS RAMP.
APPROXIMATE MINERAL EXTRACTION = 27,000M³. APPROXIMATE RESTORATION VOLUME = 24,000M³.



PHASE 7 - RESTORATION CONTINUED IN REMAINING AREA OF VOID. APPROXIMATE RESTORATION VOLUME = 174,000M³.



PHASE 8 - REMAINING RESTORATION COMPLETED UPTO FINAL RESTORATION CONTOURS. ATTENUATION BASIN SHOWN IN NORTH OF SITE.
APPROXIMATE RESTORATION VOLUME = 185,000M³.

NOTES

AREAS OF MINERAL TO BE EXTRACTED ON A PHASED BASIS

AREAS OF RESTORATION TO BE PROGRESSED ON A PHASED BASIS

REV.	REVISION DETAIL	DRAWN	DATE
01	FIRST ISSUE	RB	08/08/23

CLIENT:
BROMSBERROW SAND AND GRAVEL

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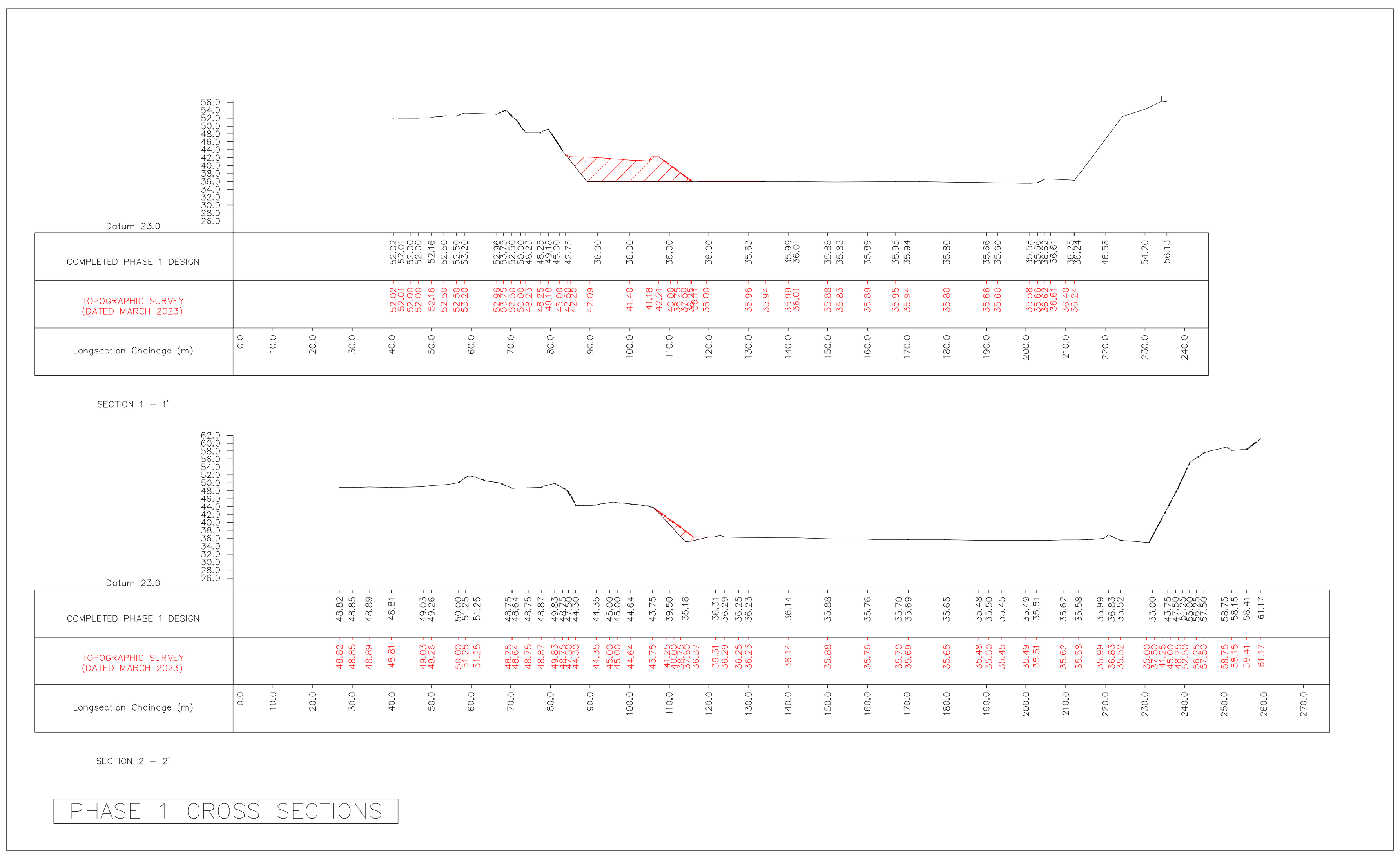
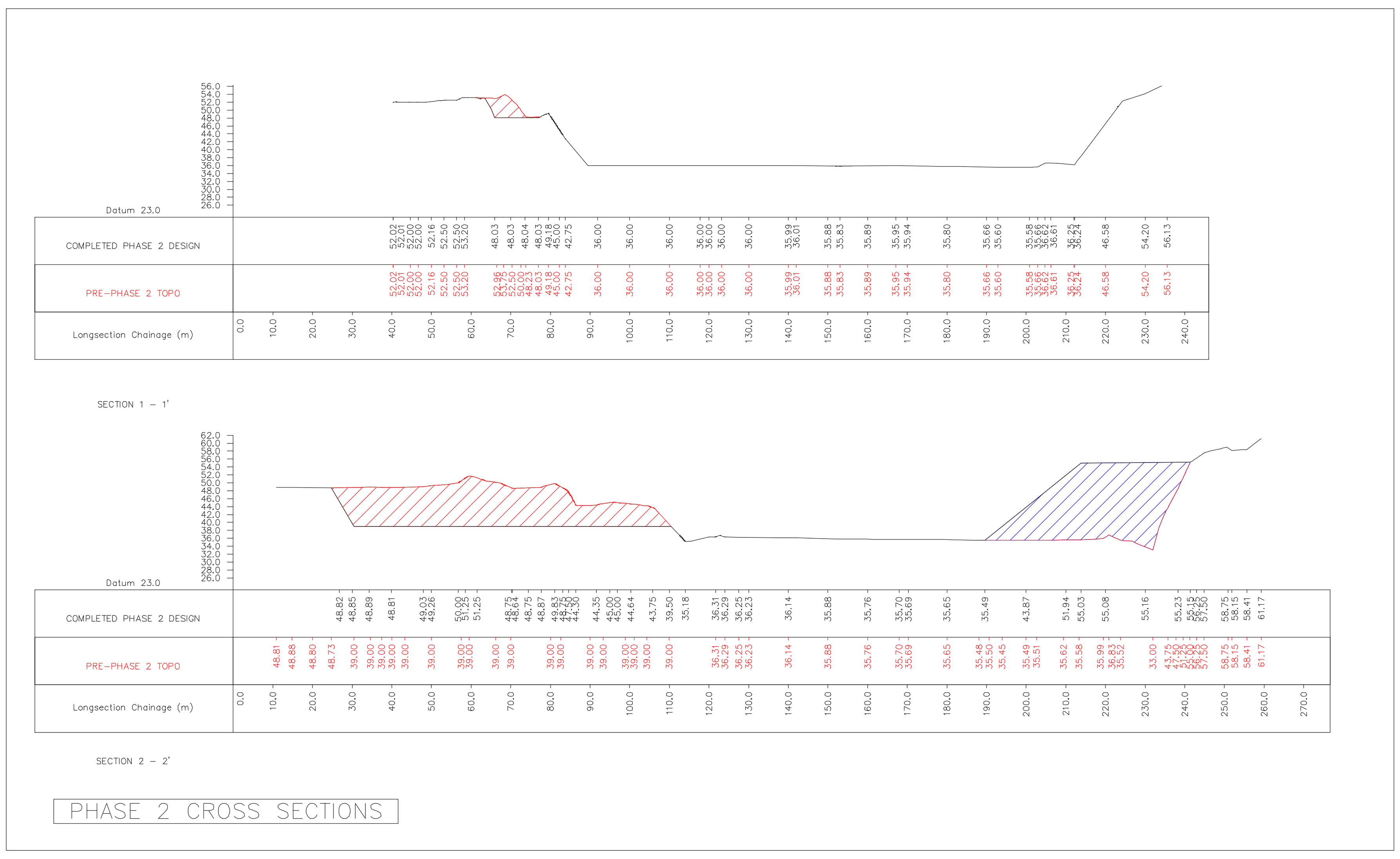
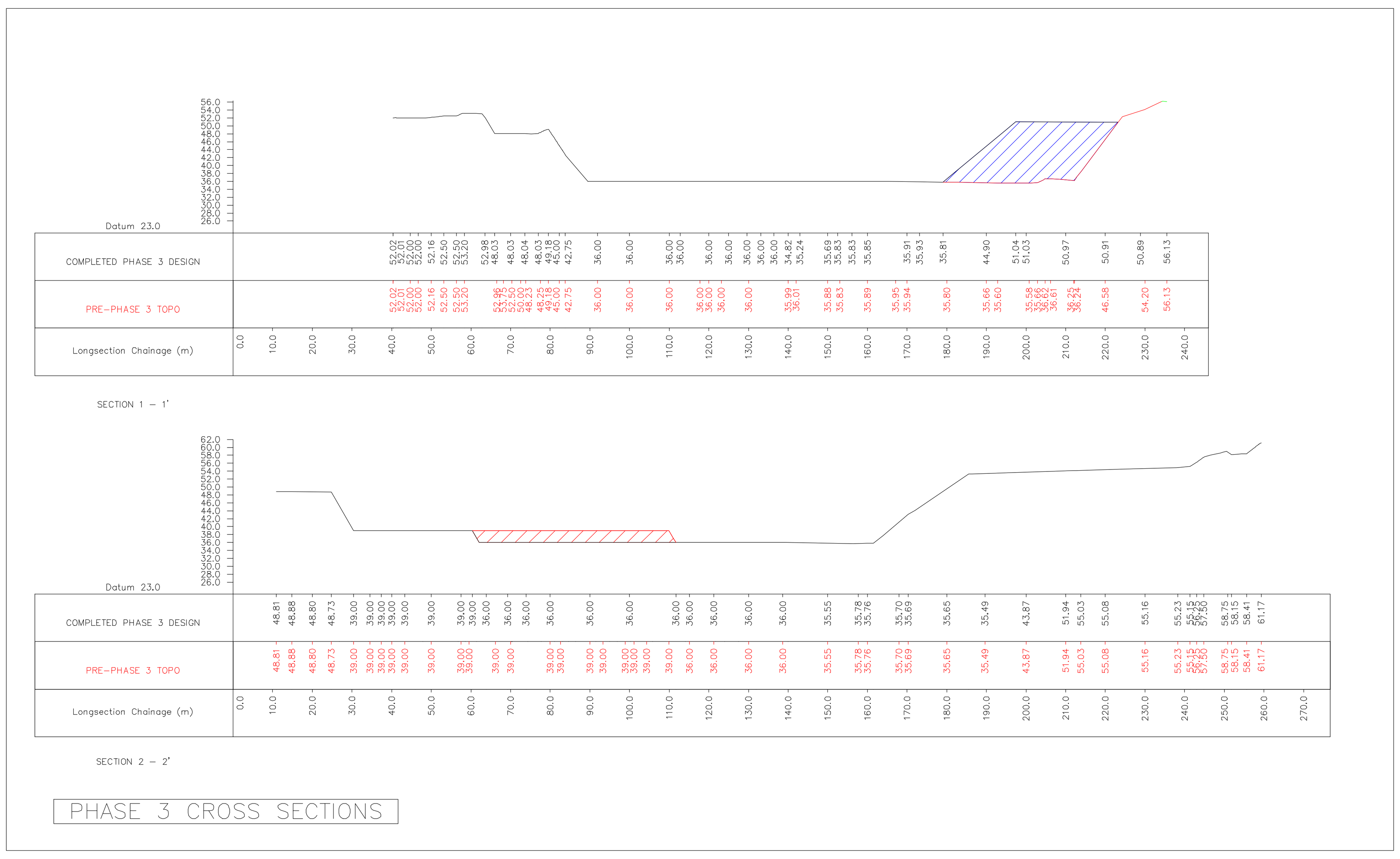
PROJECT:
BROMSBERROW QUARRY

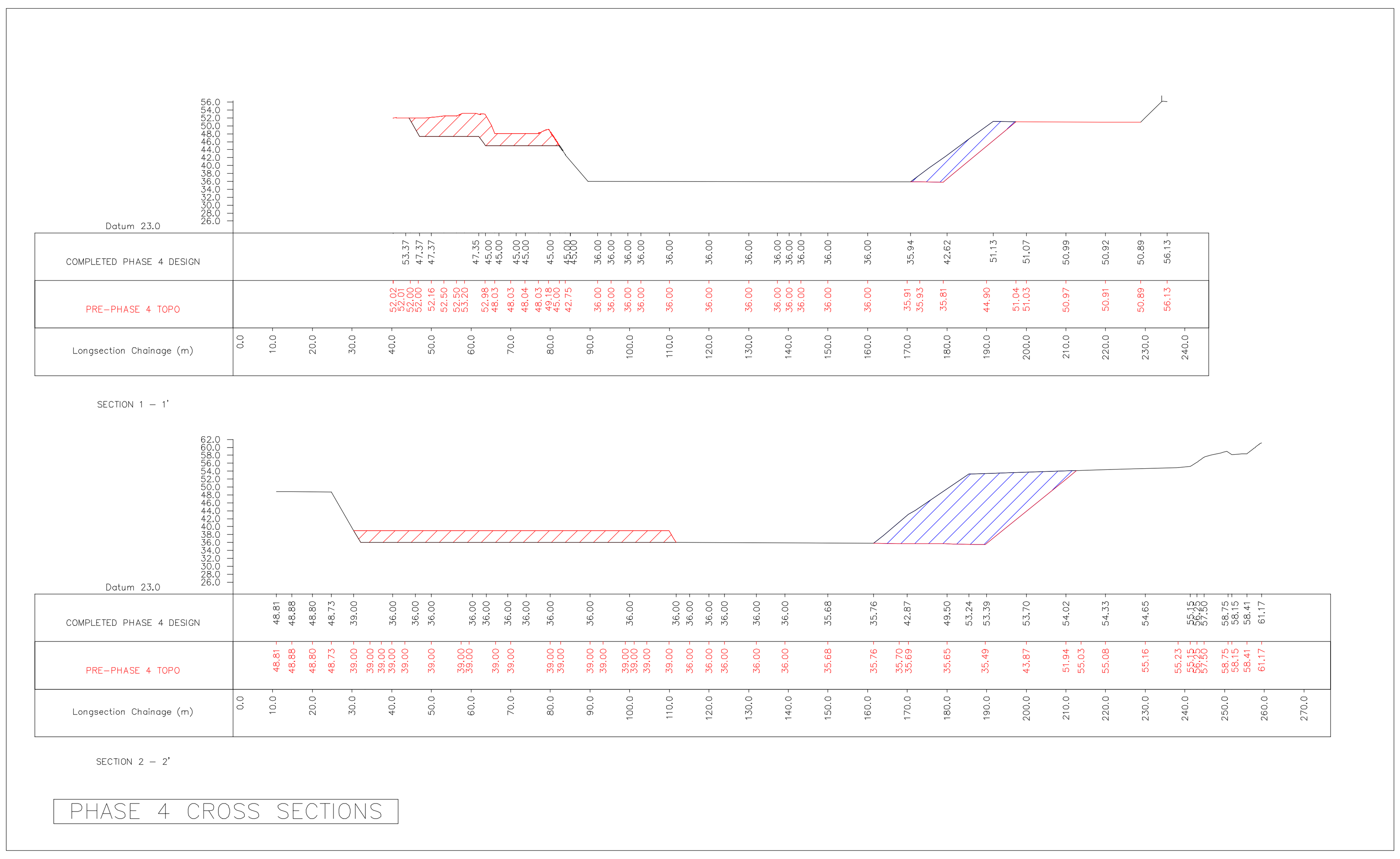
TITLE:
UPDATED QUARRY DEVELOPMENT PLAN - FLOOR AT 36MAOD

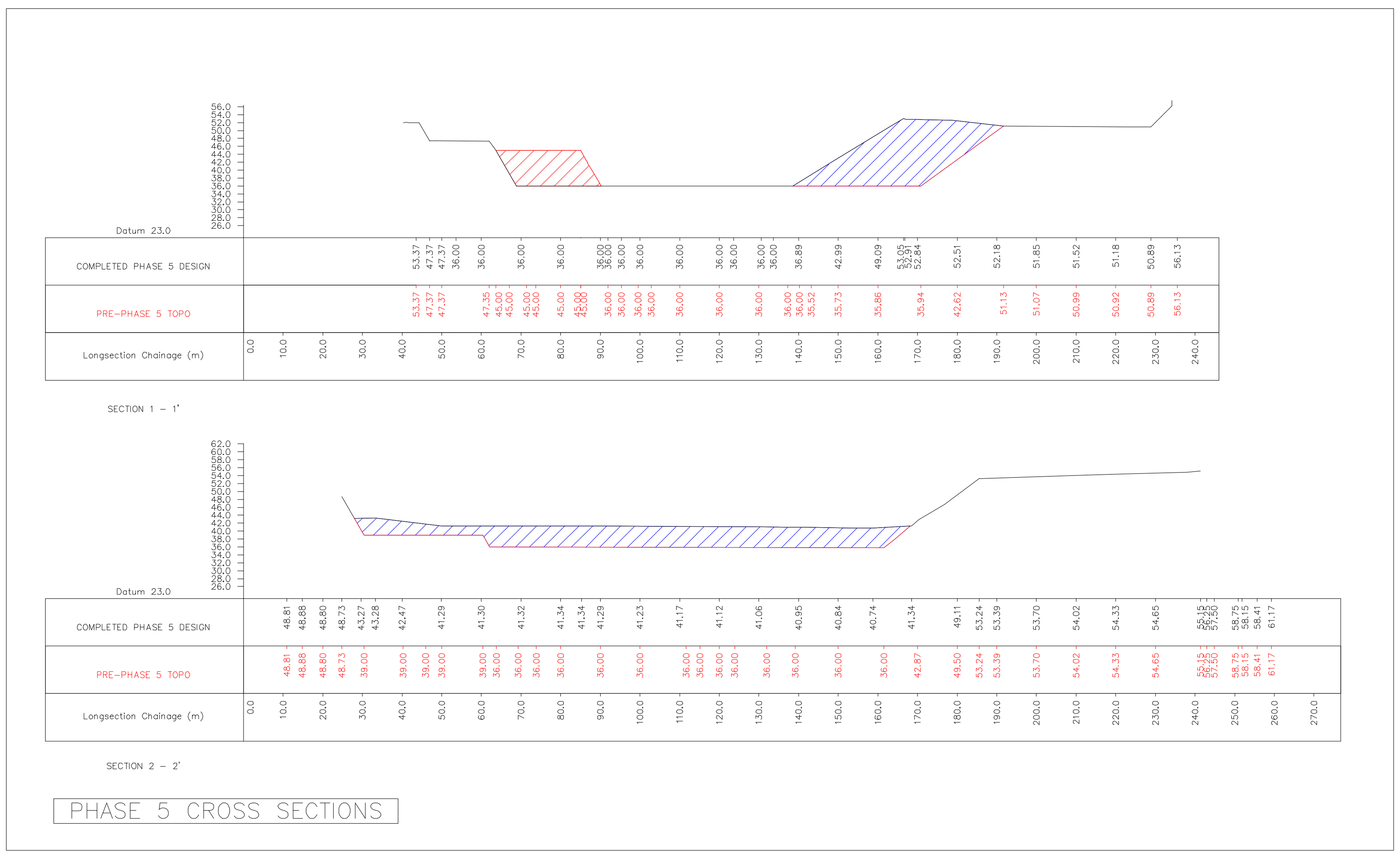
DRAWN: RB	CHECKED: BD	DATE: AUG '23
SCALE: 1:1500	ORIGINAL SHEET SIZE: A1	STATUS: DRAFT
DRAWING NO. 7873-005-D-002		REVISION: 01

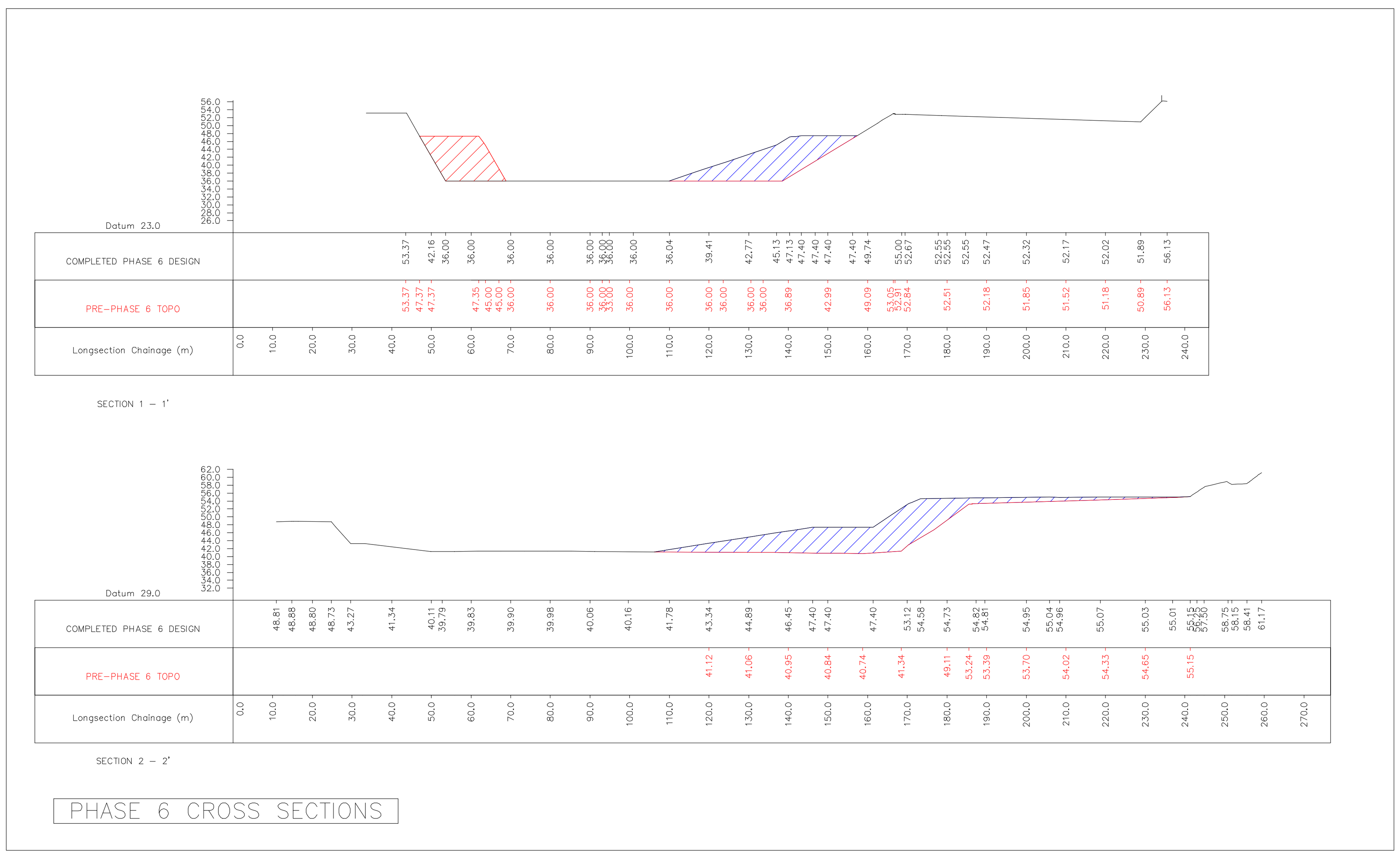


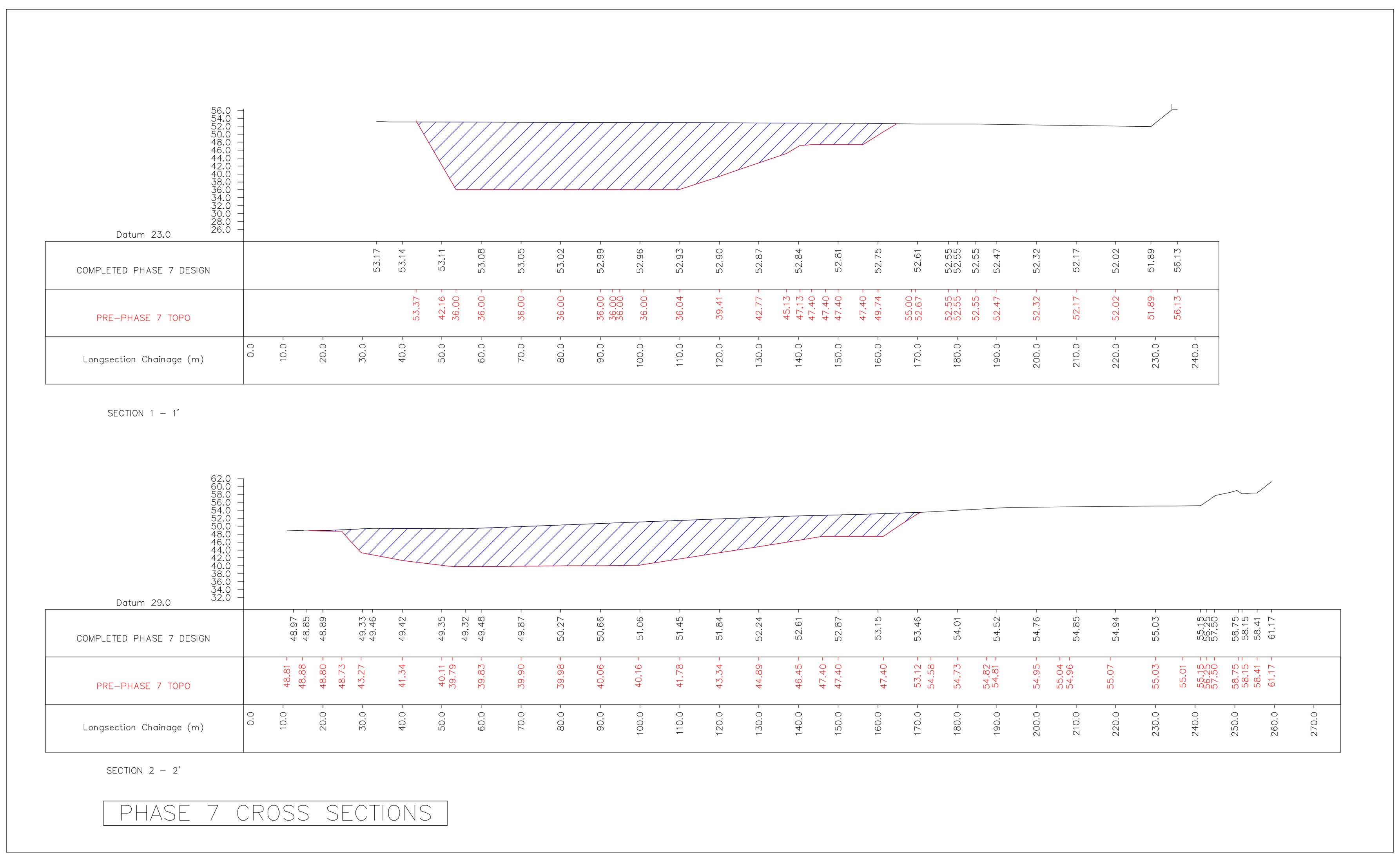


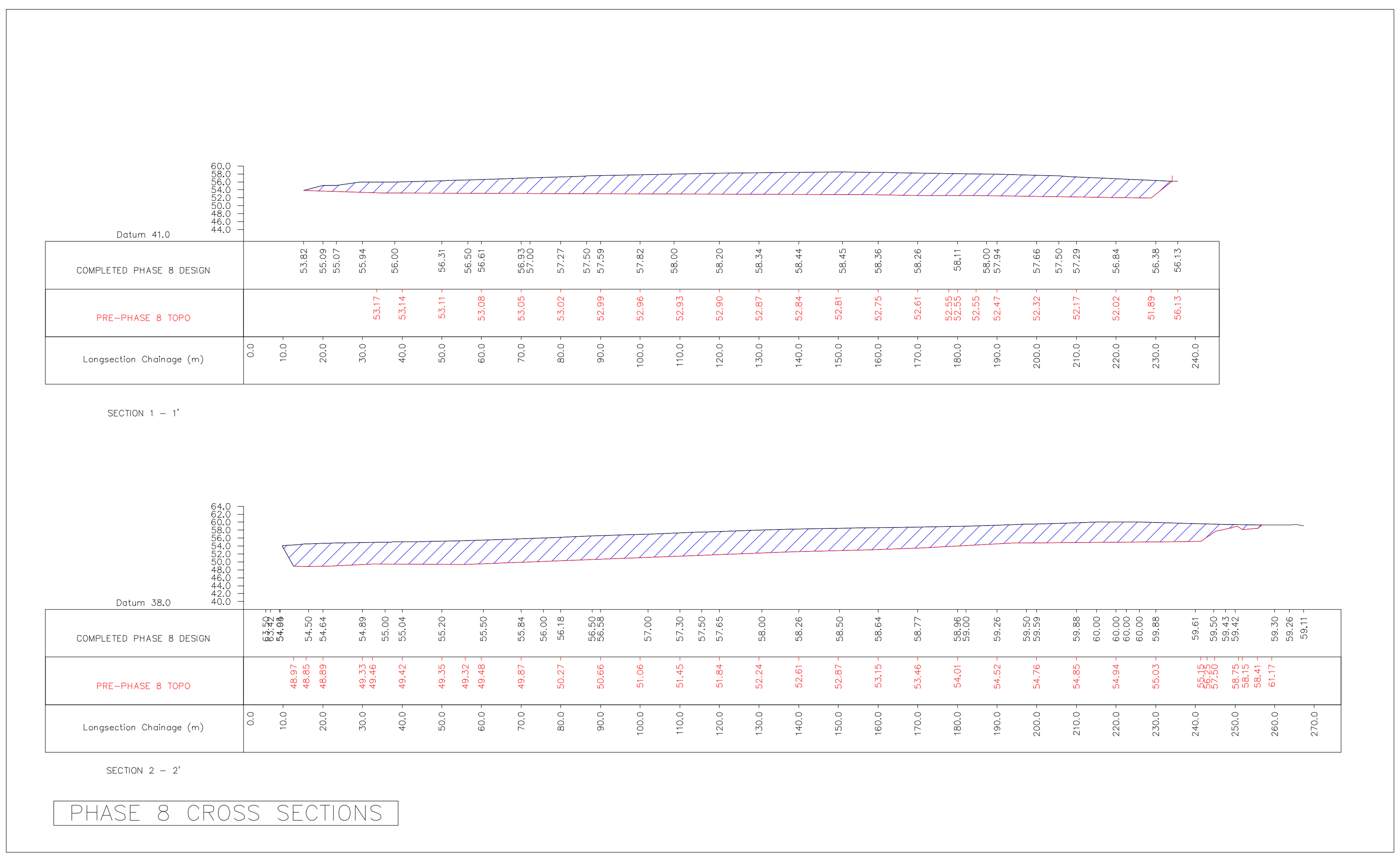












NOTES

AREAS OF MINERAL TO BE EXTRACTED ON A PHASED BASIS

AREAS OF RESTORATION TO BE PROGRESSED ON A PHASED BASIS

REV.	REVISION DETAIL	DRAWN	DATE
01	FIRST ISSUE	RB	09/08/23

CLIENT:

BROMSBERROW SAND AND GRAVEL

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WEB: WWW.KEYGS.COM

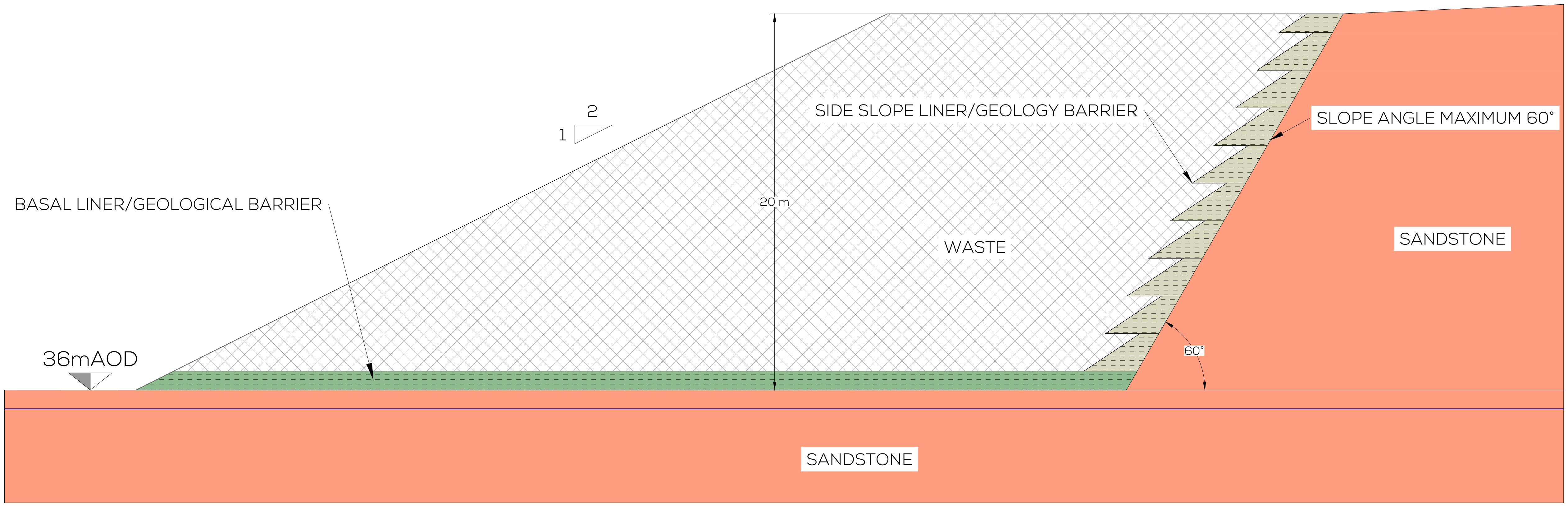
PROJECT:

BROMSBERROW QUARRY

TITLE:

UPDATED QUARRY DEVELOPMENT PLAN - FLOOR AT 36MAOD CROSS SECTIONS

DRAWN:	CHECKED:	DATE:
RB	BD	AUG '23
SCALE: 1:1250	ORIGINAL SHEET SIZE: A1	STATUS: DRAFT
DRAWING NO. 7873-005-D-004		REVISION: 01



GENERAL NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES (mm) & ALL LEVELS ARE IN METRES (m) UNLESS NOTED OTHERWISE.
2. GEOLOGICAL BARRIER MINIMUM 1m THICK WITH A MAXIMUM PERMEABILITY COEFFICIENT OF $1x10^{-9}$m/s.
3. TEMPORARY SLOPE MAXIMUM 1V:2H AND SLOPE HEIGHT MAXIMUM 20m
4. THE SIDE SLOPE LINER WILL BE PLACED IN LIFTS OF MAXIMUM 2m PER LIFT.

KEY

- WASTE
- SANDSTONE
- BASAL LINER
- SLOPE LINER
- WATER LINE

REV.	AMENDMENTS	DRW.	CHK.	DATE
P01	FIRST ISSUE	ZG	ZL	23.11.23

CLIENT

Bromsberrow Sand & Gravel Ltd

PROJECT

BROMSBERROW QUARRY

TITLE

TYPICAL CROSS SECTION USED FOR SRA

DRAWN:	ZG	DESIGN:	---
CHECKED:	ZL	APPROVED:	BD
DATE:	NOV '23	SCALE:	1:250

KEY | GS PART OF RICHTER

STATUS	SHEET SIZE
PRELIMINARY	A3
DRAWING NO.	REV.
7873-006-001	P01