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Elland Edge Quarry

Stability Risk Assessment Report for Proposed Recovery of Waste Scheme to Fill the Quarry Void made by Extracting Building Stone and Sandstone Aggregates to the Surface for Future Development

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Samuel Gledhill Limited

Elland Edge Quarry

Stability Risk Assessment Report for Proposed Recovery of Waste Scheme

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P Rand	1pdf	1							
J Carlon File	1pdf	1							

CONTENTS

Page Number

TABLES

APPENDICES

DRAWINGS

1.0 INTRODUCTION

1.1 Report Context

Elland Edge Quarry has been excavated between 1840 to the present day in order to supply building stone to build houses and mills with local materials in the Elland, Rastrick and Brighouse areas. The stone was worked by hand until the late 1880's when derrick and cranes were used to lift the blocks of stone from the quarry. The quarry was progressively infilled with predominantly mudstone and dressed sandstone shards and discarded stone and there is history of coal fly ash, from the coal fired power station at Elland being tipped in the 1960s, and smaller amounts of construction waste being deposited in the old stone quarries between 1950 to 1980.

Currently Rand & Asquith (Aceblade) Limited the sister company to the applicant excavate and process the stone to produce building products such as gabion, armour stone, lintels, jambs, sills, paving and walling stone. Landscape products are also produced such as rockery, crazy paving and dry stone walling. Sandstone aggregates have been produced and sand for use in the manufacture of concrete building blocks. Approximately 50% of the infill material which is mudstone currently within the site will be unsuitable for sale unless it is for flood defence bunds and will be used in the restoration of the site. In order to achieve the site restoration to the original surface for a platform to build houses it will be necessary to import inert material, it is proposed that this will be done under a recovery of waste scheme and 263,000 cubic metres is required, which is 500,000 tonnes. The quarry is allowed to import 78 loads per day which is 195,000 cubic metres per annum. It is unlikely this will be achieved so the volume of material to be imported is likely to take 5 years to complete based on an import of 100,000 tonnes per annum.

The application for the recovery of waste scheme is to be submitted by Samuel Gledhill Limited, (SGL) the site owner and the site is operated by that company also. The applicant has engaged Hart Environmental to prepare an updated application to address the groundwater risk assessment and to include the area to the west side of the quarry which is currently being worked for stone and clay.

Cromwell Wood Estate Company who trade as Cromwell Mining Consultants (CWECL) has been requested by SGL to provide an updated Stability Risk Assessment Report in order to assess the stability of the proposed excavation and subsequent restoration profiles. This report has been compiled in accordance with the template issued by the EA (Landfill operators: environmental permits - How to do a stability risk assessment: landfill sites for inert waste or deposit for recovery activities - Guidance - GOV.UK (www.gov.uk)), with reference to R&D Technical Reports P1-385/TR1 and TR2 where applicable. It has also been prepared in accordance with the Quarries Regulations 1999 regulations 13, 16, 30 to 38 for the safe operation of a quarry with restoration by backfill in the void areas.

This report provides an overview of the available geological data and a review of the existing ground conditions and the proposals for the recovery of waste by depositing material in the void to substitute materials that are available on the quarry but can be processed and sold as primary sandstone aggregate instead of being used in backfilling the void space made by extracting building stone.

The site has been assessed for housing as the area to the east and south has been allocated for future housing development in Calderdale and consequently the recovery of waste scheme will engineer the filling of the void to replace building stone and aggregate and then provide for the building of houses in accordance with Government Policy.

1.2 Conceptual Stability Site Model

This report deals with the proposed excavation and restoration of the site as shown on the plans that accompany the Waste Recovery Plan. The conceptual site model is shown on Drawing SRA1 provided in appendix 3 of the WRP, it is proposed that progressive restoration of the quarry faces and the mineral waste tip side slope in the void space created by the excavation will be undertaken by backfilling imported inert waste that substitutes the mineral quarried. The soil and stones imported to the site from excavation and demolition contracts in the Calderdale, Bradford and Kirklees Unitary Authorities to support their building programmes for housing and commercial development in their Local Plans will provide a facility to recover that waste to provide building land on this site in 5 to 7 years.

Elland Edge Quarry is located at National Grid Reference 413100mE, 421300mN, approximately 1km to the west of the centre of Rastrick. The British Geological Survey, 1:50,000 scale, Sheet 77 - Huddersfield, indicates that the site is underlain by strata of the Pennine Lower Coal Measures Formation (PLCMF), which consists of interbedded grey mudstone, siltstone and pale buff and grey sandstone, commonly with coal seams. The strata can be seen to be dipping gently at c. 6° to the north-east.

1.2.1 Basal Subgrade Model

The basal subgrade will be formed by in-situ strata of the Pennine Lower Coal Measures Formation, at a level of approximately 138 m AOD. The basal subgrade will be protected by a layer of sandstone boulders and 25 mm down crusher run to provide a drainage layer for groundwater if it rises to the base of the Elland Flag section.

1.2.2 Side Slope Subgrade Model

The side slopes will be formed of in-situ strata of the Pennine Lower Coal Measures Formation (PLCMF). Topographic survey data exists to show the final face positions on the north and east sides of the excavation and the mineral tipping slope configuration on the southside. The PLCMF has been exposed in the quarry around the perimeter and this has allowed detailed inspections to be made based upon the working of the east side of the quarry from 1999 and the deposit of the minerals tip on the south side over the past 20 years and previous experience elsewhere on building stone quarries as to the likely angle of the excavated faces which are sub vertical at 1V to 0.6H.

1.2.3 Basal Lining Model

The basal lining will be a sandstone drainage layer of boulder and 25 mm crusher run to provide a base for the clay liner that will be placed over the drainage layer on the floor of the quarry. The sandstone layer is 2 metres thick and the basal clay layer will be 2 metres thick and taken from the quarry stockpiles of coal measures mudstone and laid in layers of 500 mm and compacted.

1.2.4 Side Slope Lining Model

The side slope lining system will be coal measures mudstone from the quarry placed as a side slope berm up against the sandstone face and will be advanced up to 2 metres above the tipping level so the liner will form a Christmas tree on the vertical liner on the north face. The east side face has an engineered minerals tip to form a haul road from the southside into the quarry. The south side minerals tip has been buttressed with mudstone and quarry discard material to form a berm since 2015 so that the access to the void is from the lower level berm at 160 metres aod and then the upper level of 178 metres aod.

1.2.5 Waste Mass Model

The waste will consist of excavation waste from construction projects which are not too dissimilar to the materials found on the quarry. Excavation on sites for foundations, roads, services and sewers provide arisings of natural materials such as shale, mudstone, clay, sandstone, siltstone, subsoil and topsoil and all of these can be recovered and used in the restoration of the quarry void as additional materials to the restoration soils on the quarry. The company has used most of the interbedded mudstone and shale that has been extracted as stone has been quarried to backfill the southern part of the quarry to the surface. Other arisings will come from the recycling of construction waste on site to produce secondary aggregates of concrete, brick and block that will be mixed with the sandstone aggregate to widen the product range and higher specification products such as MOT Type 1 fill. The fines from this process will be used in the recovery scheme to backfill the void thereby substituting the sandstone and mudstone that has been removed. The types of inert waste are documented in Table 1 paragraph 4.7 of the Summary of the Waste Recovery Plan Reference 0322-420 Rev B and waste types are listed in table 2.5 of the standard rules 2015 No 39.

The waste shall be placed in layers in line with the restoration levels to a maximum elevation as shown on drawing number RA/LEQ/WML 22-02, REC 16-06, 16-07 and 16-08 in appendix A and SRA 1 in appendix C of the Waste Recovery Plan.

The waste materials will be placed in accordance with the Specification of Highway Works, Series 600 Clause 612. It is intended that under the recovery of waste scheme the waste will be placed at a maximum gradient of 1 vertical in 2.5 horizontal. It is then proposed that further inert waste will be placed under the recovery permit to a level of 158 metres aod to form a plateau so that mneral waste can be placed over the top upto the surface

1.2.6 Capping System Model

Mineral waste will be used as a capping medium and will be placed in layers not exceeding 1 metre and compacted with the machinery on site upto the surface levels shown on plan number RA/LEQ/16-07 included in appendix A of the WRP.

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.
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 proposed 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 Coal Measures mudstone. The Coal Measures will be of low compressibility, however there is a potential (albeit very low) for bearing capacity type failure of the subgrade and therefore this issue requires further consideration.
	Basal Heave	Ground water is encountered within the quarry at quarry floor subgrade level from upstream in the strata, hence basal heave is not considered to be a problem and therefore this aspect is not considered further.
	Cavities in the Subgrade	No cavities are considered likely to exist within the in-situ Coal Measures immediately beneath the floor of the quarry. All coal seams worked within the area are at a significant depth below the ground surface and are not considered to be an issue.
	Compressible Waste	Not applicable
	Filling on Waste	Not applicable
	Cavities in Waste	Not applicable

Given the foregoing, it is considered that the basal subgrade system does not require further assessment, but it will be reviewed as the site is commissioned and the materials available in the construction quality assurance reports.

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

Pennine Lower Coal Measures Formation	Stability	In parts the eastern side slope will be formed by in-situ sand and gravel at a maximum gradient of 1V in 2.5H, the maximum height will be 15m. The stability of the unconfined slopes will be considered further. .
	Deformation	The in-situ Coal Measures strata are 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

There is a basal lining system that is a clay layer 2 metres thick laid in layers of 500 mm over a drainage layer of sandstone boulder and crusher run to maintain a drainage pathway beneath the site.

Table SRA 2/3

Stability Components for Basal Liner

Compacted clay of Basal Liner	Compressible Subgrade	The basal subgrade will comprise in-situ Coal Measures. The Coal Measures will be of low compressibility, however there is potential (albeit low) for bearing capacity type failure of the subgrade and therefore this issue requires further consideration.
	Basal Heave	Ground water is not encountered within the quarry at subgrade level, water seepage in the face and under the mineral tip is seen, hence basal heave is not considered to be a problem and this aspect is not considered further.
	Cavities in Subgrade	No cavities are considered likely to exist within the in-situ Coal Measures immediately beneath the floor of the quarry. All coal seams worked within the area are at a significant depth below the ground surface and are not considered to be an issue.

Given the foregoing, it is considered that the basal liner system requires further assessment.

2.1.4 Side Slope Lining Screening

There is to be a side slope lining system which is coal measures mudstone from the quarry placed in layers on top of the previous mudstone to create a Christmas tree and with drainage down the back wall against the rock face to maintain drainage routes around the waste mass as shown on drawing RA/LEQ/REC 16-08 in appendix A of the WRP.

2.1.5 Waste Mass Screening

The controlling factors that will affect the stability and deformability of the side slope subgrade are detailed in Table SRA 2/3 below.

Table SRA 2/5

Stability Components for Waste Slopes

Failure wholly in waste	Stability	Temporary waste slopes will be formed at a gradient of no steeper than 1V in 2.5H. The stability of these slopes will be considered further. Surface water captured within the excavation area will be directed to a sump in the floor of the void, from here water will be re-circulated to the washing plant or be discharged off site as necessary.
Failure involving subgrade and waste	Stability	Development of the restoration works will result in the generation of temporary waste slopes. In terms of potential for movements along the basal subgrade, the presence of temporary slopes may result in instability within the waste and the basal subgrade. As such, this aspect will be considered further .

Given the foregoing, it is considered that the waste mass does require further assessment.

Leachate

As part of the site restoration the land will be formed with gradient from south to north as shown on plan number RA/LEQ/REC16-07. There is unlikely to be any leachate percolation into the waste mass as it is mostly impermeable material that will be used and there will be a collection sum on the tipping level to accept surface water run off in the site that will be sed for replenishing the water supply on site and for damping down.

2.1.6 Capping System Screening

There is to be no engineered capping layer as the materials to be accepted are inert construction waste which are mainly naturally occurring soils and strata that behave the same way as quarry waste. Quarry arisings will be placed over the imported waste from a level of 158 metres aod to the surface as shown on plan numbers RA/LEQ/REC 16-06 and 16-07 in appendix A of the WRP.

2.2 Lifecycle Phases

This aspect of the assessment identifies the critical phases during the excavation and restoration of the site.

Temporary excavation slopes have been developed as the building stone has been extracted and the Elland Flag is quarried to the base of the section and the underlying Coal Measures mudstone is exposed. Temporary waste slopes will then be developed within each phase of filling the void as the restoration progressively places imported waste against the face and on the floor against the liners made of onsite stockpiles of mudstone. To ensure the Stability Risk Assessment fully addresses the key issues throughout the life of the operation the side slope subgrade and temporary waste slope short term stability are considered.

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 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 restoring forces against disturbing 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.

Given that the proposed excavation and infilling is relatively simple, with a limited number of components it is considered that a factor of safety of 1.3 is appropriate for the long-term situation and 1.2 is appropriate for short-term temporary slopes when using conservative shear strength parameters for the rock / soil types that are involved.

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 there are two potential failure mechanisms that require to be considered, a rotational failure through the mass of the material and a sliding failure associated with the bedding planes within the Coal Measures strata.

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 rotational failure. The limit equilibrium analyses have been undertaken using the software package SLIDE Version 9.020 (Rocscience Ltd.).

For sliding failure this can be considered kinematically, i.e. can the block physically move in relation to the orientation of the slope being constructed.

A vertical loading of 20kN/m² has been applied to areas of slope where access by site traffic is envisaged.

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, and the mixed discards and inert waste materials. The parameters that have been used are provided below in Table SRA 2/6.

Table SRA 2/6

Geotechnical Parameters Used in Analyses

Material Type	Undrained Shear Strength, s_u (kN/m²)	Effective Cohesion, c' (kN/m²)	Angle of Shearing Resistance, Ø' (°)	Bulk Density (kN/m³)	Typical Description
Waste	40	0	25	18	Well mixed quarry discards and imported inert waste
Pennine Lower Coal Measures Formation – rock mass		120	25	20	Interbedded mudstone, siltstone & sandstone
Pennine Lower Coal Measures Formation - bedding	-	5	25	20	

Groundwater has not been encountered within the Coal Measures within the quarry excavation area apart from seepage in the floor of the quarry. There is surface water impounding in the quarry in the lower levels as flow paths direct water from the higher ground. however it is envisaged that as part of the restoration a series of perched lakes will be formed.

2.6.1 Parameters Selected for Basal Subgrade Analysis

The parameters are given in Table SRA2/6, these have been derived from the Hoek-Brown Classification and "The engineering properties of mudrocks". Cripps, J.C. and Taylor, R.K. 1981. Quarterly Journal of Engineering Geology, Volume 14, No 4, pp325-346.

2.6.2 Parameters Selected for Side Slope Subgrade Analysis

Two sets of parameters have been selected for these strata, the rock mass parameters and the bedding strength and these are given in Table SRA1. The mass parameters have been derived from the Hoek-Brown Classification and "The engineering properties of mudrocks". Cripps, J.C. and Taylor, R.K. 1981. Quarterly Journal of Engineering Geology, Volume 14, No 4, pp325-346. The strength parameters for the bedding planes have been chosen based upon guidance given in "TRRL Laboratory Report 1039. Rock Stability Assessment in Preliminary Site Investigations – Graphical Methods. G.D. Matheson. 1983".

2.6.3 Parameters Selected for Basal Liner Analysis

The parameters are given in Table SRA2/6. Residual shear strength parameters have been selected for the clays which will form the basal liner based on consolidated drained shear box test results shown in Appendix SRA 2.

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2.6.4 Parameters Selected for Side Slope Liner Analysis

The parameters are given in Table SRA2/6. Residual shear strength parameters have been selected for the clays which will form the basal liner based on consolidated drained shear box test results shown in Appendix SRA 2.

2.6.5 Parameters Selected for Waste Analysis

The parameters are given in Table SRA2/6. The undrained shear strength has been selected as the minimum required to allow trafficking of site vehicles. Conservative effective stress parameters have been selected for the inert waste mass to allow for the inclusion of quarry discards as cover material for the quarry process that will be used on site, the soil substitute (screened demolition and construction waste) is assumed to form the near-surface parts of this waste mass before a thick layer of on site mudstone is used as a subsoil and formation layer for the subsoil and topsoil layers. Residual shear strength parameters have been selected for the clays and mudstone which will form the capping soil layers from 158 metres od to the surface based on consolidated drained shear box test results from a number of sources of coal measures clays and mudstone commonly known as brickearth shown in Appendix SRA 2.

2.6.6 Parameter Selected for Capping Analysis

The parameters are given in Table SRA2/6. The undrained shear strength has been selected as the minimum required to allow trafficking of site vehicles. Conservative effective stress parameters have been selected for the inert waste mass to allow for the inclusion of ash discards from the washing process that will be used on site, the soil substitute (screened demolition and construction waste) is assumed to form the near-surface parts of this waste mass. Residual shear strength parameters have been selected for the clays which will form the pond liners based on consolidated drained shear box test results shown in Appendix SRA 2.

2.7 Analyses

Details of the various Stability Risk Assessment analyses undertaken for the site are presented in the following sections. Three sections have been chosen to be analysed, the location of these are the mineral tip slope in Appendix SRA 1, the slope with the bund and haul road in it, the floor of the quarry and the section through the side wall shown on plan number RA/LEQ/REC16-08.

Section A1- 1 has been chosen as it represents the deepest part of the excavation, and it incorporates an access ramp into the excavation on the east side of the site. The crest loaded as there is a pipeline easement on the east side so excavators and plant may be within the easement near the face until the area is backfilled with quarry material and suitable inert waste to build the ramp.

Section C1-1 represents the highest slope without a bench or ramp on the quarry face which is interbedded mudstone and sandstone and has been modelled to the ashlar bed, hence it is effectively steeper than Section A1- 1.

Section C1-2 is adjacent to the road and the rear gardens with the pipeline easement to the north east of the quarry and in addition the Coal Measures strata dip into of the face to the northease at 6 degrees.

Section A1-2 is on the mineral tip slope with the crest at 177 metres aod and the haul road on the berm at 160 metres aod.

Section B1-1 is for the slope to be placed against the face in inert waste to support the face and the construction of Christmas tree berms as the waste is brought up in levels to the plateau.

Section B1-2 is for the slope of 1 in 2.5 in the waste mass to support the exposed face as the void is filled.

Section B1-3 is for the slope at 1 in 4 for the waste mass as it is filled against the existing mineral tip up the slope to the haul road

Section B 1-4 is for the 1 in 4 slope

2.7.1 Basal Subgrade Analysis

The stability of the basal subgrade will be a function of two elements the height of the unconfined side slopes and the height of the temporary waste slopes. Hence, these aspects are considered as part of the side slope subgrade analysis (Section 2.7.2) and the waste analysis (Section 2.7.3).

2.7.2 Side Slope Subgrade Analysis

For the unconfined side slope Sections A and C have been considered, Section A being the highest slope and Section C being adjacent to the road. A loading has been applied in order to allow for potential construction plant trafficking along the crest of the slope. Section C has been considered for rotational failure and in addition for potential plane failure along the bedding surfaces.
Details for the analysis are summarised below in Table SRA 2/5 and analysis outputs are presented in Appendix SRA 1.

Table SRA 2/7

Summary of Stability Analysis for Side Slope Subgrade

Section	Failure Mechanism Analysed	FoS	Comments
A1-1	Rotational	1.874	Section A - Failure through side slope subgrade.
C1-1	Rotational	3.590	Section C - Failure through side slope subgrade.
C1-2	Plane	1.575	Section C - Sliding along bedding plane.

An acceptable minimum factor of safety against failure through the side slope subgrade of 1.575 has been determined.

2.7.3 Waste Mass Analysis

The stability analysis program SLIDE has been used to analyse the sections using Bishop's circular analysis. Sections A and B have been analysed, Section A because it has the main access ramp into the excavation running across it and Section B as it is the highest section of single slope, i.e. it has no benches in it.

Both sections have been analysed for temporary construction conditions (undrained parameters). Section B has then been analysed for the long-term situation, in order to model potential temporary pore fluid pressures in the waste mass due to surface water run-off and the relatively impermeable nature of the mudstone and an r_u value of 0.15 has been assumed for this situation. It is considered that this is a conservative assumption as it is unlikely, given the variability of the waste mass, that a constant pore pressure will develop throughout the whole of the waste mass. The long-term situation has been analysed for slope gradients of 1V in 2.5H and 1V in 4H. The long-term restoration proposal for the series of levels has then been analysed with a water level of 140 m AOD and a sump as the waste is filled in layers to the surface plateau of 158 metres aod and then to the surface. Impounded surface water will be collected in a low point within the site and then used on the quarry for damping down and the wheel wash.

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

Section	Failure Mechanism Analysed	FoS	Comments
A1-2	Rotational	1.522	Section A - Temporary condition, failure through waste mass at 1V in 2.5H, excavation dry.
B1-1	Rotational	1.444	Section B - Temporary condition, failure through waste mass at 1V in 2.5H, excavation dry.
B1-2	Rotational	1.026	Section B - Long-term condition, failure through waste mass at 1V in 2.5H, excavation dry.
B1-3	Rotational	1.705	Section B - Long-term condition, failure through waste mass at 1V in 4H, excavation dry.
B1-4	Rotational	1.690	Section B - Long-term condition, failure through waste mass at 1V in 4H, excavation wet.

An acceptable factor of safety is derived for the construction phase (temporary condition) with a minimum value of 1.444. However, it can be seen that the factor of safety derived for the long- term condition for the 1V in 2.5H slopes in B1-2 is not acceptable and hence it is recommended that the waste slopes should be filled to a gradient of 1V in 4H and in layers from the bottom of the quarry.

The mineral tip on the southside is safe for the period of time to bring the levels of backfill up from the floor of the quarry.

2.7.4 Capping Analysis

Not applicable as the material will be quarry mudstone and weathered sandstone that will be placed over the imported waste from 158 metres aod to the surface.

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 and waste mass assessments. These assessments indicate that the stability of the basal subgrade will be acceptable for the maximum height of side slope and the maximum height of temporary waste slope on the south and east side.

2.8.2 Side Slope Subgrade Assessment

The side slope subgrade has been assessed for both rotational and plane failures. The assessment of this component indicates that the stability of the Coal Measures strata will be acceptable for the maximum proposed height of slope of 29m.

2.8.3 Basal Lining Assessment

Assessment of the basal lining has been undertaken as part of the assessment of the waste mass assessments. These assessments indicate that the stability of the basal liner will be acceptable for the maximum height of the temporary waste slope.

2.8.4 Side Slope Lining Assessment

Assessment of the side slope lining has been undertaken as part of the assessment of the waste mass assessments. These assessments indicate that the stability of the side slope liner against the face will be acceptable for the maximum height with the temporary waste slope.

2.8.5 Waste Mass Assessment

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

The assessment indicates that an acceptable factor of safety is given for the temporary condition that will be present during the construction phase, i.e. with 1V in 2.5H slopes and with a dry excavation. However, the factor of safety for this slope gradient with reduce in the long term, hence it is recommended that slope gradients of 1V in 4H or shallower should be used for the slopes within the waste mass as the levels are brought upto 158 metres aod.

2.8.6 Capping Assessment

Assessment of the capping layers of mudstone from the quarry has been undertaken as part of the assessment of the waste mass assessments. These assessments indicate that the stability of the cap of quarry mudstone placed on the compacted imported inert waste and up against the face will be acceptable for the maximum height of the material from 158 metres aod to the surface contours minus the soil layers of 500 mm and 300 mm.

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 future development of the site. The site will be operated in accordance with the principles of the Quarries Regulations 1999.

2.9.2 Basal Subgrade Monitoring

Prior to placement of any waste / restoration fills the suitability of the basal subgrade will be confirmed by a Geotechnical Engineer. Any soft or wet areas will need to be removed and replaced with suitable granular fill to be approved by the Geotechnical Engineer. 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.

2.9.3 Side Slope Subgrade 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.

2.9.4 Basal Lining Monitoring

Monitoring during construction will comprise construction quality assurance to ensure compliance with the construction specification and a topographical survey.

2.9.5 Side Slope Lining Monitoring

Monitoring during construction will comprise construction quality assurance to ensure compliance with the construction specification of quarry mudstone built in berms 3 metres wide and a slope of 1 in 2.5 off the previous berm with a construction report..

2.9.6 Waste Mass Monitoring

Samuel Gledhill Ltd site personnel will undertake daily inspections of the waste mass to confirm its stability, a written record of all inspections will be maintained. Waste acceptance procedures will ensure the material is suitable for compaction in the void.

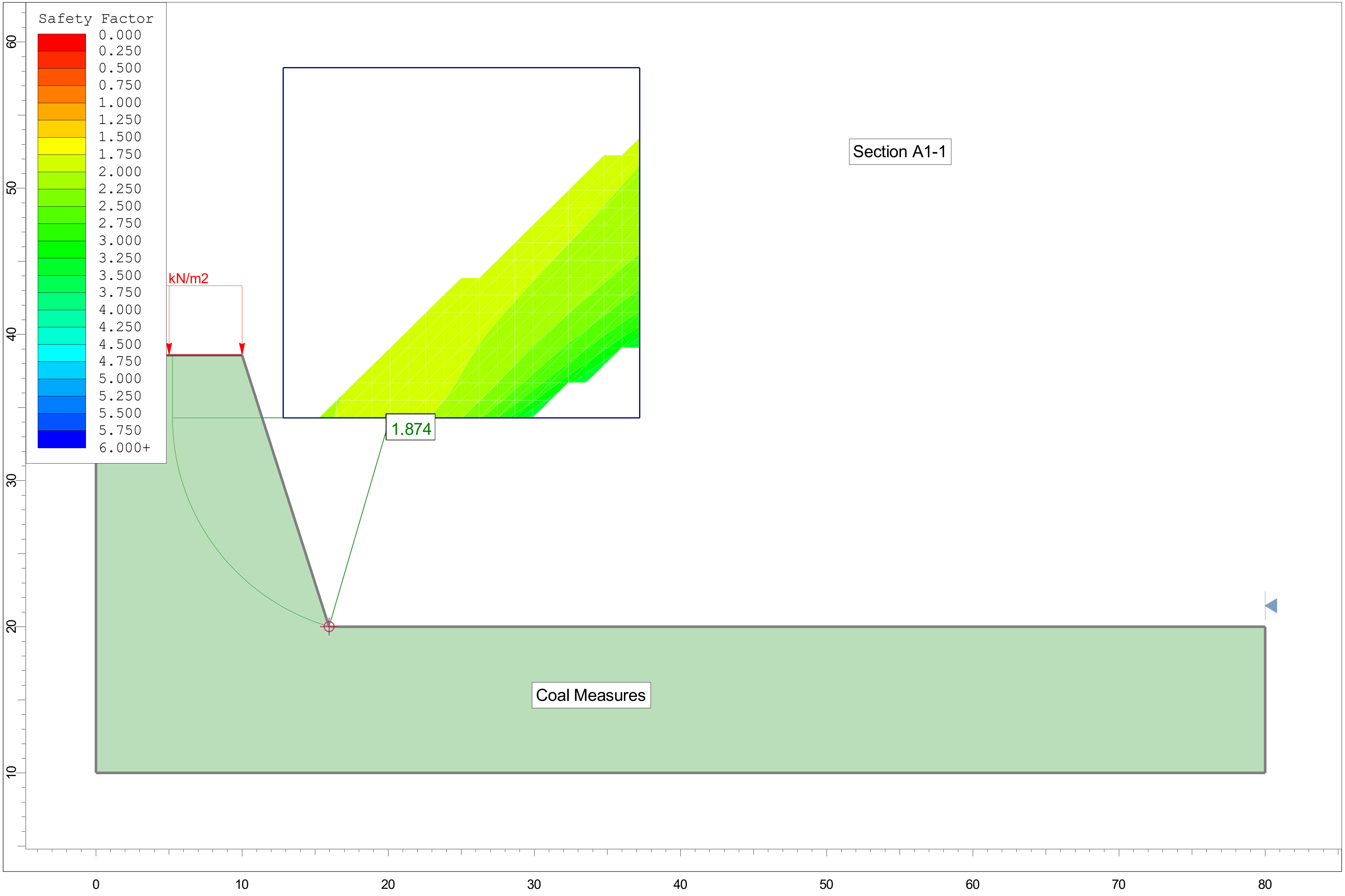
2.9.7 Capping System Monitoring

Monitoring during construction will comprise construction quality assurance to ensure compliance with the construction specification and a topographical survey.

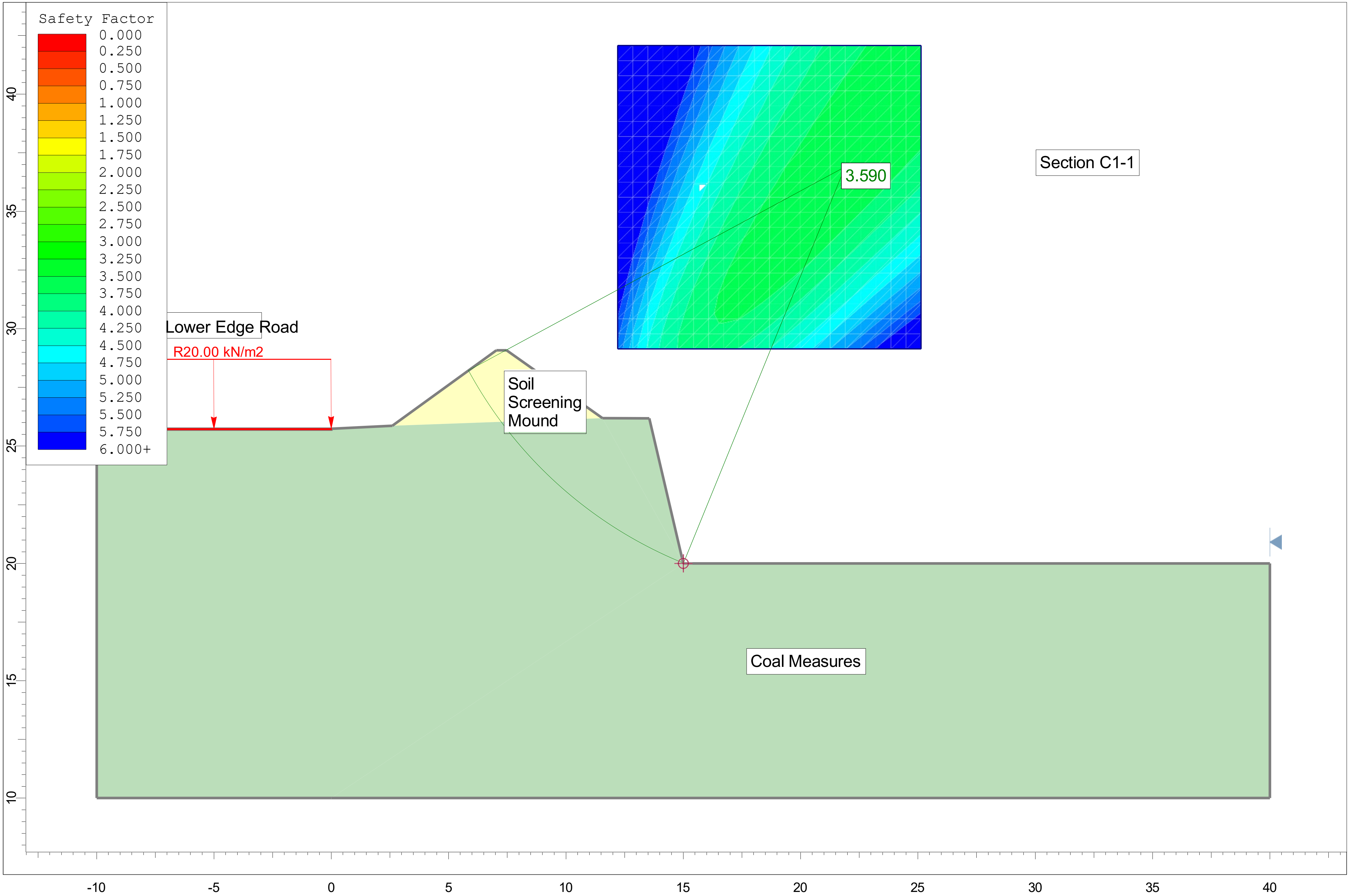
2.9.8 Restoration Monitoring

The planning permission requires that the restoration of the site is monitored by the operator and the Local Authority in the compliance visits

APPENDIX SRA 1



Safety Factor
0.000
0.250
0.500
0.750
1.000
1.250
1.500
1.750
2.000
2.250
2.500
2.750
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+
kN/m2
1.874
Section A1-1
Coal Measures



Safety Factor
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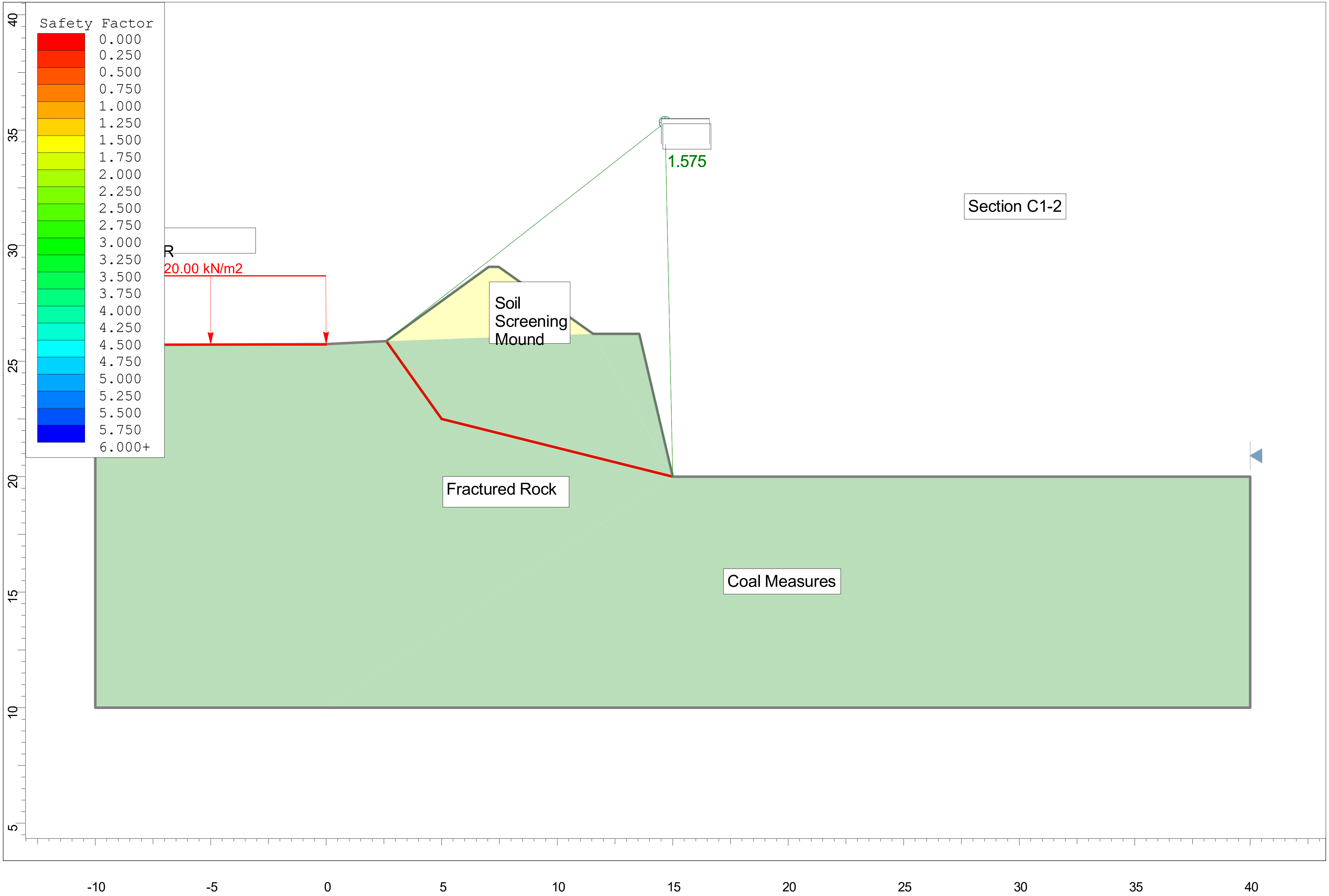
0.750
1.000
1.250
1.500
1.750
2.000
2.250
2.500
2.750
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
3.590
Section C1-1
Lower Edge Road
R20.00 kN/m2
Soil
Screening
Mound
Coal Measures
40
35
30
25
20
15
10
-10
-5
0
5
10
15
20
25
30
35
40



Safety Factor
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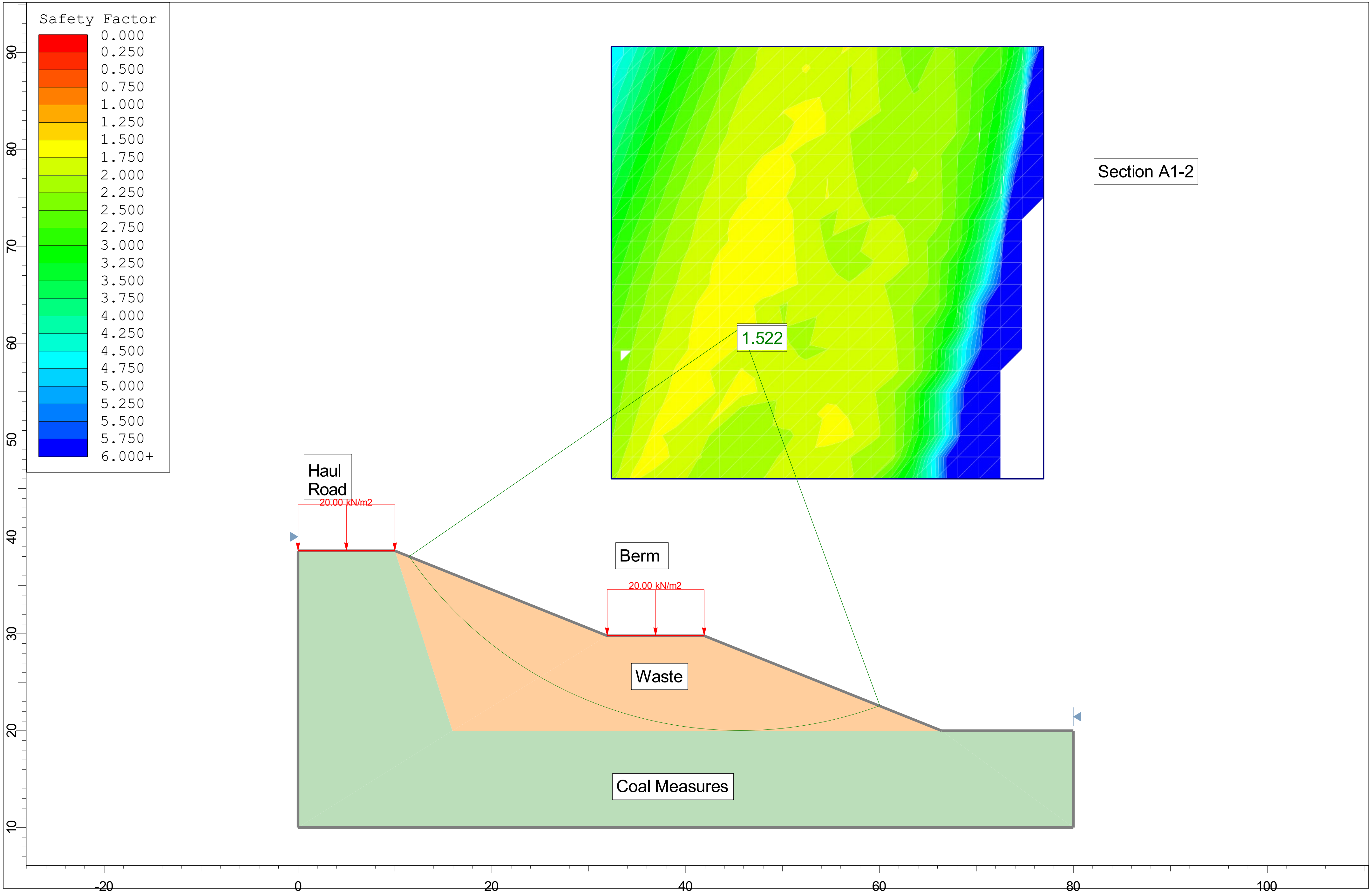
1.000
1.250
1.500
1.750
2.000
2.250
2.500
2.750
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
1.575
Section C1-2
R
20.00 kN/m2
Soil Screening Mound
Fractured Rock
Coal Measures
40
35
30
25
20
15
10
5
-10
-5
0
5
10
15
20
25
30
35
40


Safety Factor
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0.750
1.000
1.250
1.500
1.750
2.000
2.250
2.500
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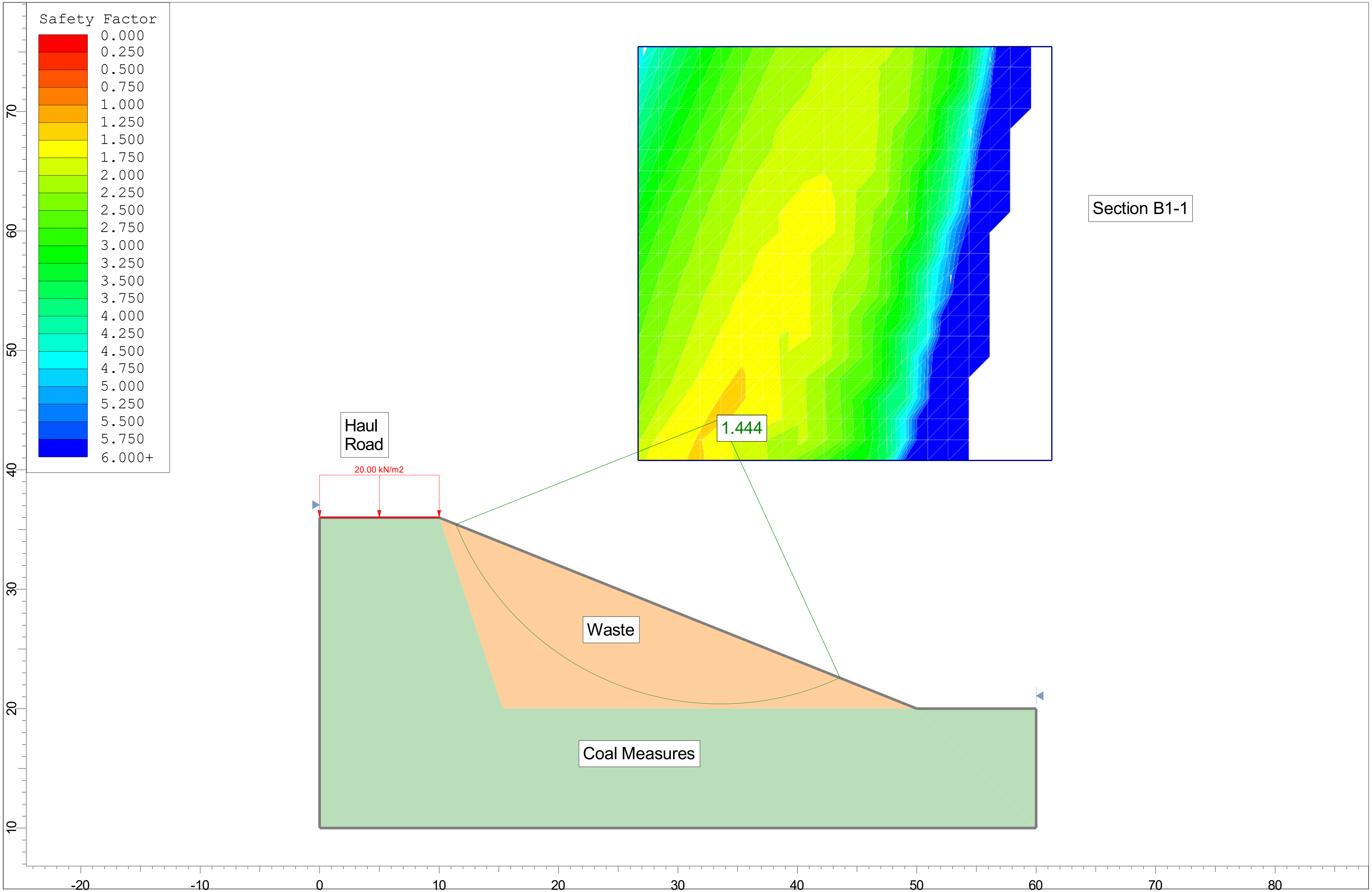
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
Section A1-2
1.522
Haul Road
20.00 kN/m2
Berm
20.00 kN/m2
Waste
Coal Measures
90
80
70
60
50
40
30
20
10
-20
0
20
40
60
80
100



Safety Factor
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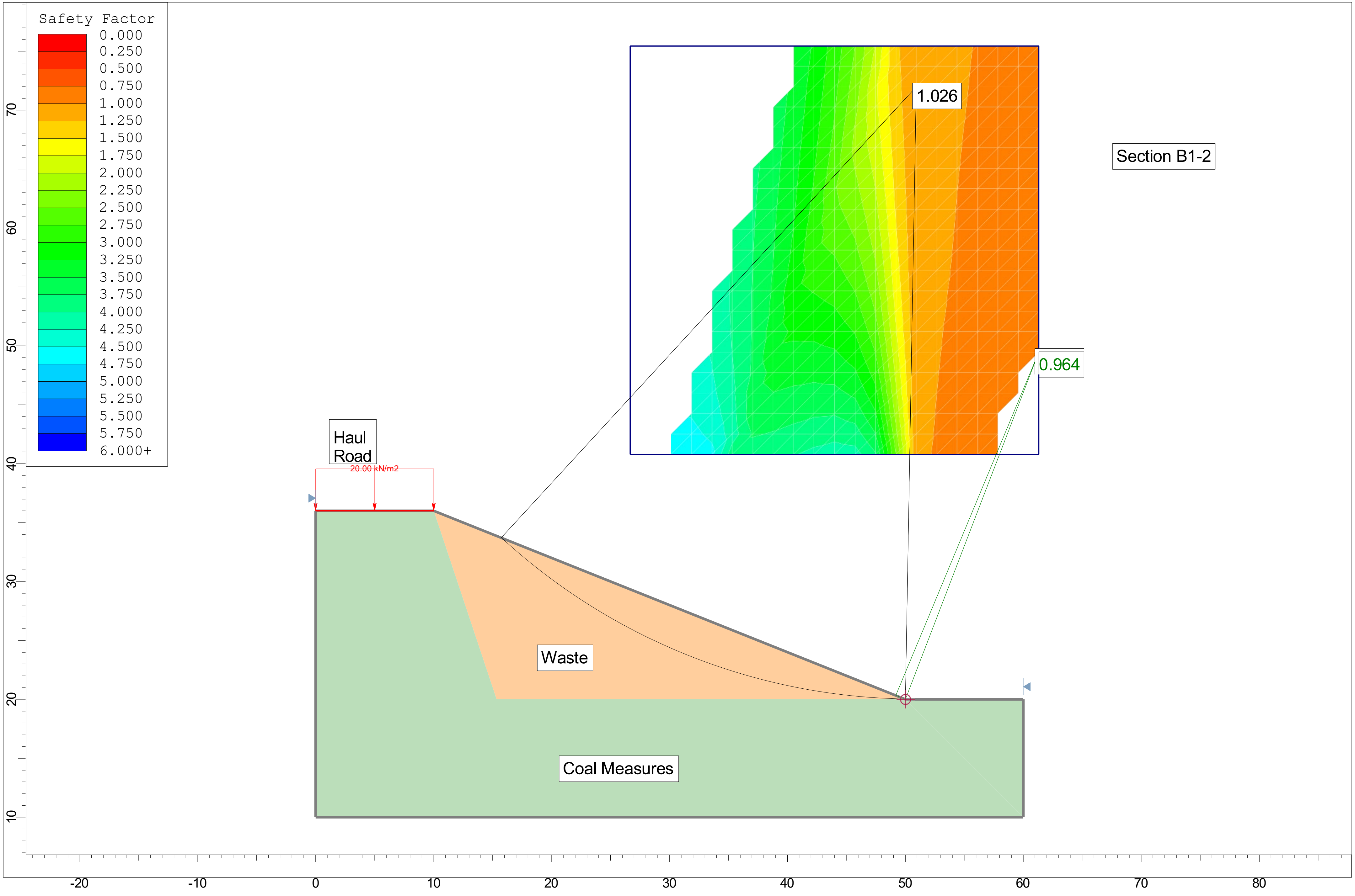
0.500
0.750
1.000
1.250
1.500
1.750
2.000
2.250
2.500
2.750
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
1.444
Section B1-1
Haul Road
20.00 kN/m2
Waste
Coal Measures
10
20
30
40
50
60
70
-20
-10
0
10
20
30
40
50
60
70
80



Safety Factor
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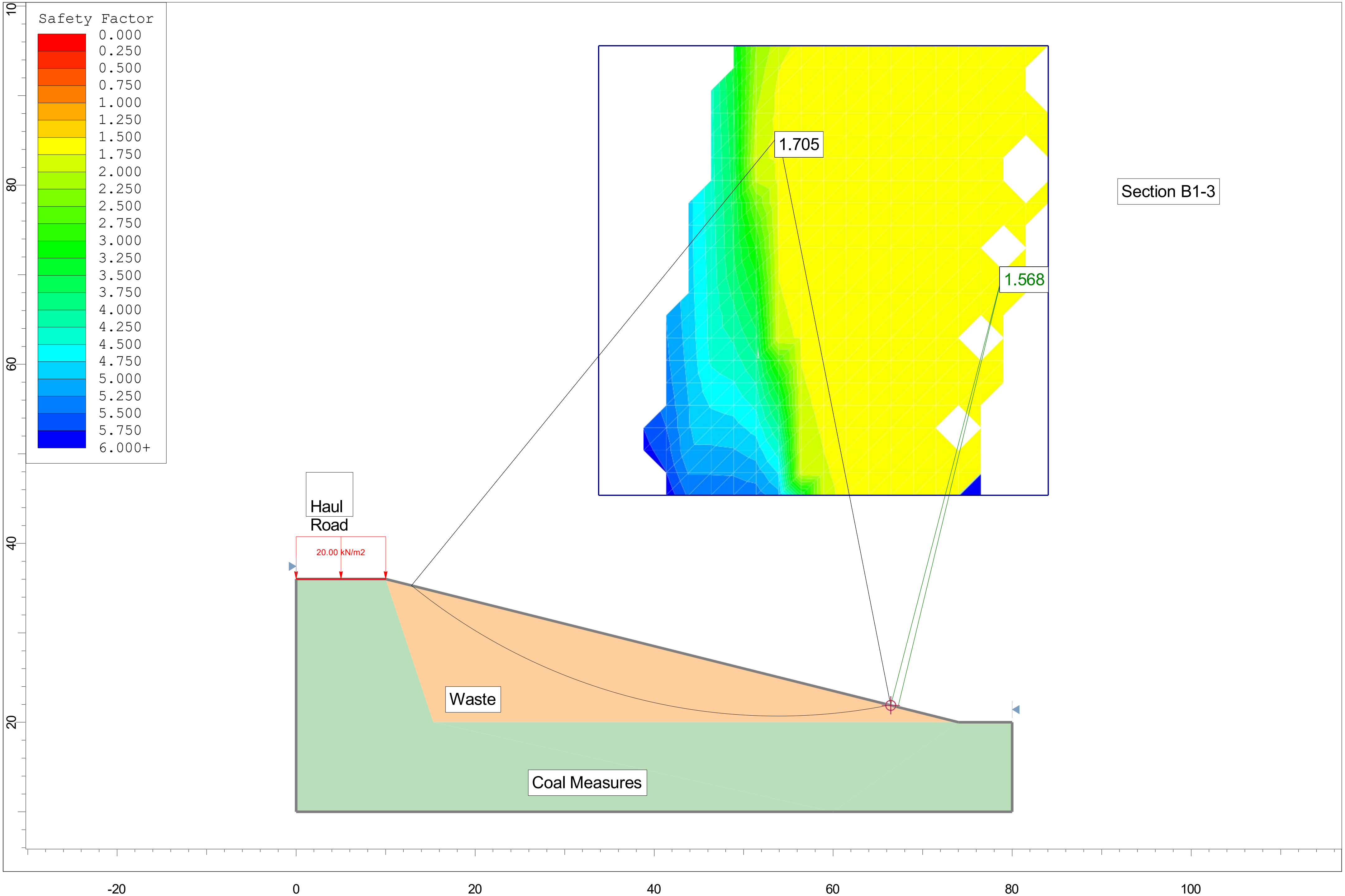
0.750
1.000
1.250
1.500
1.750
2.000
2.250
2.500
2.750
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
1.026
0.964
Section B1-2
Haul Road
20.00 kN/m2
Waste
Coal Measures
70
60
50
40
30
20
10
-20
-10
0
10
20
30
40
50
60
70
80



Safety Factor
0.000
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0.750
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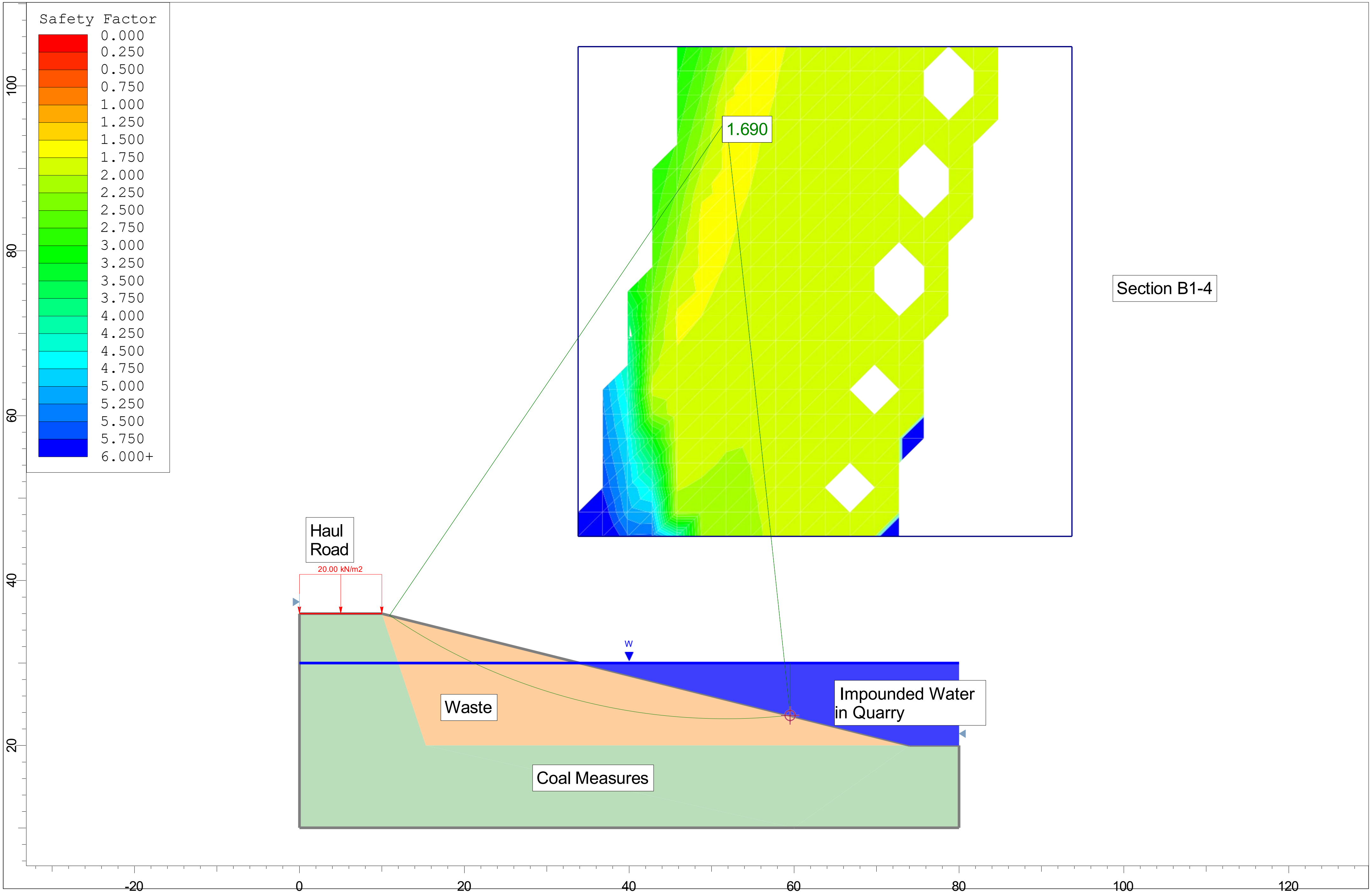
1.250
1.500
1.750
2.000
2.250
2.500
2.750
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
1.705
1.568
Section B1-3
Haul Road
20.00 kN/m2
Waste
Coal Measures
100
80
60
40
20
-20
0
20
40
60
80
100



Safety Factor
0.000
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0.750
1.000
1.250
1.500
1.750
2.000
2.250
2.500
2.750
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+
1.690
Section B1-4
Haul Road
20.00 kN/m2
W
Waste
Impounded Water in Quarry
Coal Measures
100
80
60
40
20
-20
0
20
40
60
80
100
120

APPENDIX SRA 2

DRAWINGS

APPENDIX
SRA 3

PERMIT AREA