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TOOWOOMBA RANGE RAILWAY

SITE INVESTIGATION AND REMEDIAL SLOPE DESIGN – CH 144.500 TO 144.850 KM

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REPORT

Report Number. 137632080-012-R-Rev0

Golder Associates

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1.0 INTRODUCTION

At the request of Queensland Rail (QR) a geotechnical investigation and remedial slope design has been undertaken by Golder Associates (Golder) for the slope located below the rail line between approximate Chainage (Ch) 144.500 km and Ch 144.850 km on the Toowoomba Range Railway. The field investigation was completed between 18 February and 12 March 2015.

The work was completed as per the scope detailed in Golder Proposal 137632080-008-P-Rev0 (5 February 2014).

This report presents the findings of the geotechnical investigation and analysis, together with a proposed remedial slope design for tender purposes and recommendations for further work.

2.0 BACKGROUND

The slope below the rail line between Ch 144.500 km and Ch 144.850 km has been subject to instability since at least January 2011 and the slope was remediated at this time by QR. Further instability including a landslip at the slope crest occurred in February 2013 and since this time work including geotechnical and hydrological assessments by Golder, and monitoring by QR have been undertaken. Details of the work completed to date are presented in the following documents:

1) Golder Technical Memorandum – *Toowoomba Range Railway, Geotechnical Assessment and Conceptual Remedial Design, Slope between Ch 144.500 km and Ch 144.850 km* (reference 137632080-002-TM-Rev0, 6 August 2013).
2) Golder Technical Memorandum – *Toowoomba Range Railway Scoping Study, Geotechnical Risk Assessment, Preliminary Findings and Recommendations* (reference 147632056-001-TM-Rev0, 9 July 2014).
3) Golder Report – *Toowoomba Range Railway Scoping Study, Hydrological Assessment* (reference 147632056-003-R-RevA, 9 July 2014).
4) Golder Technical Memorandum – *Toowoomba Range Railway, Geotechnical Certification of Temporary Access Tracks, Ch 142.7 km and Ch 144.7 km* (reference 137632080-010-TM-Rev0, 10 April 2015).

3.0 SITE DESCRIPTION

3.1 General

The site generally comprises the natural upslope area and downslope fill embankment, either side of the rail line and access road between approximate Ch 144.500 km and Ch 144.850 km. The rail line is inferred to be located on a combination of cut and fill along this section.

In the section of railway corridor between approximate Ch 144.52 km and 144.75 km there are two access roads (described as upper and lower). The upper access road is located adjacent to the rail line and provides local access to the western portal of Tunnel 3 located at approximate Ch 144.52 km (but no through access). The lower access road is located up to approximately 10 m below the rail line in the mid-slope area and provides through access below and around Tunnel 3.

There are three main areas of focus in this section of railway corridor, at the following approximate downslope locations: a) Landslip between Ch 144.530 – 144.610 km, b) The railway embankment including upper and lower access roads in the filled gully between Ch 144.710 – 144.740 km and c) The railway embankment between Ch 144.790 – 144.830 km. Monitoring of slope movements and tension cracks at all three sites has been on-going since early 2013.

The general site layout is shown in Figure 1 and the site is shown in Photographs 1 to 9.

Cross-sections showing topography, relevant surface features and ground conditions based on borehole drilling are presented in Drawings D001 to D004.

Further site details are provided in Document 1 referenced above in Section 2.0.

Access to the slope crest was provided by the existing access road located adjacent and parallel to the rail line. Temporary tracks were constructed to provide drill rig access to the slope toe area (for details refer to Document 4 referenced above in Section 2.0).

3.2 Existing Drainage

Three under-rail culverts are located within this site and the details as reported on the supplied QR database are summarised in Table 1. Additionally, the under-rail culvert located at Ch 144.920 km on the western boundary of the site directs surface water along the existing slope toe and it is therefore considered prudent to also include this in the assessment.

Also included is a summary of known revised culvert details, arising from the remedial work undertaken by QR in 2011.

Table 1: Summary of Under-Rail Culverts (Ch 144.500 – 144.850 km)

Chainage (km)	Original Details[1]			Observed Details[2]	
	Culvert Type	Dimension	Length (m)	Observed Culvert Type	Observed Dimension
144.560	Concrete pipe	380 mm diameter	4	Concrete pipe (inlet), Corrugated metal pipe (outlet).	380 mm diameter (inlet), 450 mm diameter (outlet).
144.620	Box drain	600 mm × 600 mm	8	Concrete box drain (inlet), Corrugated metal pipe (outlet).	600 mm high × 750 mm wide (inlet), 900 mm diameter (outlet).
144.730	Box drain	380 mm × 580 mm	20	Corrugated metal pipe	650 mm diameter inlet, 900 mm diameter outlet.
144.920	Stone arch and concrete pipe	900 mm × 1300 mm	15	Concrete pipe (inlet), Corrugated metal pipe (outlet).	900 mm diameter

Notes: 1 Based on supplied QR database.
2 Based on Golder site observations.

Remediation of the slope between Ch 144.500 km and Ch 144.850 km will require replacement and/or possible upgrading of the under-rail culverts listed above.

4.0 METHOD OF INVESTIGATION

4.1 Subsurface Investigation

The subsurface investigation comprised drilling of nine boreholes to depths of between 10.09 m and 20.63 m below ground level (bgl) using a track mounted Comacchio Geo 205 drill rig. Boreholes BH01, BH03, BH05 and BH07 were located adjacent to the rail line on the access road. Boreholes BH02A, BH02B, BH04 and BH08 were located along the toe of the embankment.

Borehole BH06 was located on the lower access road as the originally proposed borehole location downslope of this position could not be accessed due to the presence of steep and densely vegetated terrain.

The boreholes were advanced using a combination of drilling methods including open hole augering, cased washboring, and limited NMLC diamond drill coring. *In situ* testing comprised Standard Penetration Tests (SPT) completed at typical depth intervals of 1.5 m. Boreholes were backfilled with cement grout (along slope crest) or drill cuttings (slope toe).

Test locations are shown on Figure 1.

All work within the railway corridor was carried out under the supervision of a QR appointed Protection Officer (PO).

Test locations were cleared for buried services by an independent subcontractor (CRLS) engaged by Golder.

Subsurface materials were logged by a geotechnical engineer from Golder in general accordance with AS1726-1993 *Geotechnical Site Investigations*.

A summary of subsurface conditions encountered is presented in Section 5.0, and Reports of boreholes are presented in **Appendix A**. Reference should also be made to the '*Explanation of notes, abbreviations & terms used on borehole and test pit reports*' presented in the same Appendix.

North Surveys Pty Ltd were engaged by Golder to survey borehole locations, and key topographic features including slope crests and toes, to supplement the existing LiDAR survey data. Survey coordinates are relative to Australian Height Datum and Map Grid of Australia 1994.

4.2 Laboratory Testing

Laboratory testing was carried out on selected samples recovered from the boreholes and included:

- Natural moisture contents
- Atterberg limits
- Particle Size Distribution (PSD)
- Emerson Class Number (ECN)

Laboratory testing was carried out in accordance with AS1289-2000 *Methods of Testing Soils for Engineering Purposes* at Golder's NATA accredited laboratory in West End, Brisbane and the test reports are presented in **Appendix B**.

5.0 RESULTS OF INVESTIGATION

5.1 Subsurface Conditions

5.1.1 General

The subsurface conditions encountered at borehole locations generally comprised embankment fill overlying colluvium or residual soil, in turn overlying extremely weathered sandstone with some interbedded mudstone.

The presence of temporary platform fill was confined to boreholes located along the slope toe, and was associated with access tracks and work platforms constructed to provide temporary drill rig access.

It should be noted that *in situ* material was not encountered in Boreholes BH02A and BH02B, and these were terminated in colluvium at depths of 12.0 m and 19.0 m bgl respectively.

The *in situ* materials encountered during the subsurface investigation correlate with published geological maps of the area, which indicate that the bedrock comprises Jurassic aged Koukandowie Formation consisting of lithofeldspathic labile and sublabile to quartzose sandstone, siltstone, shale and minor coal.

A summary of the encountered subsurface conditions is presented in Table 2 and detailed borehole logs are presented in **Appendix A.**

Table 2: Summary of Ground Conditions (Ch 144.500 – 144.850 km)

Ground Profile and Material Description	Depth to Top (metres below ground level)							
	Along Upper Access Road				Along Slope Toe			
	BH01	BH03	BH05	BH07	BH02B	BH04	BH06	BH08
FILL – Sandy Clayey GRAVEL (Road-base) Fine to coarse, grey and brown, fine to coarse sand, low to medium plasticity clay, medium dense to dense.	0.0	0.0	0.0	0.0	NE	NE	0.0	NE
Temporary Platform FILL – Clayey SAND Fine to coarse grained, low plasticity clay, grey and brown, some gravel and occasional cobbles, moist, loose to medium dense.	NE	NE	NE	NE	0.0	0.0	NE	0.0
LANDSLIDE DEBRIS Recent Landslide Debris comprising previous Embankment Fill – Clayey SAND Fine to medium grained, brown, grey and orange, medium plasticity clay, moist to wet, very loose to loose.	NE	NE	NE	NE	NE	NE	NE	0.6
Embankment FILL – Clayey Sand/ Sandy Clay Fine to coarse grained, low to medium plasticity clay, brown, grey and orange, some gravel and occasional cobbles, moist, loose to dense/firm to very stiff. BH06: boulders and cobbles between depth of 3.30 – 3.90 m.	0.5	0.4	0.3	0.4	1.0	2.8	1.5	3.8
COLLUVIUM BH02: Sandy CLAY and BOULDERS – medium plasticity clay, brown, fine to medium sand, moist, very stiff; and high strength basalt boulders 300 – 600 mm. BH04: Gravelly Clayey SAND – fine to medium grained, dark brown, grey and orange, medium plasticity clay, fine to medium gravel.	NE	NE	NE	NE	4.1	8.0	NE	NE
RESIDUAL SOIL – Clayey SAND Fine to coarse grained, pale brown, grey and orange, low to medium plasticity clay, dry to moist, medium dense to dense. BH06: Silty SAND, fine to medium, dry, dense.	4.8	11.0	4.0	2.0	NE	NE	6.8	NE
SANDSTONE – Fine to medium grained, orange and brown, extremely low to low strength, extremely weathered, with some completely weathered zones up to 700 mm thick. Some interbedded MUDSTONE layers up to 2.0 m thick – fine grained, orange and grey, extremely low strength, extremely weathered. Occasionally decomposed to very stiff clay up to 1.3 m thick.	9.6	12.8	5.2	7.6	NE	17.4	7.6	6.6
Termination Depth	14.58	16.22	10.15	11.18	19.0	20.63	14.79	10.09
Groundwater Observations	N/O	N/O	N/O	N/O	N/O	N/O	N/O	N/O

Notes: NE – Not Encountered.
N/O – Groundwater not observed.

5.1.2 Embankment Fill

The embankment fill below the existing access road adjacent to the rail line typically comprised clayey sand/sandy clay and varied in thickness between 2.0 m (BH07) and 11.0 m (BH03 in filled gully), with SPT N values ranging between 5 and 33. The lower range of SPT N values between 5 and 11 were associated with fill in Borehole BH03 down to 10.0 m depth, and Borehole BH05 at 2.5 m depth.

It should be noted that complete drill fluid loss was observed in Borehole BH03 at 5.1 m depth in loose clayey sand fill, highlighting the permeable nature and relatively lower density of material at this location.

Embankment fill along the slope toe (including at Borehole BH06 on the lower access road) typically comprised sandy clay/clayey sand and varied in thickness between 2.8 m (Borehole BH08) and 6.8 m (Borehole BH06), with SPT N values ranging between 5 and 19.

In Borehole BH06 a layer of boulders and cobbles was encountered between 3.3 m and 3.9 m depth.

5.1.3 Landslide Debris

In Borehole BH08 landslide debris comprising displaced clayey sand embankment fill was encountered between 0.6 m and 3.8 m depth. SPT N values of 0 and 4 were recorded in this material indicating very loose to loose conditions. The material was found to be moist to wet.

5.1.4 Colluvium

Colluvium was encountered in three boreholes underlying the embankment fill (BH02A, BH02B and BH04).

At Boreholes BH02A and BH02B the colluvium comprised very stiff sandy clay and boulders (up to 600 mm in size) with a thickness of at least 14.9 m. SPT N values in this material typically varied between 14 and 21 (except at 9.0 m depth in BH02A where refusal with SPT hammer bounce was observed). The base of the colluvium was not encountered in Boreholes BH02A and BH02B.

It should be noted that the colluvium encountered in Boreholes BH02A and BH02B (comprising a mixture of clay and boulders) would not normally be recovered with the drilling techniques employed for the other boreholes on this site (wash boring). However wash boring was attempted to gather as much information as possible without the need to mobilise additional specialist equipment. Drilling progress was difficult and slow due to the numerous rock boulders encountered.

Borehole BH02A was aborted at 12.0 m depth as the SPT sampler was broken off the drill rod string at the base of the borehole in basalt boulders. A second attempt to progress this borehole was made 3.0 m away at Borehole BH02B. Borehole BH02B was progressed to 19.0 m depth before being aborted due to drill fluid loss at 18.5 m depth and refusal on basalt boulders.

At Borehole BH04 the colluvium comprised medium dense to dense gravelly clayey sand with a thickness of 9.4 m. SPT N values in this material typically varied between 14 and 41 (except at 11.5 m and 16.0 m where penetrations of 100 mm to 130 mm were observed for 30 blow counts).

Additional information about colluvium observed in the slope toe area is presented in Section 5.2.

5.1.5 Residual Soil

Residual soil was encountered in five boreholes underlying embankment fill (BH01, BH03, BH05, BH06 and BH07) and typically comprised medium dense to dense clayey sand, between 0.8 m and 5.6 m thick. SPT N values in the residual soil varied between 12 and 44.

5.1.6 Bedrock

The depth to *in situ* weathered rock varied between 5.2 m and 12.8 m bgl adjacent to the railway (below the upper access road), and between 6.6 m and 17.4 m bgl along the slope toe. Rock was encountered in all boreholes except Boreholes BH02A and BH02B.

The greatest confirmed depth to rock across this site was observed in Boreholes BH03 (12.8 m) and BH04 (17.4 m) located in the filled gully between Ch 144.710 km and 144.740 km. In Borehole BH02B the depth to rock was greater than 19.0 m.

The *in situ* rock typically comprised extremely low to low strength, extremely weathered sandstone with interbedded extremely low strength mudstone layers up to 2.0 m thick.

Decomposed zones were observed within the bedrock at the following borehole locations:
BH01/11.2 – 12.5 m (completely weathered mudstone comprising very stiff silty clay), and
BH06/12.9 – 13.6 m (completely weathered sandstone comprising medium dense silty sand).

The results of the current investigation, specifically Borehole BH08, generally correlate with the results of the previous test pit investigation in this area (TP1 to TP3, June 2013) and confirmed the presence of *in situ* very low strength, extremely weathered mudstone at a depth of 6.6 m bgl (which includes 0.6 m thickness of temporary platform fill). At Borehole BH08 the mudstone was found to be 0.5 m thick and underlain by very low to low strength, extremely weathered sandstone.

5.1.7 Groundwater Observations and Drill Fluid Loss

Groundwater observations were not possible in the boreholes (whether it was present or not) due to the addition of water into the borehole during the drilling process. However, it is possible that groundwater is present, or may be present in the future, in the materials underlying the railway corridor (particularly after heavy or prolonged rainfall). It should be noted that the ground investigation was completed during the months of February and March after a relatively wet summer.

Drill fluid loss, indicating the likely presence of permeable and relatively lower density/poorer quality materials, was observed at the following borehole locations: BH01/7.5 m in residual clayey sand, BH02A/5.6 m and BH02B/18.5 m in sandy clay and boulder colluvium, BH03/5.1 m in clayey sand fill, and BH04/5.0 m in sandy clay fill.

5.2 Site Walk-Over Inspection

During the ground investigation it was discovered that the colluvium at Borehole BH02B extended to a depth of at least 19.0 m bgl (borehole termination depth). The thickness of colluvium at this location is greater than anticipated and it was expected that bedrock would have been encountered before the termination depth.

To supplement the findings of the ground investigation a site walk-over inspection was undertaken on 14 April 2015 in the area downslope of Borehole BH02B with the aim of identifying any relevant features that could inform the remedial slope design. One of the main objectives was to identify any existing outcrops of *in situ* bedrock, if present.

Key geological observations were made at five locations (labelled G1 to G5 on Figure 1) and these are summarised below:

- The presence of colluvium, typically comprising basalt cobbles and boulders, was noted at the surface at all five locations. Outcrops of *in situ* bedrock were not observed. These observations together with the results of drilling at Borehole BH02B suggest that the actual northern edge of basaltic colluvial deposits is located up to approximately 100 m further north than indicated on published geological maps. The inferred revised colluvial boundary is shown on Figure 1.
- Geological Observation G2 is located in a gully which forms the outflow channel for the under-rail culvert located at Ch 144.92 km. The gully is filled with colluvium comprising basalt cobbles and boulders, and some minor clay.

5.3 Laboratory Test Results

The laboratory test results are summarised in Table 3 below.

The results indicate that the tested materials include medium to high plasticity clay.

Emerson Class Numbers (ECN) of 3, 5 and 6 were recorded for the eleven samples that were tested. Three samples of the eleven tested had an ECN of 3 which indicates a moderate to high potential for dispersion. These samples included clayey sand and gravelly sandy clay fill, and natural mudstone. The remaining eight samples had ECNs of 5 and 6 which are generally indicative of non-dispersive materials. These samples included sandy clay fill, sandy clay colluvium, residual clayey sand, completely decomposed mudstone and weathered sandstone.

Table 3: Laboratory Testing Summary (Ch 144.500 – 144.850 km)

BH ID	Sample Depth		Moisture (%)	Atterberg Limits			Particle Size Distribution			Emerson Class Number
	From (m)	To (m)		Liquid Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)	Gravel (%)	Sand (%)	Fines (%)	
BH01	4	4.45	19	-	-	-	9	59	32	-
BH01	5.5	5.95	32.1	-	-	-	0	71	29	-
BH01	11.5	11.95	24.3	53	32	15	-	-	-	6
BH02	4	4.45	26.4	-	-	-	9	17	74	-
BH02	7.5	7.95	31.5	-	-	-	-	-	-	6
BH03	4	4.45	26.4	-	-	-	6	38	56	3
BH03	7	7.45	31.8	-	-	-	-	-	-	5
BH03	8.5	8.95	29.5	-	-	-	15	30	55	-
BH03	11.5	11.95	15.5	-	-	-	3	49	48	5
BH04	4	4.45	19.9	46	30	15	-	-	-	6
BH04	5.5	5.95	14.9	-	-	-	8	42	50	-
BH04	8.5	8.95	12.6	-	-	-	12	51	37	-
BH04	17.5	17.57	-	-	-	-	-	-	-	6
BH05	2.5	2.95	17.5	-	-	-	24	62	14	-
BH05	5.5	5.93	22.2	-	-	-	1	63	36	5
BH06	1.7	2.15	13.1	-	-	-	29	35	36	-
BH06	2.5	2.95	16	-	-	-	-	-	-	3
BH06	7	7.45	13.2	-	-	-	0	63	37	-
BH06	11.5	11.95	20.2	55	32	16.5	-	-	-	3
BH07	4	4.45	15.1	-	-	-	1	60	39	5
BH08	5.5	5.95	21.4	-	-	-	3	28	69	-

6.0 SLOPE STABILITY ASSESSMENT

6.1 General

Observations made on the Toowoomba Range Railway by Golder since 2011 indicate that poor or inadequately maintained surface water drainage, leading to an increase in pore water pressure in the embankment fill, is a key contributing factor to slope instability. Other factors contributing to slope instability are considered to include the following:

- Inadequately prepared foundation along the slope toe.
- Lack of restraining force or a shear key along the slope toe.
- Lack of an adequately benched and drained slope core.
- Poor or lack of surface water drainage along the slopes and lower access road.

Slope stability analysis was undertaken using the Morgenstern-Price limit equilibrium method and the computer program SLOPE/W (GEO-SLOPE, 2012). Several cases were analysed including a back analysis to assess the likely conditions present at the time of failure, and the proposed remedial design to verify its adequacy.

The material type and strength properties adopted for the stability analyses are summarised in Table 4. These are based on the ground conditions revealed in the investigation boreholes, laboratory test results and previous experience of slope behaviour in this region.

Table 4: Adopted Geotechnical Parameters for Slope Stability Analysis

Material	Unit Weight γ (kN/m^3)	Cohesion c' (kPa)	Friction Angle ϕ' (degrees)
Embankment Fill	18	2 – 4	26
Colluvium	18	5	30
Residual Soil	18	5	30
Extremely Weathered Rock	22	25	30
Rock Fill	20	0 – 2	40

6.2 Back Analysis

A back analysis was undertaken to model the inferred slope conditions at the time of failure between approximate Ch 144.500 km and Ch 144.850 km, and this was based on the following assumptions:

- Material properties summarised in Table 4.
- Slope angle of 27 – 35° below horizontal.
- Slope heights ranging between approximately 15 – 25 m.
- Groundwater conditions:
  - Dry.
  - Wet, with a Pore Water Pressure Ratio (Ru) of 0.15 and 0.2.

The investigation results indicate variable ground conditions across the site and it was therefore necessary to model slopes at four separate locations, represented by sections AA, BB, CC and DD (refer Figure 1).

The results of the slope stability analysis including the adopted geological models and critical failure surfaces are presented in **Appendix C**.

The back analysis results indicate that the analysed slopes are likely to be marginally stable in dry conditions with a Factor of Safety (FoS) of about 1.0. This suggests that any increase in driving forces (for example, due to development of pore water pressures or introduction of surcharge loads) could possibly lead to slope instability.

In wet conditions, with an Ru of 0.15 in the embankment fill and underlying colluvium and residual soil, a FoS of less than unity was obtained (typically 0.8). The critical failure surfaces were located within the embankment fill and the results support the hypothesis that slope failures were probably triggered by the infiltration of surface water into the embankment fill combined with poor drainage.

7.0 PROPOSED REMEDIAL SLOPE DESIGN

7.1 General Approach

The following general approach is proposed for slope remediation at the Ch 144.7 km site:

- Excavation and removal of fill, colluvium and residual soil to expose a suitable founding material at the slope toe and across the slope. The foundation material at the slope toe will vary across the site and it is anticipated to comprise colluvial clay and sand in the western half of the site, and *in situ* weathered rock in the eastern half of the site.
- Excavation of a shear key trench at the slope toe to provide the foundation and lateral restraint for the new construction.
- Preparation of a temporary benched cut across the slope to provide the base for the new construction.
- Reconstruction of the slope to a 1V:1.5H batter using select rock fill, and assuming that the existing slope crest positions adjacent to the rail line and lower access road levels are to be maintained. This proposed solution has the benefit of being relatively easy to construct with conventional earth moving equipment, and results in a free-draining slope which reduces the risk of pore water pressure build up and the potential instability associated with this condition.

Details of the proposed remedial design, suitable to inform the tender process, are presented in Drawings D001 to D004.

7.2 Design Assumptions and Verification

The global stability of slopes is typically defined by a FoS of 1.3 for the temporary condition, and a FoS of 1.5 for the permanent condition and this general approach was adopted for the remedial slope design.

In addition to constraints imposed by material types and geometry, the proposed remedial design also considered the following surcharge loads:

- 12 kPa attributable to railway ballast, sleepers and track.
- 80 kPa for train loading (worst case, e.g. train stationary on slope).
- 10 kPa on the access roads.

Slope stability analysis was undertaken to verify the proposed remedial design and a summary of the results is presented in Table 5.

Further details of the slope stability analysis including the adopted geological models and critical failure surfaces are presented in **Appendix C**.

Table 5: Summary of Slope Stability Analysis (Ch 144.500 – 144.850 km)

Location (Section[1])	Batter Angle[2]	Approx. Slope Height (m)	Mid-Slope Bench (5 m width)	Rock Fill Properties[3]	Founding Material Below Rock Fill[4a]	Founding Material Behind Rock Fill[4b]	Groundwater Conditions[5]	Factor of Safety[6]
AA	35°	17.0	No	c'=2, ϕ'=40°	Colluvium	Colluvium	Dry	1.38
							Wet, Ru = 0.15	1.16
	35°	19.5	Yes	c'=2, ϕ'=40°	Colluvium	Colluvium	Dry	1.43
							Wet, Ru = 0.15	1.20
	33°	18.5	No	c'=2, ϕ'=40°	Colluvium	Weathered Rock	Dry	1.43
							Wet, Ru = 0.15	1.41
BB	35°	22.5	Yes	c'=2, ϕ'=40°	Colluvium	Colluvium	Dry	1.38
							Wet, Ru = 0.2	1.16
	33°	23.5	Yes	c'=2, ϕ'=40°	Colluvium	Weathered Rock	Dry	1.49
							Wet, Ru = 0.2	1.47
CC	35°	28.0	Yes	c'=2, ϕ'=40°	Weathered Rock	Weathered Rock	Dry	1.35
							Wet, Ru = 0.15	1.35
DD	35°	22.0	Yes	c'=2, ϕ'=40°	Weathered Rock	Weathered Rock	Dry	1.43
							Wet, Ru = 0.15	1.43

Notes:
1 – Refer to Figure 1 for Section locations.
2 – A batter of 1V:1.5H is approximately equal to 34°.
3 – c' is cohesion in kPa, ϕ' is friction angle.
4a – Horizontal cut surface at slope toe.
4b – Sloping benched cut.
5 – For wet condition, Ru is pore water pressure ratio in colluvium and residual soil.
6 – Assuming surcharge loads comprise 92 kPa on rail line, and 10 kPa on upper and lower access roads.

For the proposed rock fill construction with batter angles of approximately 1V:1.5H and the slope heights and surcharge loads summarised in Table 5, the slope stability results indicate that it is unlikely that a Safety Factor of 1.5 could be achieved if the rock fill is placed against a sloping benched cut comprising colluvium or residual soil. This was particularly the case for wet conditions where Safety Factors of 1.16 and 1.20 were obtained.

The results also show that if the volume of material excavated is increased laterally such that *in situ* weathered rock is exposed in the proposed sloping benched cut behind the rock fill, the Safety Factor increases to between 1.35 and 1.49 for dry conditions, and 1.35 to 1.47 for wet conditions (Ru between 0.15 and 0.2).

The founding material on the proposed horizontal cut surface at the slope toe was modelled as comprising colluvium at Sections AA and BB (western half of site), and *in situ* weathered rock at Sections CC and DD (eastern half of site).

It should be noted that the rock fill was modelled with a small cohesion value of 2 kPa to simulate the interlocking and self-supporting nature of coarse rock fill. This is considered to be a realistic simulation of what could be achieved if using coarse rock fill (≤ 500 mm size) to re-construct the slopes.

In the circumstances (existing earthworks on steep ground and the presence of an extensive thickness of colluvium) a safety factor of 1.35 to 1.49 for dry conditions is considered satisfactory.

8.0 ENGINEERING COMMENTS AND RECOMMENDATIONS

8.1 Proposed Slope Remediation

It is anticipated that slope remediation at the Ch 144.7 km site will require reconstruction of the slope across an approximate width of 300 m, with the slope height varying between approximately 15 m and 25 m.

Ground conditions vary across the site and foundation materials at the slope toe are anticipated to comprise colluvium in the western half of the site, and *in situ* weathered rock in the eastern half of the site. It should be noted that the investigation findings varied significantly from anticipated ground conditions based on published geological maps of this area (with colluvium covering a larger than expected area).

A transition between these two founding conditions is anticipated at approximate Ch 144.670 km. However, stratigraphic boundaries (including the base of fill, top of *in situ* weathered rock and areal extent of colluvium) are expected to vary both vertically and laterally across the slope. Therefore the full extent of the proposed remediation can only be accurately defined at the time of re-construction following the removal of fill and other unsuitable material.

Reconstruction of the slope to a 1V:1.5H batter is proposed using select coarse rock fill (< 500 mm size) and assuming that the existing slope crest position and lower access road elevation is to be maintained. This proposed solution has the benefit of being relatively easy to construct with conventional earth moving equipment, and results in a free-draining slope which reduces the risk of pore water pressure build up and the potential instability associated with this condition.

Moving in an easterly direction the existing access road located adjacent to the rail line splits into two roads at approximate Ch 144.75 km, to form the upper and lower access roads. The proposed remedial slope design incorporates a 5 m wide mid-slope bench below the rail line to accommodate reconstruction of the lower access road at its approximate existing elevation.

Further details are presented in Section 7.1 and Drawings D001 and D004.

Temporary removal of the existing rail line and replacement of a new capping layer and rail line will be required as part of the proposed slope remediation, particularly at the site of the filled gully between Ch 144.710 – 144.740 km.

The existing slope is densely vegetated by mature trees and these would need to be removed to facilitate the slope remediation.

It is likely that the reconstructed slope toe will impact on the neighbouring privately owned land located south of the railway corridor. It is recommended that QR accurately establish the position of the site boundary so that this can be considered during the next stages of design and construction.

8.2 QR Specifications

Reference should be made to the QR specifications and drawings listed on Drawings D001 and D004 in this report, which provide direction on foundation excavation, earthworks and construction of railway embankments and slopes.

8.3 General Excavatability

Excavation of the existing fill, colluvium, residual soils and extremely low to low strength, extremely weathered sandstone and mudstone is anticipated to be achievable utilising medium to large excavators (e.g. ≥ 20 tonne) and medium size dozers (e.g. Caterpillar D6). Excavation of low strength or stronger rock may require larger plant or specialised rock excavation equipment such as a ripper (rock pick) or pneumatic rock breaking attachments.

It should be noted that stratigraphic boundaries are likely to vary in both vertical and lateral directions across the slope, particularly the base of fill and top of *in situ* weathered rock. Additionally the composition of the fill is likely to be variable and include soil, rock and possible ash.

8.4 Foundation Preparation and Trafficability

The foundation materials exposed after site stripping and bulk excavation could be subject to strength loss if they become wet. Due to the potential for poor trafficability across parts of the site during wet weather, site stripping should be scheduled to occur during periods of dry weather and shortly before the commencement of fill placement. Placement of a granular working platform may be required to maintain trafficability in heavily trafficked areas particularly during wet weather.

The site should be graded to shed surface water runoff away from the construction area.

It is recommended that foundation areas and temporary cuts be assessed by a qualified geotechnical engineer during the construction phase and prior to placement of rock fill.

8.5 Groundwater in Excavations

Groundwater observations were not possible in the boreholes (whether it was present or not) due to the addition of water into the borehole during the drilling process. However, it is possible that groundwater is present, or may be present in the future, in the materials underlying the railway corridor (particularly after heavy or prolonged rainfall). It should be noted that the ground investigation was completed during the months of February and March after a relatively wet summer.

In excavations where groundwater is encountered softening of exposed soil and weathered rock is likely, and excavation sidewalls may be unstable (especially in gravelly/sandy materials). At locations where groundwater is encountered in excavations, it should be directed away from the construction area or towards excavated sumps from which the collected water can be pumped away.

8.6 Site Drainage

8.6.1 General

The re-instatement and possible upgrading of existing drains is considered crucial to the successful remediation of the slope at the Ch 144.7 km site. Drains include longitudinal table drains running along the upslope side of the rail line, and under-rail culverts which divert surface water from the upslope to downslope sides of the rail line.

It is recommended that regular inspection and maintenance of all drainage infrastructure be undertaken as this is an important part of managing the risk of slope instability.

The proposed remedial design incorporates drainage measures within the slope core to reduce the likelihood of pore water pressure build-up or foundation softening. Control measures include grading all benches and excavations within the slope core, and inclusion of agricultural drains, to divert any surface water that infiltrates through the rock fill away from the slope.

8.6.2 Table Drains

Cleaning out and regrading of existing table drains either side of the proposed slope remediation will be required as part of this work. Additionally it is recommended that the reinstated table drain to be located at the top of the new slope is lined to reduce the likelihood of surface water being inadvertently diverted into the newly constructed slope core through the rock fill. It is considered that this could best be achieved by constructing a concrete lined table drain at this location.

8.6.3 Under-Rail Culverts

Existing under-rail culverts at Ch 144.56 km, 144.62 km, 144.73 km and 144.92 km will require replacement and possible upgrading. These culverts are the subject of a separate study to confirm their capacity, suitability and scour potential.

Site observations indicate that the length of existing under-rail culverts has typically been increased on the downslope side by addition of corrugated metal pipes, presumably at the time of access road construction when fill was placed against the existing railway embankment. It should be noted that the type and dimension of an under-rail culvert typically varies between the upslope (inlet) and downslope (outlet) sides. The type and quality of the connection between the two sections of under-rail culverts is unknown.

It should be noted that the existing under-rail culvert at Ch 144.73 km comprises a corrugated metal pipe that varies in diameter between 650 mm at the inlet and 900 mm at the outlet. The position of the culvert connection is likely to be in the general vicinity of Borehole BH03 which is located along the approximate upslope edge of the access road (though the type of connection is unknown). The inferred invert level of this culvert intersects the line of Borehole BH03 at the location of drill fluid loss and loose ground conditions (at 5.1 m depth). These details are presented graphically on Drawing D002. This suggests that the culvert connection has probably been compromised at this location, and that stormwater leakage and erosion and softening of embankment fill has occurred as a result. This is likely to have contributed to the rail line settlement and formation of tension cracks in the slope crest and lower access road at this location.

It should also be noted that railway embankment and general slope instability should be anticipated at other under-rail culvert locations where the culvert connection is inadequate or has been compromised.

It is recommended that discharge from culvert outlets be directed away from slopes (including the toe area). For example, this could be achieved by the use of plastic hose extensions on culvert outlets or preferably by constructing concrete lined channels down slopes. In the case of rock fill slopes it is particularly important to ensure that water is not directed onto the slope where it can infiltrate into the slope core and cause possible softening of foundation materials.

9.0 LIMITATIONS

Your attention is drawn to the document “Limitations” presented in **Appendix D**. The statements presented in this document are intended to advise you of what your realistic expectations of this report should be, and to present you with recommendations on how to minimise the risks associated with the services provided for this project. The document is not intended to reduce the level of responsibility accepted by Golder Associates, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.

Report Signature Page

GOLDER ASSOCIATES PTY LTD

Greg Rogos
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Principal Geotechnical Engineer

GR/DCS/gr

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FIGURE

TOOWOOMBA RANGE RAILWAY
GEOTECHNICAL ASSESSMENT
AND SLOPE REMEDIATION

QUEENSLAND RAIL LIMITED

SITE PLAN - CH 144.7 KM

LEGEND

- Test Pit (June 2013)
- Borehole (Feb - Mar 2015)
- Geological Observation (April 2015)
- Approximate Chainage
- Under Rail Culvert
- Section Line
- Linear Topographic Survey
- Contour - 2m Interval
- Inferred Areal Extent of Basaltic Colluvium

GEOLOGY

- TQcb / LATE TERTIARY - QUATERNARY / Colluvium basalt - soil, clay, cobbles and boulders
- Tm / TERTIARY / Olivine basalt
- Jbmk / JURASSIC / Lithofeldspathic labile and sublabile to quartzose sandstone, siltstone, shale, minor coal, ferruginous oolite marker

COPYRIGHT

0 5 10 20 30 40 50 metres

SCALE (at A3) 1:1,500

DATUM GDA 94, PROJECTION MGA Zone 56

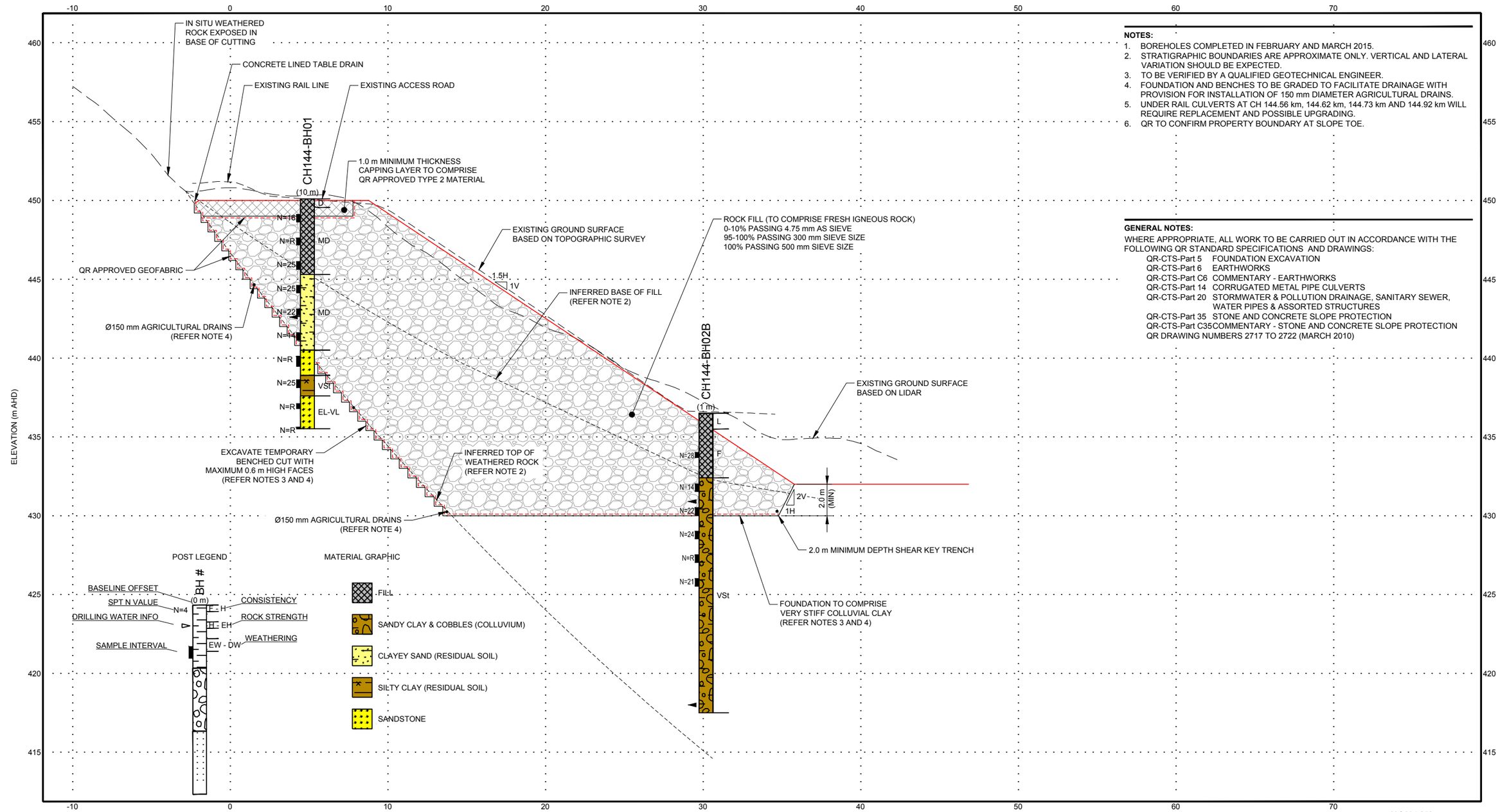
PROJECT: 137632080-012
DATE: 21 MAY 2015
DRAWN: SL
CHECKED: GR

FIGURE 1

Golder Associates

File Location: R:\01 Client\Queensland Rail\137632080\Programs\ArcGIS\137632080-012-D-Rev0-F001-144-7.mxd

DRAWINGS



NOTES:

1. BOREHOLES COMPLETED IN FEBRUARY AND MARCH 2015.
2. STRATIGRAPHIC BOUNDARIES ARE APPROXIMATE ONLY. VERTICAL AND LATERAL VARIATION SHOULD BE EXPECTED.
3. TO BE VERIFIED BY A QUALIFIED GEOTECHNICAL ENGINEER.
4. FOUNDATION AND BENCHES TO BE GRADED TO FACILITATE DRAINAGE WITH PROVISION FOR INSTALLATION OF 150 mm DIAMETER AGRICULTURAL DRAINS.
5. UNDER RAIL CULVERTS AT CH 144.56 km, 144.62 km, 144.73 km AND 144.92 km WILL REQUIRE REPLACEMENT AND POSSIBLE UPGRADING.
6. QR TO CONFIRM PROPERTY BOUNDARY AT SLOPE TOE.

GENERAL NOTES:

WHERE APPROPRIATE, ALL WORK TO BE CARRIED OUT IN ACCORDANCE WITH THE FOLLOWING QR STANDARD SPECIFICATIONS AND DRAWINGS:

QR-CTS-Part 5 FOUNDATION EXCAVATION
QR-CTS-Part 6 EARTHWORKS
QR-CTS-Part C6 COMMENTARY - EARTHWORKS
QR-CTS-Part 14 CORRUGATED METAL PIPE CULVERTS
QR-CTS-Part 20 STORMWATER & POLLUTION DRAINAGE, SANITARY SEWER, WATER PIPES & ASSORTED STRUCTURES
QR-CTS-Part 35 STONE AND CONCRETE SLOPE PROTECTION
QR-CTS-Part C35 COMMENTARY - STONE AND CONCRETE SLOPE PROTECTION
QR DRAWING NUMBERS 2717 TO 2722 (MARCH 2010)

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0	2015-05-25	ISSUED FOR TENDER	SCF	MPB	GR	DCS

CLIENT
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PROJECT
TOOWOOMBA RANGE RAILWAY
REMEDIAL SLOPE DESIGN

TITLE
CH144.500 TO 144.850 km
SECTION AA

PROJECT NO.	CONTROL	REV.	of	FIGURE
137632080	012	0		D001

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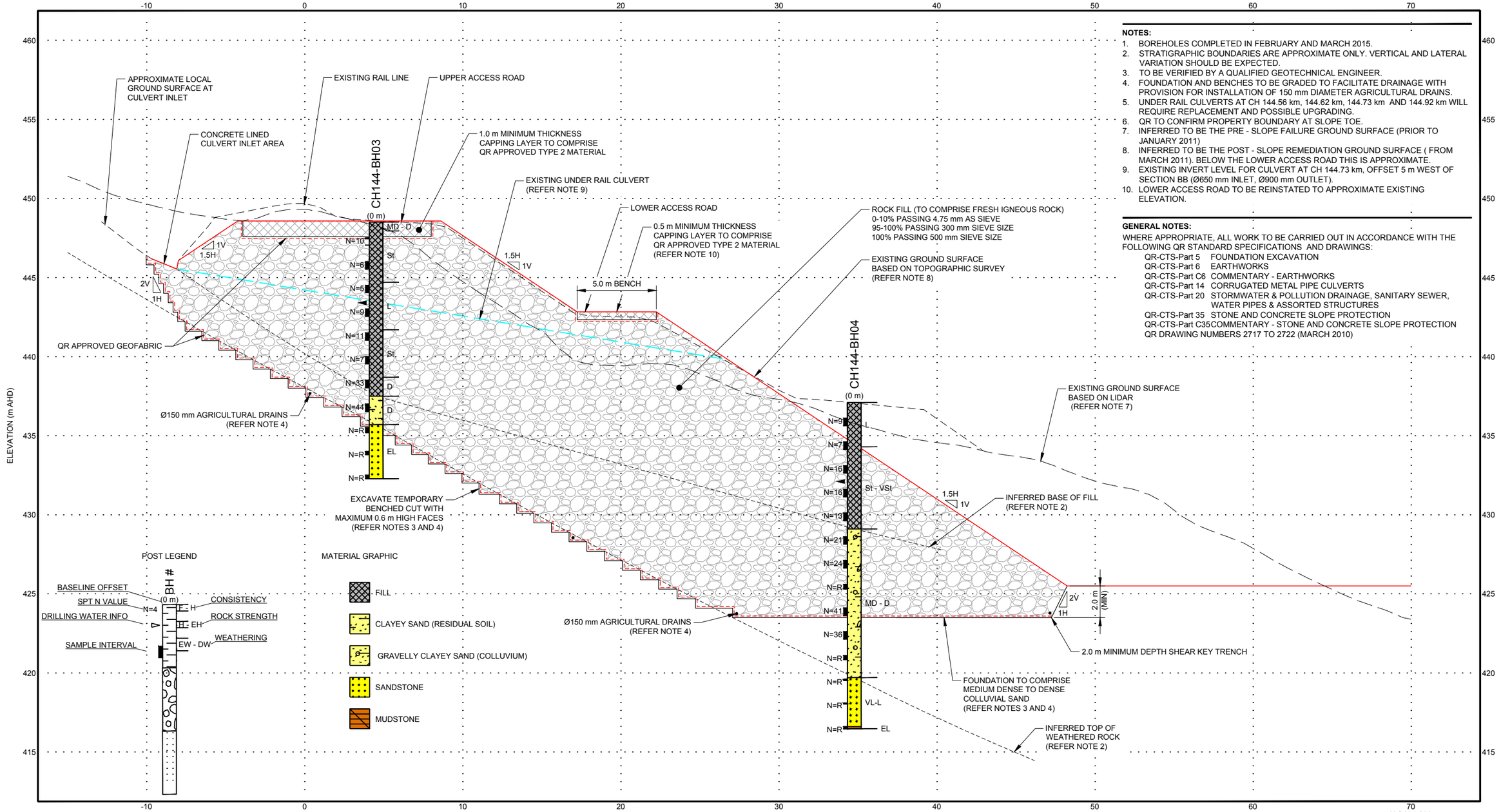

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Coord.System: MGA94 Zone 56 Height Datum: AHD

NOTES:

1. BOREHOLES COMPLETED IN FEBRUARY AND MARCH 2015.
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3. TO BE VERIFIED BY A QUALIFIED GEOTECHNICAL ENGINEER.
4. FOUNDATION AND BENCHES TO BE GRADED TO FACILITATE DRAINAGE WITH PROVISION FOR INSTALLATION OF 150 mm DIAMETER AGRICULTURAL DRAINS.
5. UNDER RAIL CULVERTS AT CH 144.56 km, 144.62 km, 144.73 km AND 144.92 km WILL REQUIRE REPLACEMENT AND POSSIBLE UPGRADING.
6. QR TO CONFIRM PROPERTY BOUNDARY AT SLOPE TOE.
7. INFERRED TO BE THE PRE - SLOPE FAILURE GROUND SURFACE (PRIOR TO JANUARY 2011)
8. INFERRED TO BE THE POST - SLOPE REMEDIATION GROUND SURFACE (FROM MARCH 2011). BELOW THE LOWER ACCESS ROAD THIS IS APPROXIMATE.
9. EXISTING INVERT LEVEL FOR CULVERT AT CH 144.73 km, OFFSET 5 m WEST OF SECTION BB (Ø650 mm INLET, Ø900 mm OUTLET).
10. LOWER ACCESS ROAD TO BE REINSTATED TO APPROXIMATE EXISTING ELEVATION.

GENERAL NOTES:

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QR-CTS-Part 6	EARTHWORKS
QR-CTS-Part C6	COMMENTARY - EARTHWORKS
QR-CTS-Part 14	CORRUGATED METAL PIPE CULVERTS
QR-CTS-Part 20	STORMWATER & POLLUTION DRAINAGE, SANITARY SEWER, WATER PIPES & ASSORTED STRUCTURES
QR-CTS-Part 35	STONE AND CONCRETE SLOPE PROTECTION
QR-CTS-Part C35	COMMENTARY - STONE AND CONCRETE SLOPE PROTECTION

QR DRAWING NUMBERS 2717 TO 2722 (MARCH 2010)

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PROJECT
TOOWOOMBA RANGE RAILWAY
REMEDIAL SLOPE DESIGN

TITLE
CH144.500 TO 144.850 km
SECTION BB

PROJECT NO.	CONTROL	REV.	of	FIGURE
137632080	012	0		D002

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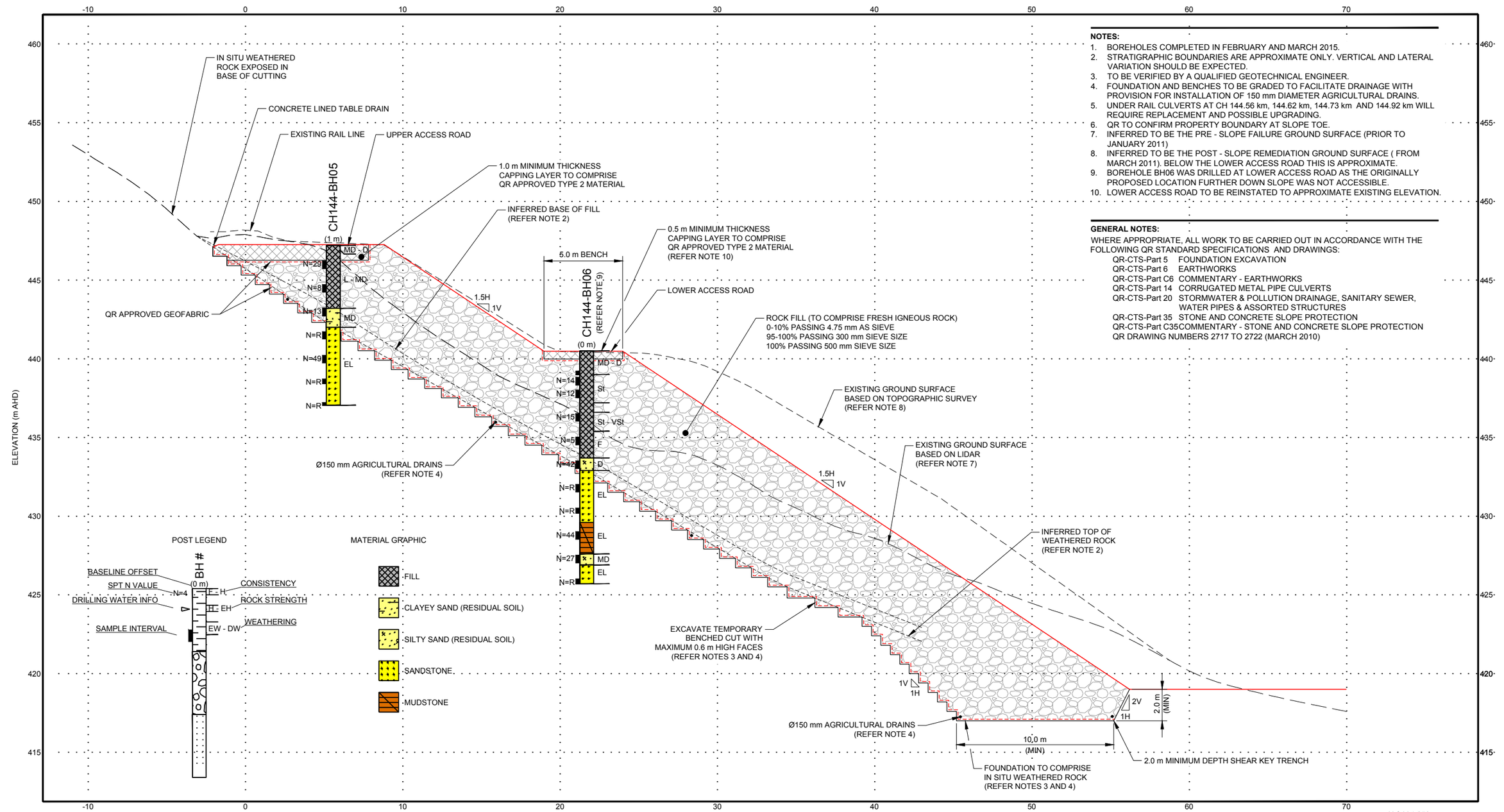

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6. QR TO CONFIRM PROPERTY BOUNDARY AT SLOPE TOE.
7. INFERRED TO BE THE PRE - SLOPE FAILURE GROUND SURFACE (PRIOR TO JANUARY 2011)
8. INFERRED TO BE THE POST - SLOPE REMEDIATION GROUND SURFACE (FROM MARCH 2011). BELOW THE LOWER ACCESS ROAD THIS IS APPROXIMATE.
9. BOREHOLE BH06 WAS DRILLED AT LOWER ACCESS ROAD AS THE ORIGINALLY PROPOSED LOCATION FURTHER DOWN SLOPE WAS NOT ACCESSIBLE.
10. LOWER ACCESS ROAD TO BE REINSTATED TO APPROXIMATE EXISTING ELEVATION.

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QR-CTS-Part 6	EARTHWORKS
QR-CTS-Part C6	COMMENTARY - EARTHWORKS
QR-CTS-Part 14	CORRUGATED METAL PIPE CULVERTS
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QR-CTS-Part 35	STONE AND CONCRETE SLOPE PROTECTION
QR-CTS-Part C35	COMMENTARY - STONE AND CONCRETE SLOPE PROTECTION
QR DRAWING NUMBERS 2717 TO 2722 (MARCH 2010)	

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Coord.System: MGA94 Zone 56 Height Datum: AHD

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PROJECT
TOOWOOMBA RANGE RAILWAY
REMEDIAL SLOPE DESIGN

TITLE
CH144.500 TO 144.850 km
SECTION CC

PROJECT NO.	CONTROL	REV.	of	FIGURE
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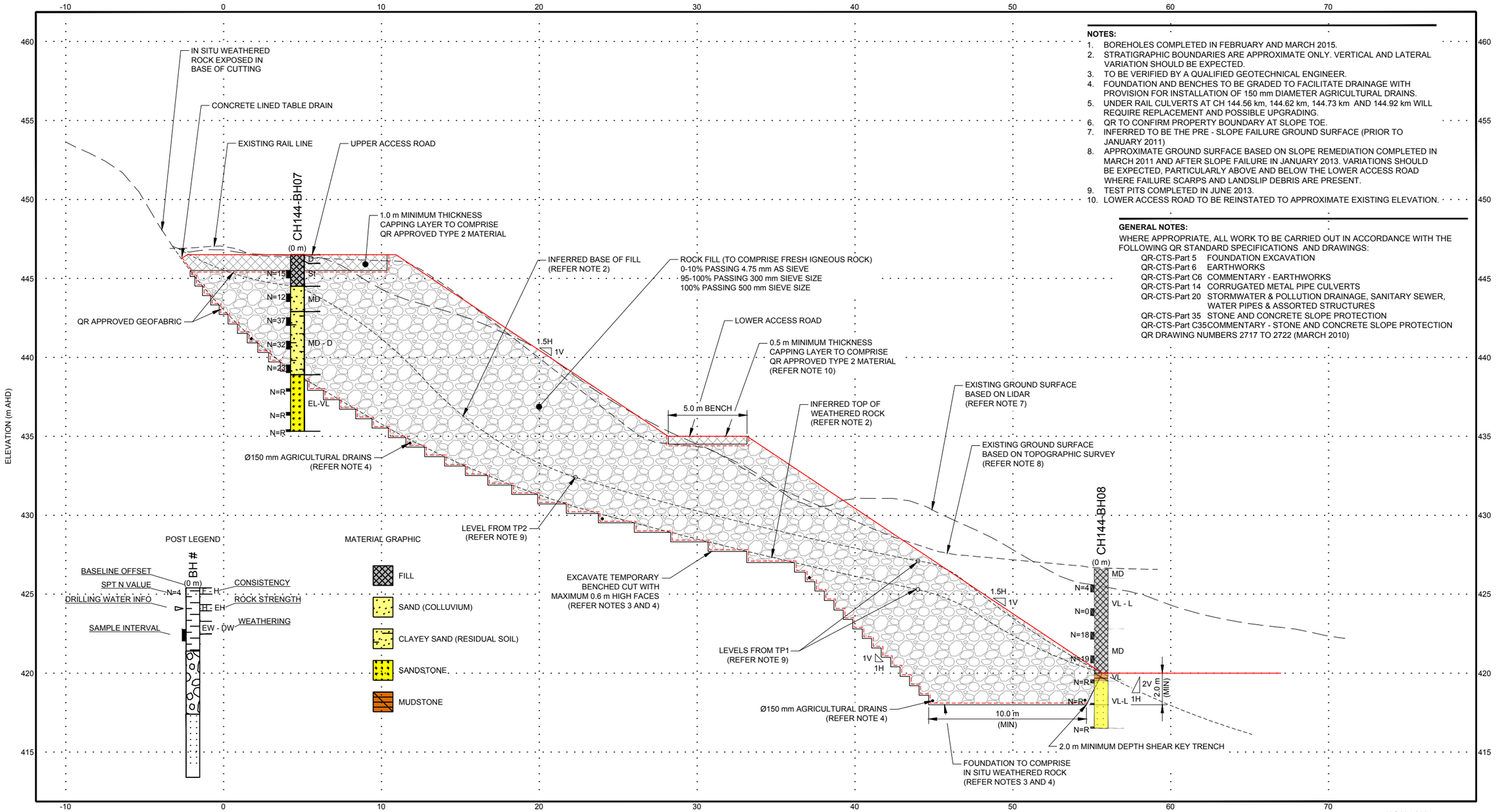

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6. QR TO CONFIRM PROPERTY BOUNDARY AT SLOPE TOE.
7. INFERRED TO BE THE PRE - SLOPE FAILURE GROUND SURFACE (PRIOR TO JANUARY 2011)
8. APPROXIMATE GROUND SURFACE BASED ON SLOPE REMEDIATION COMPLETED IN MARCH 2011 AND AFTER SLOPE FAILURE IN JANUARY 2013. VARIATIONS SHOULD BE EXPECTED, PARTICULARLY ABOVE AND BELOW THE LOWER ACCESS ROAD WHERE FAILURE SCARPS AND LANDSLIP DEBRIS ARE PRESENT.
9. TEST PITS COMPLETED IN JUNE 2013.
10. LOWER ACCESS ROAD TO BE REINSTATED TO APPROXIMATE EXISTING ELEVATION.

GENERAL NOTES:

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QR-CTS-Part 35	STONE AND CONCRETE SLOPE PROTECTION
QR-CTS-Part C35	COMMENTARY - STONE AND CONCRETE SLOPE PROTECTION

QR DRAWING NUMBERS 2717 TO 2722 (MARCH 2010)

Coord.System: MGA94 Zone 56 Height Datum: AHD

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PROJECT
TOOWOOMBA RANGE RAILWAY
REMEDIAL SLOPE DESIGN

TITLE
CH144.500 TO 144.850 km
SECTION DD

PROJECT NO.	CONTROL	REV.	of	DRAWING
137632080	012	0		D004

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PHOTOGRAPHS

Photograph 1: View east showing drilling at Borehole BH07 on the upper access road at approximate Ch 144.57 km, with Tunnel 3 visible in the background. Note: *in situ* distinctly weathered sandstone exposed in the upslope cutting adjacent to the rail line.

Photograph 2: View west along the railway corridor showing the upper access road and rail line at approximate Ch 144.7 km (near Borehole BH03). The inlet area for the under-rail culvert at Ch 144.73 km is visible in the right foreground of the image (marked in yellow).

Photograph 3: View north from Borehole BH01 at approximate Ch 144.8 km showing *in situ* extremely weathered rock exposed in the upslope cutting adjacent to the rail line (sandstone above and mudstone below the yellow dashed line).

Photograph 4: View north showing the slope below the railway corridor at approximate Ch 144.8 km and the temporary work platform for Borehole BH02 (indicated by the yellow dashed line).

Photograph 5: View north-west at Geological Observation point G2 (located downslope of Borehole BH02) showing a gully filled with colluvium comprising predominantly basalt cobbles and boulders. This gully is the outflow channel for the under-rail culvert located at Ch 144.92 km.

Photograph 6: View south-east showing drilling at Borehole BH04 (approximate Ch 144.7 km).

Photograph 7: View north showing the slope below the railway corridor at approximate Ch 144.7 km and the temporary work platform for Borehole BH04 (indicated by the top yellow dashed line). Note: the slope height between the two yellow dashed lines is approximately 20 m.

Photograph 8: View east along the lower access road from Borehole BH06 showing the location of the landslip centred on approximate Ch 144.55 km (yellow dashed lines). Note: some minor remedial works have been undertaken by QR to re-instate the lower access road within the landslip zone, however the slopes immediately above and below the road remain untouched since the time of the failure in February 2013.

Photograph 9: View west showing drilling at Borehole BH08 within the landslip zone at approximate Ch 144.55 km.

APPENDIX A

Borehole Reports & Explanation of notes, abbreviations & terms used on Borehole and Test Pit Reports

REPORT OF BOREHOLE: CH144-BH01

SHEET: 1 OF 2

CLIENT: Queensland Rail Limited
PROJECT: Remedial Slope Design
LOCATION: Toowoomba Range Railway
JOB NO: 137632080

COORDS: 400012.0 m E 6961818.0 m N MGA94 56
SURFACE RL: 450.10 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 14.58 m

DRILL RIG: Comacchio Geo 205
CONTRACTOR: GeoDrill Pty Ltd
LOGGED: SCF DATE: 23/2/15
CHECKED: GR DATE: 1/4/15

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADT	M		0	450.10				GC	FILL: Sandy Clayey GRAVEL fine to coarse grained, sub-angular, grey, medium plasticity clay, fine to coarse sand	D	D	Road-base
				0.50								
				449.60				SC	FILL: Clayey SAND fine to coarse grained, brown, grey and orange, medium plasticity clay, with some cobbles throughout, trace gravel			Embankment Fill
			1		144BH01-001 SPT 1.00-1.45 m 4, 8, 8 N=16							
				1.50								
				448.60					increasing cobble content below 1.5 m depth			
			2									
					144BH01-002 SPT 2.50-2.90 m 2, 2, 25/100 mm					D	MD	
			3									
			4		144BH01-003 SPT 4.00-4.45 m 3, 10, 15 N=25							
				4.80								
RD	L-M			445.30				SC	Clayey SAND fine to medium grained, pale brown and orange, low plasticity clay			Residual Soil
			5									
					144BH01-004 SPT 5.50-5.95 m 16, 10, 15 N=25							
			6									
			7		144BH01-005 SPT 7.00-7.45 m 4, 6, 16 N=22					D	MD	
		◄										Loss of drill fluid circulation at 7.5 m depth
			8									
					144BH01-006 SPT 8.50-8.95 m 3, 6, 8 N=14							
			9									
				9.60								
				440.50								
			10									

REPORT OF BOREHOLE: CH144-BH01

SHEET: 2 OF 2

CLIENT: Queensland Rail Limited
PROJECT: Remedial Slope Design
LOCATION: Toowoomba Range Railway
JOB NO: 137632080

COORDS: 400012.0 m E 6961818.0 m N MGA94 56
SURFACE RL: 450.10 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 14.58 m

DRILL RIG: Comacchio Geo 205
CONTRACTOR: GeoDrill Pty Ltd
LOGGED: SCF DATE: 23/2/15
CHECKED: GR DATE: 1/4/15

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
RD	L-M		10		144BH01-007 SPT 10.00-10.06 m 25/60 mm 144BH01-008 C 10.20-10.60 m				SANDSTONE fine to medium grained, orange and brown, extremely low to very low strength, extremely weathered, with some completely weathered zones up to 300 mm thick			Koukandowie Formation
			11	*11.20* 438.90				CI-CH	Silty CLAY medium to high plasticity, grey and brown	M	VSt	Decomposed Mudstone
					144BH01-009 SPT 11.50-11.95 m 11, 10, 15 N=25							
			12	*12.50* 437.60					SANDSTONE fine to medium grained, orange and brown, extremely low to very low strength, extremely weathered, with some completely weathered zones up to 300 mm thick			
			13		144BH01-010 SPT 13.00-13.29 m 15, 30/140 mm							
			14									
				435.52	144BH01-011 SPT 14.50-14.58 m 30/80 mm				END OF BOREHOLE @ 14.58 m TARGET DEPTH GROUNDWATER NOT OBSERVED GROUTED Two boreholes were attempted and refused at 2.0 m depth on concrete fill, before progressing BH01			
			15									
			16									
			17									
			18									
			19									
			20									

REPORT OF BOREHOLE: CH144-BH02A

SHEET: 1 OF 2

CLIENT: Queensland Rail Limited
PROJECT: Remedial Slope Design
LOCATION: Toowoomba Range Railway
JOB NO: 137632080

COORDS: 399990.0 m E 6961799.0 m N MGA94 56
SURFACE RL: 436.60 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 12.00 m

DRILL RIG: Comacchio Geo 205
CONTRACTOR: GeoDrill Pty Ltd
LOGGED: SCF DATE: 27/2/15
CHECKED: GR DATE: 1/4/15

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADT			0	436.60				SC	FILL: Clayey SAND fine to medium grained, dark grey, low plasticity clay, with some medium to coarse gravel, with some cobbles and boulders		L	Temporary Platform Fill
				1.00								
			1	435.60				Cl	FILL: Sandy CLAY medium plasticity, dark brown, fine to medium sand			Embankment Fill
			2									
					144BH02-001 SPT 2.50-2.78 m 22, 28/130 mm						F	
			3									
			4	*4.10*								
				432.50					Sandy CLAY and BOULDERS medium plasticity, brown, fine to medium sand, and boulders 300 mm to 600 mm present throughout (approximately 1.0 m to 1.5 m spacing, comprising slightly weathered, high strength basalt)			Colluvium
					144BH02-002 SPT 4.50-4.95 m 7, 7, 7 N=14					M		
RT		◄	5									Borehole collapse in gravel layer approx 100 mm thick and loss of drill fluid circulation at 5.6 m.
			6		144BH02-003 SPT 6.00-6.45 m 9, 11, 11 N=22							
			7								VSt	
					144BH02-004 SPT 7.50-7.95 m 12, 12, 12 N=24							
			8									
			9		144BH02-005 SPT 9.00 m 5/0 mm HB							
			10									

REPORT OF BOREHOLE: CH144-BH02A

SHEET: 2 OF 2

CLIENT: Queensland Rail Limited
PROJECT: Remedial Slope Design
LOCATION: Toowoomba Range Railway
JOB NO: 137632080

COORDS: 399990.0 m E 6961799.0 m N MGA94 56
SURFACE RL: 436.60 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 12.00 m

DRILL RIG: Comacchio Geo 205
CONTRACTOR: GeoDrill Pty Ltd
LOGGED: SCF DATE: 27/2/15
CHECKED: GR DATE: 1/4/15

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
RT			10		144BH02-006 SPT 10.50-10.95 m 8, 10, 11 N=21				Sandy CLAY and BOULDERS medium plasticity, brown, fine to medium sand, and boulders 300 mm to 600 mm present throughout (approximately 1.0 m to 1.5 m spacing, comprising slightly weathered, high strength basalt)	M	VSt	
			11									
			12	424.60					END OF BOREHOLE @ 12.00 m EQUIPMENT FAILURE GROUNDWATER NOT OBSERVED BACKFILLED Borehole was pre-excavated to 4.1 m depth with 12 tonne excavator to remove boulders. Borehole aborted at 12 m due to SPT sampler breaking off down hole.			
			13									
			14									
			15									
			16									
			17									
			18									
			19									
			20									

REPORT OF BOREHOLE: CH144-BH02B

SHEET: 1 OF 2

CLIENT: Queensland Rail Limited
PROJECT: Remedial Slope Design
LOCATION: Toowoomba Range Railway
JOB NO: 137632080

COORDS: 399993.0 m E 6961799.0 m N MGA94 56
SURFACE RL: 436.50 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 19.00 m

DRILL RIG: Comacchio Geo 205
CONTRACTOR: GeoDrill Pty Ltd
LOGGED: SCF DATE: 16/3/15
CHECKED: GR DATE: 1/4/15

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADT			0	436.50				SC	FILL: Clayey SAND fine to medium grained, dark grey, low plasticity clay, with some medium to coarse gravel, with some cobbles and boulders		L	Temporary Platform Fill
				1.00								
			1	435.50				Cl	FILL: Sandy CLAY medium plasticity, dark brown, fine to medium sand		F	Embankment Fill
			2									
			3									
			4	*4.10*								
RT				432.40					Sandy CLAY and BOULDERS medium plasticity, dark brown, fine to medium sand, and boulders 300 mm to 600 mm present throughout (approximately 1.0 m to 1.5 m spacing, comprising slightly weathered, high strength basalt)	M	VSt	Colluvium
			5									
			6									
			7									
			8									
			9									
			10									

REPORT OF BOREHOLE: CH144-BH02B

SHEET: 2 OF 2

CLIENT: Queensland Rail Limited
PROJECT: Remedial Slope Design
LOCATION: Toowoomba Range Railway
JOB NO: 137632080

COORDS: 399993.0 m E 6961799.0 m N MGA94 56
SURFACE RL: 436.50 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 19.00 m

DRILL RIG: Comacchio Geo 205
CONTRACTOR: GeoDrill Pty Ltd
LOGGED: SCF DATE: 16/3/15
CHECKED: GR DATE: 1/4/15

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
RT		◄	10						Sandy CLAY and BOULDERS medium plasticity, dark brown, fine to medium sand, and boulders 300 mm to 600 mm present throughout (approximately 1.0 m to 1.5 m spacing, comprising slightly weathered, high strength basalt)	M	VSt	Drill fluid loss at 18.5 m depth
			19	417.50					END OF BOREHOLE @ 19.00 m REFUSAL ON BOULDERS GROUNDWATER NOT OBSERVED SAMPLING NOT UNDERTAKEN BACKFILLED Borehole was pre-excavated to 4.1 m depth with 12 tonne excavator to remove boulders.			
			20									

This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

GAP gINT FN. F01a RL3

REPORT OF BOREHOLE: CH144-BH03

SHEET: 1 OF 2

CLIENT: Queensland Rail Limited
PROJECT: Remedial Slope Design
LOCATION: Toowoomba Range Railway
JOB NO: 137632080

COORDS: 400120.0 m E 6961802.0 m N MGA94 56
SURFACE RL: 448.50 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 16.22 m

DRILL RIG: Comacchio Geo 205
CONTRACTOR: GeoDrill Pty Ltd
LOGGED: SCF DATE: 2/3/15
CHECKED: GR DATE: 1/4/15

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			0	448.50				GC	FILL: Sandy Clayey GRAVEL fine to coarse grained, sub-angular, dark grey, low plasticity clay, fine to medium sand	M	MD - D	Road-base
				0.40 448.10				CL-CI	FILL: Sandy CLAY low to medium plasticity, dark brown, fine to medium sand, with some fine to coarse gravel			Embankment Fill
ADT			1		144BH03-001 SPT 1.00-1.45 m 2, 4, 6 N=10							
			2							M	St	
					144BH03-002 SPT 2.50-2.95 m 3, 2, 4 N=6							
			3	*3.60* 444.90					gravel layer			
				3.80 444.70				SC	FILL: Clayey SAND / Sandy CLAY fine to medium grained, brown, grey and orange, medium plasticity clay			
			4		144BH03-003 SPT 4.00-4.45 m 2, 2, 3 N=5							
				4.60 443.90					with some fine to medium gravel			
RD		◀	5							M	L	Complete drill fluid loss at 5.1 m depth
			6		144BH03-004 SPT 5.50-5.95 m 3, 5, 4 N=9							
				6.80 441.70				CL-CI	FILL: Sandy CLAY low to medium plasticity, dark brown, fine to medium sand, with some fine to medium gravel			
			7		144BH03-005 SPT 7.00-7.45 m 3, 5, 6 N=11							
			8							M	St	
					144BH03-006 SPT 8.50-8.95 m 4, 3, 4 N=7							
			9	*9.80* 438.70						M	D	
			10									

REPORT OF BOREHOLE: CH144-BH03

SHEET: 2 OF 2

CLIENT: Queensland Rail Limited
PROJECT: Remedial Slope Design
LOCATION: Toowoomba Range Railway
JOB NO: 137632080

COORDS: 400120.0 m E 6961802.0 m N MGA94 56
SURFACE RL: 448.50 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 16.22 m

DRILL RIG: Comacchio Geo 205
CONTRACTOR: GeoDrill Pty Ltd
LOGGED: SCF DATE: 2/3/15
CHECKED: GR DATE: 1/4/15

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
RD			10		144BH03-007 SPT 10.00-10.45 m 17, 12, 21 N=33				FILL: SAND fine to medium grained, orange, with some dark brown sandy clay bands	M	D	
			11	*11.00* 437.50				SC	Clayey SAND fine to medium grained, orange and grey, medium plasticity clay			Residual Soil
					144BH03-008 SPT 11.50-11.95 m 5, 17, 27 N=44					M	D	
			12	*12.80* 435.70					SANDSTONE fine to medium grained, orange and pale brown, extremely low strength, extremely weathered, with some completely weathered zones up to 300 mm thick, and low strength seams up to 100 mm thick			Koukandowie Formation
			13		144BH03-009 SPT 13.00-13.30 m 21, 30/150 mm							
			14									
					144BH03-010 SPT 14.50-14.70 m 27, 30/50 mm							
			15									
			16		144BH03-011 SPT 16.00-16.22 m 25, 30/70 mm							
				432.28					END OF BOREHOLE @ 16.22 m REFUSAL GROUNDWATER NOT OBSERVED BACKFILLED			
			17									
			18									
			19									
			20									

REPORT OF BOREHOLE: CH144-BH04

SHEET: 1 OF 3

CLIENT: Queensland Rail Limited
PROJECT: Remedial Slope Design
LOCATION: Toowoomba Range Railway
JOB NO: 137632080

COORDS: 400116.0 m E 6961772.0 m N MGA94 56
SURFACE RL: 437.10 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 20.63 m

DRILL RIG: Comacchio Geo 205
CONTRACTOR: GeoDrill Pty Ltd
LOGGED: SCF DATE: 25/2/15
CHECKED: GR DATE: 1/4/15

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADT			0	437.10				SC	FILL: Clayey Gravelly SAND fine to coarse grained, grey, fine to coarse gravel, low plasticity clay	M	L	Temporary Platform Fill
			1		144BH04-001 SPT 1.00-1.45 m 5, 5, 4 N=9							
			2		144BH04-002 SPT 2.50-2.95 m 1, 2, 5 N=7							
RD				*2.80* 434.30				CI	FILL: Sandy CLAY medium plasticity, brown, grey and orange, fine to medium sand, with some medium to coarse, sub-angular gravel, trace coal	M	St - VSt	Embankment Fill
			3									
			4		144BH04-003 SPT 4.00-4.45 m 7, 8, 8 N=16							
		◀	5									Complete drill fluid loss at 5.0 m
			6		144BH04-004 SPT 5.50-5.95 m 5, 8, 8 N=16							
				6.60 430.50					300 mm boulder, rock roller required to drill through hard drilling			
			7		144BH04-005 SPT 7.00-7.45 m 5, 6, 7 N=13							
				8.00 429.10				SC	Gravelly Clayey SAND fine to medium grained, dark brown, grey and orange, medium plasticity clay, fine to medium gravel, with some gravel bands 200 mm to 400 mm thick	M	MD - D	Colluvium
RT			8		144BH04-006 SPT 8.50-8.95 m 7, 7, 14 N=21							
			9									
			10									

REPORT OF BOREHOLE: CH144-BH04

CLIENT: Queensland Rail Limited
PROJECT: Remedial Slope Design
LOCATION: Toowoomba Range Railway
JOB NO: 137632080

COORDS: 400116.0 m E 6961772.0 m N MGA94 56
SURFACE RL: 437.10 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 20.63 m

DRILL RIG: Comacchio Geo 205
CONTRACTOR: GeoDrill Pty Ltd
LOGGED: SCF DATE: 25/2/15
CHECKED: GR DATE: 1/4/15

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
RT			10		144BH04-007 SPT 10.00-10.45 m 6, 10, 14 N=24			SC	Gravelly Clayey SAND fine to medium grained, dark brown, grey and orange, medium plasticity clay, fine to medium gravel, with some gravel bands 200 mm to 400 mm thick	M	MD - D	
			11		144BH04-008 SPT 11.50-11.78 m 20, 30/130 mm							
			12									
			13		144BH04-009 SPT 13.00-13.45 m 7, 24, 17 N=41							
			14									
			15		144BH04-010 SPT 14.50-14.95 m 7, 22, 14 N=36							
			16		144BH04-011 SPT 16.00-16.25 m 17, 30/100 mm							
			17	*17.40* 419.70								
			18		144BH04-012 SPT 17.50-17.57 m 30/70 mm				SANDSTONE fine to medium grained, pale brown and orange, very low to low strength, extremely weathered, with some completely weathered zones up to 300 mm thick			Koukandowie Formation
			19		144BH04-013 SPT 19.00-19.05 m 30/50 mm							
			20									

REPORT OF BOREHOLE: CH144-BH04

SHEET: 3 OF 3

CLIENT: Queensland Rail Limited
PROJECT: Remedial Slope Design
LOCATION: Toowoomba Range Railway
JOB NO: 137632080

COORDS: 400116.0 m E 6961772.0 m N MGA94 56
SURFACE RL: 437.10 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 20.63 m

DRILL RIG: Comacchio Geo 205
CONTRACTOR: GeoDrill Pty Ltd
LOGGED: SCF DATE: 25/2/15
CHECKED: GR DATE: 1/4/15

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
RT			20	20.50					SANDSTONE fine to medium grained, pale brown and orange, very low to low strength, extremely weathered, with some completely weathered zones up to 300 mm thick		
				416.47	144BH04-014 SPT 20.50-20.63 m 30/130 mm				MUDSTONE fine grained, grey, extremely low strength, extremely weathered		
			21						END OF BOREHOLE @ 20.63 m TARGET DEPTH GROUNDWATER NOT OBSERVED BACKFILLED		
			22								
			23								
			24								
			25								
			26								
			27								
			28								
			29								
			30								

REPORT OF BOREHOLE: CH144-BH05

SHEET: 1 OF 2

CLIENT: Queensland Rail Limited
PROJECT: Remedial Slope Design
LOCATION: Toowoomba Range Railway
JOB NO: 137632080

COORDS: 400210.0 m E 6961809.0 m N MGA94 56
SURFACE RL: 447.20 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 10.15 m

DRILL RIG: Comacchio Geo 205
CONTRACTOR: GeoDrill Pty Ltd
LOGGED: SCF DATE: 16/3/15
CHECKED: GR DATE: 1/4/15

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADT			0	447.20				GC	FILL: Sandy Clayey GRAVEL fine to medium grained, grey, low plasticity clay, fine to medium sand	M	MD - D	Road-base
				0.30								
				446.90				SC	FILL: Gravelly Clayey SAND fine to medium grained, brown, medium plasticity clay, fine to medium gravel			Embankment Fill
			1		144BH05-001 SPT 1.00-1.45 m 12, 17, 12 N=29							
			2							M	L - MD	
					144BH05-002 SPT 2.50-2.95 m 5, 4, 4 N=8							
			3									
				4.00								
			4	443.20	144BH05-003 SPT 4.00-4.45 m 6, 7, 6 N=13			SC	Clayey SAND fine to coarse grained, orange, medium plasticity clay	M	MD	Residual Soil
			5									
				5.20								
RD				442.00					SANDSTONE fine to medium grained, orange, extremely low strength, extremely weathered, with some completely weathered zones up to 300 m thick			Koukandowie Formation
			6		144BH05-004 SPT 5.50-5.93 m 17, 18, 30/130 mm							
			7		144BH05-005 SPT 7.00-7.45 m 17, 27, 22 N=49							
			8									
					144BH05-006 SPT 8.50-8.76 m 25, 30/110 mm							
			9									
			10									

REPORT OF BOREHOLE: CH144-BH05

SHEET: 2 OF 2

CLIENT: Queensland Rail Limited
PROJECT: Remedial Slope Design
LOCATION: Toowoomba Range Railway
JOB NO: 137632080

COORDS: 400210.0 m E 6961809.0 m N MGA94 56
SURFACE RL: 447.20 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 10.15 m

DRILL RIG: Comacchio Geo 205
CONTRACTOR: GeoDrill Pty Ltd
LOGGED: SCF DATE: 16/3/15
CHECKED: GR DATE: 1/4/15

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
RD			10	437.05	144BH05-007 SPT 10.00-10.15 m 30/150 mm				END OF BOREHOLE @ 10.15 m TARGET DEPTH GROUNDWATER NOT OBSERVED GROUTED		
			11								
			12								
			13								
			14								
			15								
			16								
			17								
			18								
			19								
			20								

REPORT OF BOREHOLE: CH144-BH06

SHEET: 1 OF 2

CLIENT: Queensland Rail Limited
PROJECT: Remedial Slope Design
LOCATION: Toowoomba Range Railway
JOB NO: 137632080

COORDS: 400212.0 m E 6961793.0 m N MGA94 56
SURFACE RL: 440.50 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 14.79 m

DRILL RIG: Comacchio Geo 205
CONTRACTOR: GeoDrill Pty Ltd
LOGGED: SCF DATE: 9/3/15
CHECKED: GR DATE: 1/4/15

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADT			0	440.50				GC	FILL: Clayey Sandy GRAVEL fine to coarse grained, dark brown, fine to medium sand, low plasticity clay, with some cobbles throughout	M	MD - D	Road-base
			1	*1.50*	144BH06-001 DS 1.30-1.50 m							
				439.00	144BH06-002 SPT 1.70-2.15 m 3, 7, 7 N=14			CI	FILL: Gravelly Sandy CLAY medium plasticity, brown, fine to medium sand, fine to coarse gravel	M	St	Embankment Fill
			2		144BH06-003 SPT 2.50-2.95 m 4, 7, 5 N=12							
			3	*3.30*								
				437.20					FILL: BOULDERS and COBBLES dark grey, basalt boulders and cobbles, sandy clay matrix	M		
			4	*3.90*								
RD				436.60	144BH06-004 SPT 4.00-4.45 m 4, 8, 7 N=15			CI	FILL: Gravelly Sandy CLAY medium plasticity, brown, fine to medium sand, fine to medium gravel	M	St - VSt	
			5	*5.10*								
				435.40				CI	FILL: Sandy CLAY medium plasticity, brown, grey and orange, fine to medium sand	M	F	
			6	*6.80*	144BH06-005 SPT 5.50-5.95 m 2, 1, 4 N=5							
				433.70	144BH06-006 SPT 7.00-7.45 m 9, 17, 25 N=42			SM	Silty SAND fine to medium grained, orange and brown	D	D	Residual Soil
			7	*7.60*								
				432.90					SANDSTONE fine to medium grained, orange and brown, extremely low strength, extremely weathered, with some completely weathered zones up to 300 mm thick			Koukandowie Formation
			8		144BH06-007 SPT 8.50-8.94 m 9, 19, 30/140 mm							
			9									
			10									

REPORT OF BOREHOLE: CH144-BH06

SHEET: 2 OF 2

CLIENT: Queensland Rail Limited
PROJECT: Remedial Slope Design
LOCATION: Toowoomba Range Railway
JOB NO: 137632080

COORDS: 400212.0 m E 6961793.0 m N MGA94 56
SURFACE RL: 440.50 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 14.79 m

DRILL RIG: Comacchio Geo 205
CONTRACTOR: GeoDrill Pty Ltd
LOGGED: SCF DATE: 9/3/15
CHECKED: GR DATE: 1/4/15

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
RD			10		144BH06-008 SPT 10.00-10.30 m 19, 30/150 mm				SANDSTONE fine to medium grained, orange and brown, extremely low strength, extremely weathered, with some completely weathered zones up to 300 mm thick			
				10.90 429.60					MUDSTONE fine grained, orange and dark grey, extremely low strength, extremely weathered			
			11		144BH06-009 SPT 11.50-11.95 m 9, 19, 25 N=44							
			12									
				12.90 427.60				SM	Silty SAND fine to medium grained, orange and brown, residual rock structure	M	MD	Decomposed Sandstone
			13		144BH06-010 SPT 13.00-13.45 m 9, 12, 15 N=27							
				13.60 426.90					SANDSTONE fine to medium grained, orange and brown, extremely low strength, extremely weathered, with some completely weathered bands up to 300 mm thick			
			14		144BH06-011 SPT 14.50-14.79 m 19, 30/140 mm							
				425.71					END OF BOREHOLE @ 14.79 m TARGET DEPTH GROUNDWATER NOT OBSERVED GROUTED			
			15									
			16									
			17									
			18									
			19									
			20									

REPORT OF BOREHOLE: CH144-BH07

SHEET: 1 OF 2

CLIENT: Queensland Rail Limited
PROJECT: Remedial Slope Design
LOCATION: Toowoomba Range Railway
JOB NO: 137632080

COORDS: 400274.0 m E 6961822.0 m N MGA94 56
SURFACE RL: 446.50 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 11.18 m

DRILL RIG: Comacchio Geo 205
CONTRACTOR: GeoDrill Pty Ltd
LOGGED: SCF DATE: 23/2/15
CHECKED: GR DATE: 1/4/15

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADT			0	446.50				GC	FILL: Sandy Clayey GRAVEL fine to coarse grained, sub-angular, grey and brown, low plasticity clay, fine to coarse sand	M	D	Road-base
				0.40								
				446.10				CL-CI	FILL: Gravelly Sandy CLAY low to medium plasticity, brown, fine to coarse sand, fine gravel			Embankment Fill
			1		144BH07-001 SPT 1.00-1.45 m 6, 6, 9 N=15					M	St	
				2.00								
			2	444.50				SW	SAND fine to coarse grained, orange, relic rock structure and slightly cemented in parts			Possible Colluvium
					144BH07-002 SPT 2.50-2.95 m 5, 8, 4 N=12					M	MD	
			3	*3.60*								
				442.90				SC	Clayey SAND / Sandy CLAY fine to medium grained, orange, low to medium plasticity clay, relic rock structure, 4.2 m 2 mm thick clay infill joint			Residual Soil
			4		144BH07-003 SPT 4.00-4.45 m 10, 16, 21 N=37							
RD	L-M		5									
					144BH07-004 SPT 5.50-5.95 m 12, 14, 18 N=32					M	MD - D	
			6									
			7		144BH07-005 SPT 7.00-7.45 m 17, 8, 15 N=23							
				7.60								
				438.90					SANDSTONE fine to medium grained, orange, extremely low to very low strength, extremely weathered, with some completely weathered zones up to 300 mm thick			Koukandowie Formation
			8									
					144BH07-006 SPT 8.50-8.63 m 30/130 mm							
			9									
			10									

REPORT OF BOREHOLE: CH144-BH07

SHEET: 2 OF 2

CLIENT: Queensland Rail Limited
PROJECT: Remedial Slope Design
LOCATION: Toowoomba Range Railway
JOB NO: 137632080

COORDS: 400274.0 m E 6961822.0 m N MGA94 56
SURFACE RL: 446.50 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 11.18 m

DRILL RIG: Comacchio Geo 205
CONTRACTOR: GeoDrill Pty Ltd
LOGGED: SCF DATE: 23/2/15
CHECKED: GR DATE: 1/4/15

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION / CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
RD	L-M		10		144BH07-007 SPT 10.00-10.15 m 30/150 mm				SANDSTONE fine to medium grained, orange, extremely low to very low strength, extremely weathered, with some completely weathered zones up to 300 mm thick		Koukandowie Formation
			11	435.32	144BH07-008 SPT 11.10-11.18 m 30/80 mm				END OF BOREHOLE @ 11.18 m TARGET DEPTH GROUNDWATER NOT OBSERVED GROUTED First attempt at borehole was unsuccessful (refusal on rockfill at 1.0 m depth) - relocated 1.0 m away.		
			12								
			13								
			14								
			15								
			16								
			17								
			18								
			19								
			20								

REPORT OF BOREHOLE: CH144-BH08

SHEET: 1 OF 2

CLIENT: Queensland Rail Limited
PROJECT: Remedial Slope Design
LOCATION: Toowoomba Range Railway
JOB NO: 137632080

COORDS: 400291.0 m E 6961774.0 m N MGA94 56
SURFACE RL: 426.60 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 10.09 m

DRILL RIG: Comacchio Geo 205
CONTRACTOR: GeoDrill Pty Ltd
LOGGED: SCF DATE: 3/3/15
CHECKED: GR DATE: 1/4/15

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADT			0	426.60				SC	FILL: Gravelly Clayey SAND fine to medium grained, dark brown, low plasticity clay, fine to coarse gravel	M	MD	Temporary Platform Fill
				0.60								
				426.00				Cl	FILL: Clayey SAND fine to medium grained, brown, grey and orange, medium plasticity clay			Landslide Debris (Previous embankment fill)
			1		144BH08-001 SPT 1.00-1.45 m 2, 2, 2 N=4							
			2							M - W	VL - L	
					144BH08-002 SPT 2.50-2.95 m 1, 0 N=0							
			3									
				3.80								
				422.80				Cl	FILL: Clayey SAND fine to medium grained, brown, grey and orange, medium plasticity clay			Embankment fill
			4		144BH08-003 SPT 4.00-4.45 m 3, 8, 10 N=18							
				5.00								
RD			5	421.60					becoming Sandy CLAY below 5.0 m	M	MD	
					144BH08-004 SPT 5.50-5.95 m 3, 8, 11 N=19							
			6									
				6.60								
				420.00					MUDSTONE fine grained, pale grey, very low strength, extremely weathered,			Koukandowie Formation
			7	*7.10*	144BH08-005							
				419.50	SPT 7.00-7.21 m 18, 30/60mm				SANDSTONE fine to medium grained, orange and brown, very low to low strength, extremely weathered, with some completely weathered zones up to 300 mm thick			
			8		144BH08-006 SPT 8.50-8.58 m 30/80mm							
			9									
			10									

REPORT OF BOREHOLE: CH144-BH08

SHEET: 2 OF 2

CLIENT: Queensland Rail Limited
PROJECT: Remedial Slope Design
LOCATION: Toowoomba Range Railway
JOB NO: 137632080

COORDS: 400291.0 m E 6961774.0 m N MGA94 56
SURFACE RL: 426.60 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 10.09 m

DRILL RIG: Comacchio Geo 205
CONTRACTOR: GeoDrill Pty Ltd
LOGGED: SCF DATE: 3/3/15
CHECKED: GR DATE: 1/4/15

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
RD			10	416.51	144BH08-007 SPT 10.00-10.09 m 30/90mm				END OF BOREHOLE @ 10.09 m TARGET DEPTH GROUNDWATER NOT OBSERVED BACKFILLED			
			11									
			12									
			13									
			14									
			15									
			16									
			17									
			18									
			19									
			20									

EXPLANATION OF NOTES, ABBREVIATIONS & TERMS USED ON BOREHOLE AND TEST PIT REPORTS

DRILLING/EXCAVATION METHOD

AS*	Auger Screwing	RD	Rotary blade or drag bit	NQ	Diamond Core - 47 mm
AD*	Auger Drilling	RT	Rotary Tricone bit	NMLC	Diamond Core - 52 mm
*V	V-Bit	RAB	Rotary Air Blast	HQ	Diamond Core - 63 mm
*T	TC-Bit, e.g. ADT	RC	Reverse Circulation	HMLC	Diamond Core – 63mm
HA	Hand Auger	PT	Push Tube	BH	Tractor Mounted Backhoe
ADH	Hollow Auger	CT	Cable Tool Rig	EX	Tracked Hydraulic Excavator
DTC	Diatube Coring	JET	Jetting	EE	Existing Excavation
WB	Washbore or Bailer	NDD	Non-destructive digging	HAND	Excavated by Hand Methods

PENETRATION/EXCAVATION RESISTANCE

L **Low resistance.** Rapid penetration possible with little effort from the equipment used.

M **Medium resistance.** Excavation/possible at an acceptable rate with moderate effort from the equipment used.

H **High resistance** to penetration/excavation. Further penetration is possible at a slow rate and requires significant effort from the equipment.

R **Refusal or Practical Refusal.** No further progress possible without the risk of damage or unacceptable wear to the digging implement or machine.

These assessments are subjective and are dependent on many factors including the equipment power, weight, condition of excavation or drilling tools, and the experience of the operator.

WATER

▽	Water level at date shown	◁	Partial water loss
▷	Water inflow	◀	Complete water loss

GROUNDWATER NOT OBSERVED	The observation of groundwater, whether present or not, was not possible due to drilling water, surface seepage or cave in of the borehole/test pit.
GROUNDWATER NOT ENCOUNTERED	The borehole/test pit was dry soon after excavation. However, groundwater could be present in less permeable strata. Inflow may have been observed had the borehole/test pit been left open for a longer period.

SAMPLING AND TESTING

SPT	Standard Penetration Test to AS1289.6.3.1-2004
4,7,11 N=18	4,7,11 = Blows per 150mm. N = Blows per 300mm penetration following 150mm seating
30/80mm	Where practical refusal occurs, the blows and penetration for that interval are reported
RW	Penetration occurred under the rod weight only
HW	Penetration occurred under the hammer and rod weight only
HB	Hammer double bouncing on anvil
DS	Disturbed sample
BDS	Bulk disturbed sample
G	Gas Sample
W	Water Sample
FP	Field permeability test over section noted
FV	Field vane shear test expressed as uncorrected shear strength (s_v = peak value, s_r = residual value)
PID	Photoionisation Detector reading in ppm
PM	Pressuremeter test over section noted
PP	Pocket penetrometer test expressed as instrument reading in kPa
U63	Thin walled tube sample - number indicates nominal sample diameter in millimetres
WPT	Water pressure tests
DCP	Dynamic cone penetration test
CPT	Static cone penetration test
CPTu	Static cone penetration test with pore pressure (u) measurement

Ranking of Visually Observable Contamination and Odour (for specific soil contamination assessment projects)

R = 0	No visible evidence of contamination	R = A	No non-natural odours identified
R = 1	Slight evidence of visible contamination	R = B	Slight non-natural odours identified
R = 2	Visible contamination	R = C	Moderate non-natural odours identified
R = 3	Significant visible contamination	R = D	Strong non-natural odours identified

ROCK CORE RECOVERY

TCR = Total Core Recovery (%)

$$= \frac{\text{Length of core recovered}}{\text{Length of core run}} \times 100$$

SCR = Solid Core Recovery (%)

$$= \frac{\sum \text{Length of cylindrical core recovered}}{\text{Length of core run}} \times 100$$

RQD = Rock Quality Designation (%)

$$= \frac{\sum \text{Axial lengths of core} > 100 \text{ mm}}{\text{Length of core run}} \times 100$$

METHOD OF SOIL DESCRIPTION USED ON BOREHOLE AND TEST PIT REPORTS

 FILL

 GRAVEL (GP or GW)

 SAND (SP or SW)

 SILT (ML or MH)

 CLAY (CL, CI or CH)

 ORGANIC SOILS (OL or OH or Pt)

 COBBLES or BOULDERS

Combinations of these basic symbols may be used to indicate mixed materials such as sandy clay.

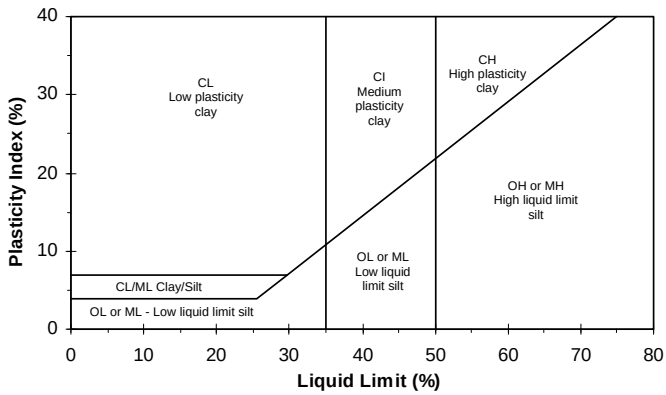
CLASSIFICATION AND INFERRED STRATIGRAPHY

Soil and Rock is classified and described in Reports of Boreholes and Test Pits using the preferred method given in AS1726 – 1993, (Amdt1 – 1994 and Amdt2 – 1994), Appendix A. The material properties are assessed in the field by visual/tactile methods.

Particle Size

Major Division	Sub Division	Particle Size
BOULDERS		> 200 mm
COBBLES		63 to 200 mm
GRAVEL	Coarse	20 to 63 mm
	Medium	6.0 to 20 mm
	Fine	2.0 to 6.0 mm
SAND	Coarse	0.6 to 2.0 mm
	Medium	0.2 to 0.6 mm
	Fine	0.075 to 0.2 mm
SILT		0.002 to 0.075 mm
CLAY		< 0.002 mm

Plasticity Properties



MOISTURE CONDITION

AS1726 - 1993

Symbol	Term	Description
D	Dry	Sands and gravels are free flowing. Clays & Silts may be brittle or friable and powdery.
M	Moist	Soils are darker than in the dry condition & may feel cool. Sands and gravels tend to cohere.
W	Wet	Soils exude free water. Sands and gravels tend to cohere.

CONSISTENCY AND DENSITY

AS1726 - 1993

Symbol	Term	Undrained Shear Strength
VS	Very Soft	0 to 12 kPa
S	Soft	12 to 25 kPa
F	Firm	25 to 50 kPa
St	Stiff	50 to 100 kPa
VSt	Very Stiff	100 to 200 kPa
H	Hard	Above 200 kPa

Symbol	Term	Density Index %	SPT "N" #
VL	Very Loose	Less than 15	0 to 4
L	Loose	15 to 35	4 to 10
MD	Medium Dense	35 to 65	10 to 30
D	Dense	65 to 85	30 to 50
VD	Very Dense	Above 85	Above 50

In the absence of test results, consistency and density may be assessed from correlations with the observed behaviour of the material.

SPT correlations are not stated in AS1726 – 1993, and may be subject to corrections for overburden pressure and equipment type.

TERMS FOR ROCK MATERIAL STRENGTH & WEATHERING AND ABBREVIATIONS FOR DEFECT DESCRIPTIONS

STRENGTH

Symbol	Term	Point Load Index, $Is_{(50)}$ (MPa)	Field Guide
EL	Extremely Low	< 0.03	Easily remoulded by hand to a material with soil properties.
VL	Very Low	0.03 to 0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with knife; too hard to cut a triaxial sample by hand. Pieces up to 30 mm can be broken by finger pressure.
L	Low	0.1 to 0.3	Easily scored with a knife; indentations 1 mm to 3 mm show in the specimen with firm blows of pick point; has dull sound under hammer. A piece of core 150 mm long by 50 mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.
M	Medium	0.3 to 1	Readily scored with a knife; a piece of core 150 mm long by 50 mm diameter can be broken by hand with difficulty.
H	High	1 to 3	A piece of core 150 mm long by 50 mm diameter cannot be broken by hand but can be broken with pick with a single firm blow; rock rings under hammer.
VH	Very High	3 to 10	Hand specimen breaks with pick after more than one blow; rock rings under hammer.
EH	Extremely High	>10	Specimen requires many blows with geological pick to break through intact material; rock rings under hammer.

ROCK STRENGTH TEST RESULTS

▼ Point Load Strength Index, $I_s(50)$, Axial test (MPa)

◀ Point Load Strength Index, $I_s(50)$, Diametral test (MPa)

Relationship between $I_s(50)$ and UCS (unconfined compressive strength) will vary with rock type and strength, and should be determined on a site-specific basis. UCS is typically 10 to 30 x $I_s(50)$, but can be as low as 5.

ROCK MATERIAL WEATHERING

Symbol		Term	Field Guide
RS		Residual Soil	Soil developed on extremely weathered rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported.
EW		Extremely Weathered	Rock is weathered to such an extent that it has soil properties - i.e. it either disintegrates or can be remoulded, in water.
DW	HW	Distinctly Weathered	Rock strength usually changed by weathering. The rock may be highly discoloured, usually by iron staining. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores. In some environments it is convenient to subdivide into Highly Weathered and Moderately Weathered, with the degree of alteration typically less for MW.
	MW		
SW		Slightly Weathered	Rock is slightly discoloured but shows little or no change of strength relative to fresh rock.
FR		Fresh	Rock shows no sign of decomposition or staining.

ABBREVIATIONS FOR DEFECT TYPES AND DESCRIPTIONS

Defect Type

B	Bedding parting
X	Foliation
C	Contact
L	Cleavage
J	Joint
SS/SZ	Sheared seam/zone (Fault)
CS/CZ	Crushed seam/zone (Fault)
DS/DZ	Decomposed seam/zone
IS/IZ	Infilled seam/zone
S	Schistocity
V	Vein

Coating or Infilling

Cn	Clean
Sn	Stain
Vr	Veneer
Ct	Coating or Infill

Planarity

Pl	Planar
Un	Undulating
St	Stepped

Roughness

Sl	Slickensided
Sm	Smooth
Ro	Rough

Vertical Boreholes – The dip (inclination from horizontal) of the defect is given.
Inclined Boreholes – The inclination is measured as the acute angle to the core axis.

APPENDIX B

Laboratory Test Reports

Golder Associates Pty Ltd
A.B.N. 64 006 107 857
Brisbane Laboratory
28 Bank Street
West End QLD 4101
(PO Box 3247 South Brisbane BC QLD 4101)
T: (61-7) 3840 9500
F: (61-7) 3840 9501
E: BNELab@golder.com.au

Moisture Content Report

Client :	**Queensland Rail Limited (Toowoomba)**	Report Number:	**137632080-20300 - 1**
Client Address:	**PO Box 3357 Toowoomba QLD 4350**		
Job Number :	**137632080-20300**	Report Date:	**13/04/2015**
Project :	**Remedial Slope Design**	Order Number:	
Location :	**Ch 144.7 km Toowoomba Range Railway ,**	Test Method:	**AS1289.2.1.1**

Lab No :	15300787	15300788	15300789	15300790
ID No :	-	-	-	-
Lot No :	-	-	-	-
Item No :	-	-	-	-
Date Sampled / Received :	1/4/2015	1/4/2015	1/4/2015	1/4/2015
Date Tested :	2/4/2015	2/4/2015	2/4/2015	2/4/2015
Material Source :	-	-	-	-
For Use As :	-	-	-	-
Sample Location :	CH144-BH01 (4.0-4.45 m) Sample CH144-BH01-003 SPT	CH144-BH01 (5.5-5.95 m) Sample CH144-BH01-004 SPT	CH144-BH01 (11.5-11.95 m) Sample CH144-BH01-009 SPT on Silty Clay	CH144-BH02 (4.0-4.45 m) Sample CH144-BH02-002 SPT
Drying Temperature(°C):	**105 to 110**	**105 to 110**	**105 to 110**	**105 to 110**
Moisture Content(%):	**19.0**	**32.1**	**24.3**	**26.4**
Remarks :				

Lab Number:	Soil Description
15300787	
15300788	
15300789	
15300790	

NATA
WORLD RECOGNISED ACCREDITATION

Accredited for compliance with ISO/IEC 17025.
THIS DOCUMENT SHALL ONLY BE REPRODUCED IN FULL.

APPROVED SIGNATORY

Mike Sandilands - Laboratory Manager

NATA Accred No:1961

FORM NUMBER: R69-RL-17

Golder Associates Pty Ltd
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Brisbane Laboratory
28 Bank Street
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E: BNELab@golder.com.au

Moisture Content Report

Client :	**Queensland Rail Limited (Toowoomba)**	Report Number:	**137632080-20300 - 1**
Client Address:	**PO Box 3357 Toowoomba QLD 4350**		
Job Number :	**137632080-20300**	Report Date:	**13/04/2015**
Project :	**Remedial Slope Design**	Order Number:	
Location :	**Ch 144.7 km Toowoomba Range Railway ,**	Test Method:	**AS1289.2.1.1**

Lab No :	15300791	15300792	15300793	15300794
ID No :	-	-	-	-
Lot No :	-	-	-	-
Item No :	-	-	-	-
Date Sampled / Received :	1/4/2015	1/4/2015	1/4/2015	1/4/2015
Date Tested :	2/4/2015	2/4/2015	2/4/2015	2/4/2015
Material Source :	-	-	-	-
For Use As :	-	-	-	-
Sample Location :	CH144-BH02 (7.5-7.95 m) Sample CH144-BH02-004 SPT	CH144-BH03 (4.0-4.45 m) Sample CH144-BH03-003 SPT	CH144-BH03 (7.0-7.45 m) Sample CH144-BH03-005 SPT	CH144-BH03 (8.5-8.95 m) Sample CH144-BH03-006 SPT
Drying Temperature(°C):	**105 to 110**	**105 to 110**	**105 to 110**	**105 to 110**
Moisture Content(%):	**31.5**	**24.6**	**31.8**	**29.5**
Remarks :				

Lab Number:	Soil Description
15300791	
15300792	
15300793	
15300794	

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Moisture Content Report

Client :	**Queensland Rail Limited (Toowoomba)**	Report Number:	**137632080-20300 - 1**
Client Address:	**PO Box 3357 Toowoomba QLD 4350**		
Job Number :	**137632080-20300**	Report Date:	**13/04/2015**
Project :	**Remedial Slope Design**	Order Number:	
Location :	**Ch 144.7 km Toowoomba Range Railway ,**	Test Method:	**AS1289.2.1.1**

Lab No :	15300795	15300796	15300797	15300798
ID No :	-	-	-	-
Lot No :	-	-	-	-
Item No :	-	-	-	-
Date Sampled / Received :	1/4/2015	1/4/2015	1/4/2015	1/4/2015
Date Tested :	2/4/2015	2/4/2015	2/4/2015	2/4/2015
Material Source :	-	-	-	-
For Use As :	-	-	-	-
Sample Location :	CH144-BH03 (11.5-11.95 m) Sample CH144-BH03-008 SPT	CH144-BH04 (4.0-4.45 m) Sample CH144-BH04-003 SPT	CH144-BH04 (5.5-5.95 m) Sample CH144-BH04-004 SPT	CH144-BH04 (8.5-8.95 m) Sample CH144-BH04-006 SPT
Drying Temperature(°C):	**105 to 110**	**105 to 110**	**105 to 110**	**105 to 110**
Moisture Content(%):	**15.5**	**19.9**	**14.9**	**12.6**
Remarks :				

Lab Number:	Soil Description
15300795	
15300796	
15300797	
15300798	

NATA
WORLD RECOGNISED ACCREDITATION

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APPROVED SIGNATORY

Mike Sandilands - Laboratory Manager

NATA Accred No:1961

FORM NUMBER: R69-RL-17

Golder Associates Pty Ltd
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Moisture Content Report

Client :	**Queensland Rail Limited (Toowoomba)**	Report Number:	**137632080-20300 - 1**
Client Address:	**PO Box 3357 Toowoomba QLD 4350**		
Job Number :	**137632080-20300**	Report Date:	**13/04/2015**
Project :	**Remedial Slope Design**	Order Number:	
Location :	**Ch 144.7 km Toowoomba Range Railway ,**	Test Method:	**AS1289.2.1.1**

Lab No :	15300800	15300801	15300802	15300803
ID No :	-	-	-	-
Lot No :	-	-	-	-
Item No :	-	-	-	-
Date Sampled / Received :	1/4/2015	1/4/2015	1/4/2015	1/4/2015
Date Tested :	2/4/2015	2/4/2015	2/4/2015	2/4/2015
Material Source :	-	-	-	-
For Use As :	-	-	-	-
Sample Location :	CH144-BH05 (2.5-2.95 m) Sample CH144-BH05-002 SPT	CH144-BH05 (5.5-5.93 m) Sample CH144-BH05-004 SPT	CH144-BH06 (1.7-2.15 m) Sample CH144-BH06-002 SPT	CH144-BH06 (2.5-2.95 m) Sample CH144-BH06-003 SPT
Drying Temperature(°C):	**105 to 110**	**105 to 110**	**105 to 110**	**105 to 110**
Moisture Content(%):	**17.5**	**22.2**	**13.1**	**16.0**
Remarks :				

Lab Number:	Soil Description
15300800	
15300801	
15300802	
15300803	

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Mike Sandilands - Laboratory Manager

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Moisture Content Report

Client :	**Queensland Rail Limited (Toowoomba)**	Report Number:	**137632080-20300 - 1**
Client Address:	**PO Box 3357 Toowoomba QLD 4350**		
Job Number :	**137632080-20300**	Report Date:	**13/04/2015**
Project :	**Remedial Slope Design**	Order Number:	
Location :	**Ch 144.7 km Toowoomba Range Railway ,**	Test Method:	**AS1289.2.1.1**

Lab No :	15300804	15300805	15300806	15300807
ID No :	-	-	-	-
Lot No :	-	-	-	-
Item No :	-	-	-	-
Date Sampled / Received :	1/4/2015	1/4/2015	1/4/2015	1/4/2015
Date Tested :	2/4/2015	2/4/2015	2/4/2015	2/4/2015
Material Source :	-	-	-	-
For Use As :	-	-	-	-
Sample Location :	CH144-BH06 (7.0-7.45 m) Sample CH144-BH06-006 SPT	CH144-BH06 (11.5-11.95 m) Sample CH144-BH06-009 SPT	CH144-BH07 (4.0-4.45 m) Sample CH144-BH07-003 SPT	CH144-BH08 (5.5-5.95 m) Sample CH144-BH08-004 SPT
Drying Temperature(°C):	**105 to 110**	**105 to 110**	**105 to 110**	**105 to 110**
Moisture Content(%):	**13.2**	**20.2**	**15.1**	**21.4**
Remarks :				

Lab Number:	Soil Description
15300804	
15300805	
15300806	
15300807	

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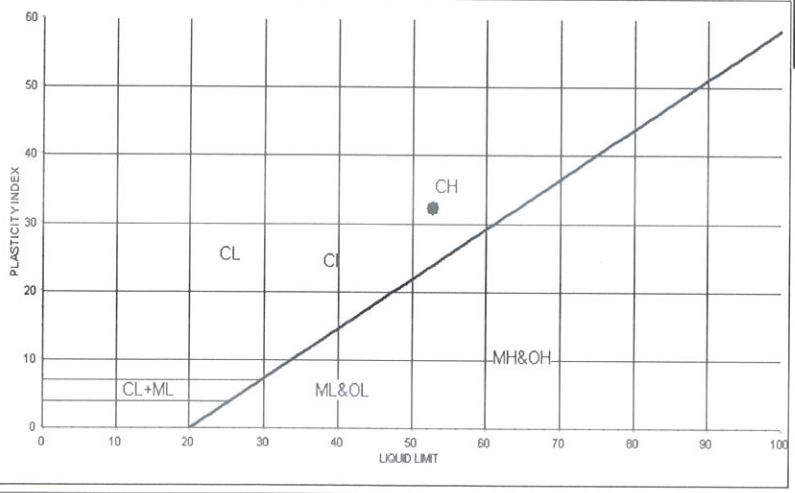
Atterberg Limits Report

Client:	**Queensland Rail Limited (Toowoomba)**	Report Number:	**137632080-20300 - 2**
Client Address:	**PO Box 3357 Toowoomba QLD 4350**		
Job Number:	**137632080-20300**	Report Date:	**13/04/2015**
Project:	**Remedial Slope Design**	Order Number:	-
Location	**Ch 144.7 km Toowoomba Range Railway ,**		Page 1 of 3
Lab No:	**15300789**	Sample Location	CH144-BH01 (11.5-11.95 m)
Date Sampled / Received:	**1/04/2015**		Sample CH144-BH01-009
Date Tested:	**8/04/2015**		SPT
Sampled By:	**Client's Rep.**		on Silty Clay
Sample Method:	-	Spec Description:	-
Material Source:	-	Lot Number:	-
For Use As:	-	Spec Number:	-
Remarks:	-		

Plasticity Tests		Test Method	Specification Minimum	Result	Specification Maximum
Sample History:	Oven Dried low temp.				
Moisture Content (%):°C	105 to 110	**AS1289.2.1.1**	-	**24.3**	-
Liquid Limit (%)		**AS1289.3.1.2**		**53**	
Plastic Limit (%)		**AS1289.3.2.1**		**21**	
Plasticity Index (%)		**AS1289.3.3.1**		**32**	
Linear Shrinkage (%)		**AS1289.3.4.1**		**15.0**	
			Linear Shrinkage State after drying	No crumbling or curling	



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FORM NUMBER: R37-RL-25

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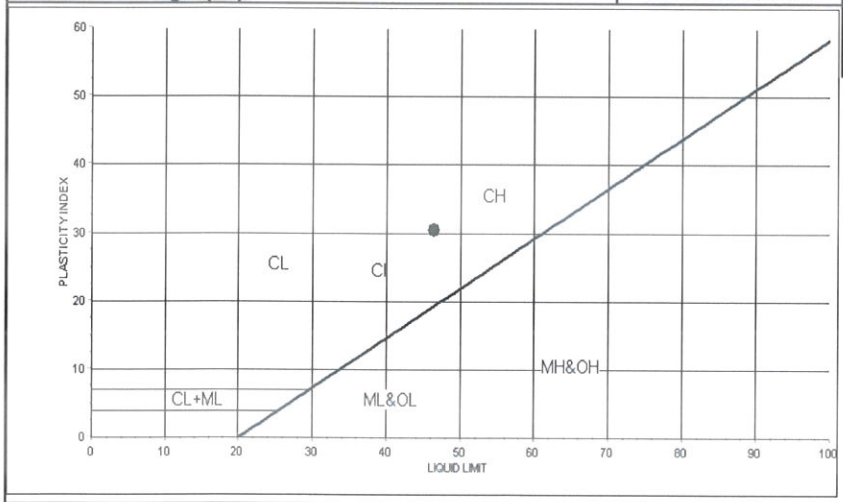
Atterberg Limits Report

Client:	**Queensland Rail Limited (Toowoomba)**	Report Number:	**137632080-20300 - 2**
Client Address:	**PO Box 3357 Toowoomba QLD 4350**		
Job Number:	**137632080-20300**	Report Date:	**13/04/2015**
Project:	**Remedial Slope Design**	Order Number:	-
Location	**Ch 144.7 km Toowoomba Range Railway ,**		
Lab No:	**15300796**	Sample Location	
Date Sampled / Received:	**1/04/2015**	CH144-BH04 (4.0-4.45 m)	
Date Tested:	**8/04/2015**	Sample CH144-BH04-003	
Sampled By:	**Client's Rep.**	SPT	
Sample Method:	-		
Material Source:	-	Spec Description:	-
For Use As:	-	Lot Number:	-
Remarks:	-	Spec Number:	-

Plasticity Tests		Test Method	Specification Minimum	Result	Specification Maximum
Sample History:	Oven Dried low temp.				
Moisture Content (%):°C	105 to 110	**AS1289.2.1.1**	-	**19.9**	-
Liquid Limit (%)		**AS1289.3.1.2**		**46**	
Plastic Limit (%)		**AS1289.3.2.1**		**16**	
Plasticity Index (%)		**AS1289.3.3.1**		**30**	
Linear Shrinkage (%)		**AS1289.3.4.1**		**15.0**	



Linear Shrinkage State after drying	Some Curling

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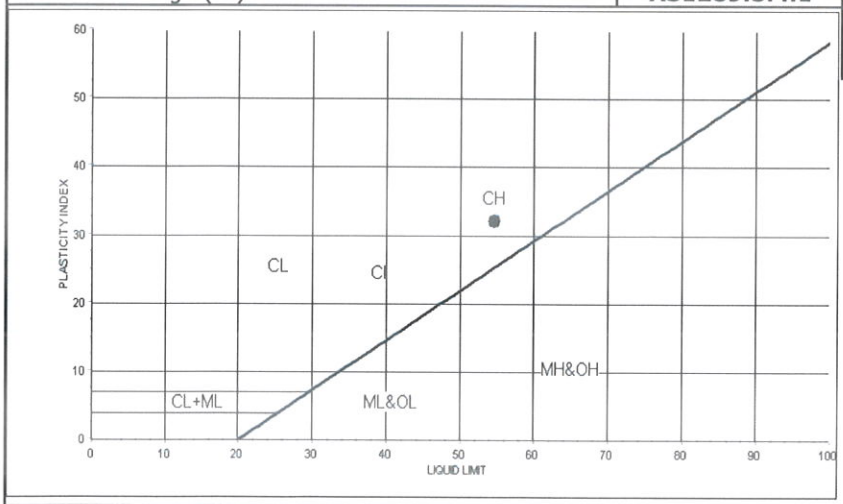
Atterberg Limits Report

Client:	**Queensland Rail Limited (Toowoomba)**	Report Number:	**137632080-20300 - 2**
Client Address:	**PO Box 3357 Toowoomba QLD 4350**		
Job Number:	**137632080-20300**	Report Date:	**13/04/2015**
Project:	**Remedial Slope Design**	Order Number:	-
Location	**Ch 144.7 km Toowoomba Range Railway ,**		Page 3 of 3
Lab No:	**15300805**	Sample Location	CH144-BH06 (11.5-11.95 m)
Date Sampled / Received:	**1/04/2015**		Sample CH144-BH06-009
Date Tested:	**8/04/2015**		SPT
Sampled By:	**Client's Rep.**		
Sample Method:	-		
Material Source:	-	Spec Description:	-
For Use As:	-	Lot Number:	-
Remarks:	-	Spec Number:	-

Plasticity Tests		Test Method	Specification Minimum	Result	Specification Maximum
Sample History:	Oven Dried low temp.				
Moisture Content (%):°C	105 to 110	**AS1289.2.1.1**	-	**20.2**	-
Liquid Limit (%)		**AS1289.3.1.2**		**55**	
Plastic Limit (%)		**AS1289.3.2.1**		**23**	
Plasticity Index (%)		**AS1289.3.3.1**		**32**	
Linear Shrinkage (%)		**AS1289.3.4.1**		**16.5**	



Linear Shrinkage State after drying	Some Curling

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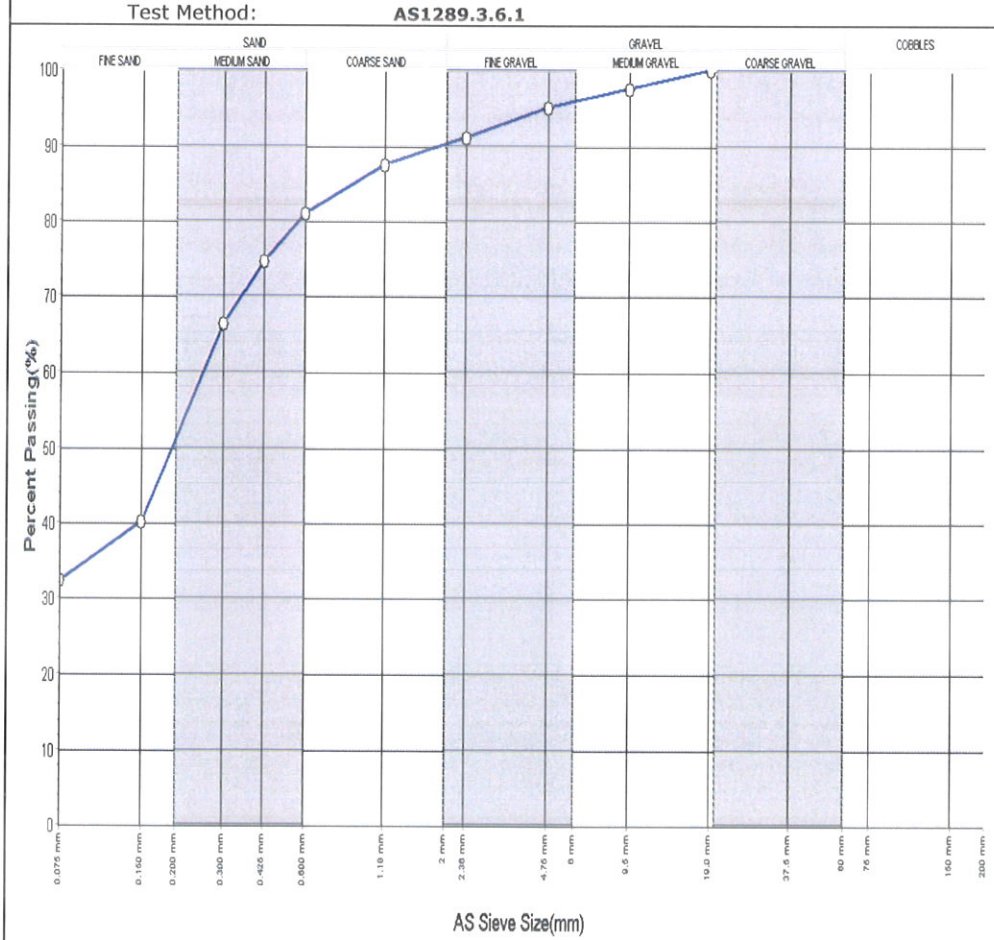
Particle Size Distribution Report

Client:	Queensland Rail Limited (Toowoomba)	Job Number:	137632080-20300
Client Address:	PO Box 3357 Toowoomba QLD 4350	Report Number:	137632080-20300 - 3
Project:	Remedial Slope Design	Report Date:	13/04/2015
Location	Ch 144.7 km Toowoomba Range Railway ,		Page 1 of 14
Lab No:	15300787	Sample Location	
Date Sampled / Received:	1/04/2015	CH144-BH01 (4.0-4.45 m)	
Date Tested:	8/04/2015	Sample CH144-BH01-003	
Sampled By:	Client's Rep.	SPT	
Sample Method:	-		
Material Source:	-		
For Use As:	-		
Remarks:	-		

Test Method: AS1289.3.6.1



A.S. Sieve Sizes	Percent Passing
75.00 mm	
53.00 mm	
37.50 mm	
26.50 mm	
19.00 mm	100
13.2 mm	-
9.50 mm	98
4.75 mm	95
2.36 mm	91
1.18 mm	88
0.600 mm	81
0.425 mm	75
0.300 mm	67
0.150 mm	40
0.075 mm	32
Moisture Content (%)	19.0

Visual Classification:

Approved Signatory

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Form Number : R77-RL-16

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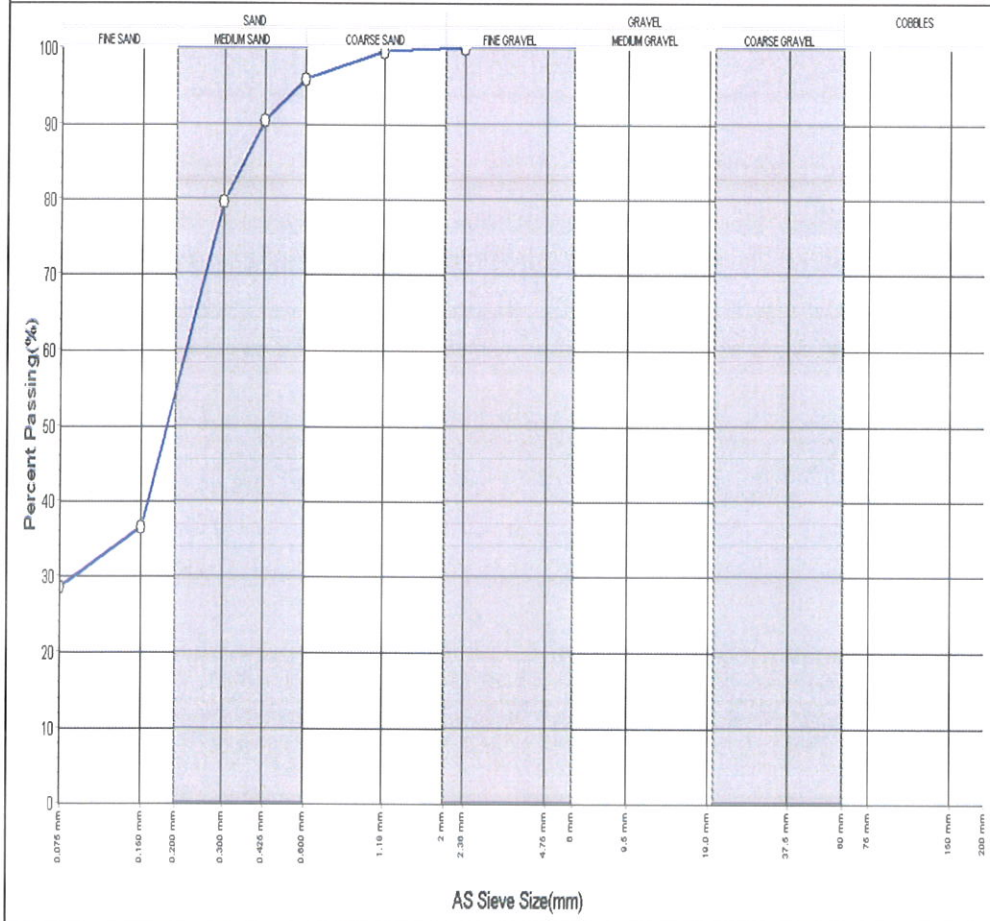
Particle Size Distribution Report

Client:	**Queensland Rail Limited (Toowoomba)**	Job Number:	**137632080-20300**
Client Address:	**PO Box 3357 Toowoomba QLD 4350**	Report Number:	**137632080-20300 - 3**
Project:	**Remedial Slope Design**	Report Date:	**13/04/2015**
Location	**Ch 144.7 km Toowoomba Range Railway ,**		**Page 2 of 14**
Lab No:	**15300788**	Sample Location	CH144-BH01 (5.5-5.95 m)
Date Sampled / Received:	**1/04/2015**		Sample CH144-BH01-004
Date Tested:	**8/04/2015**		SPT
Sampled By:	**Client's Rep.**		
Sample Method:	-		
Material Source:	-		
For Use As:	-		
Remarks:	-		

Test Method: **AS1289.3.6.1**



A.S. Sieve Sizes	Percent Passing
75.00 mm	
53.00 mm	
37.50 mm	
26.50 mm	
19.00 mm	
13.2 mm	
9.50 mm	
4.75 mm	
2.36 mm	**100**
1.18 mm	**100**
0.600 mm	**96**
0.425 mm	**90**
0.300 mm	**80**
0.150 mm	**37**
0.075 mm	**29**
Moisture Content (%)	**32.1**

Visual Classification:

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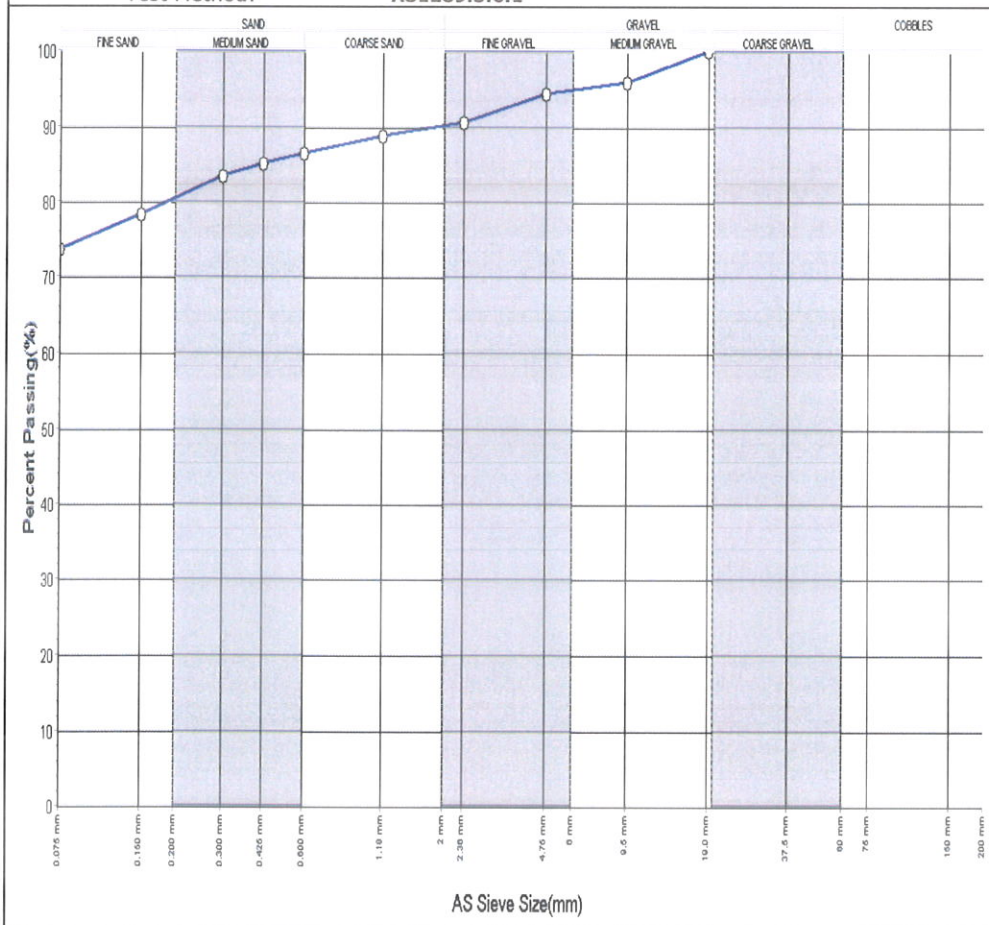
Particle Size Distribution Report

Client:	**Queensland Rail Limited (Toowoomba)**	Job Number:	**137632080-20300**
Client Address:	**PO Box 3357 Toowoomba QLD 4350**	Report Number:	**137632080-20300 - 3**
Project:	**Remedial Slope Design**	Report Date:	**13/04/2015**
Location	**Ch 144.7 km Toowoomba Range Railway ,**		**Page 3 of 14**
Lab No:	**15300790**	Sample Location	
Date Sampled / Received:	**1/04/2015**	CH144-BH02 (4.0-4.45 m)	
Date Tested:	**8/04/2015**	Sample CH144-BH02-002	
Sampled By:	**Client's Rep.**	SPT	
Sample Method:	-		
Material Source:	-		
For Use As:	-		
Remarks:	-		

Test Method: **AS1289.3.6.1**



A.S. Sieve Sizes	Percent Passing
75.00 mm	
53.00 mm	
37.50 mm	
26.50 mm	
19.00 mm	**100**
13.2 mm	**-**
9.50 mm	**96**
4.75 mm	**94**
2.36 mm	**91**
1.18 mm	**89**
0.600 mm	**87**
0.425 mm	**85**
0.300 mm	**84**
0.150 mm	**78**
0.075 mm	**74**
Moisture Content (%)	**26.4**

Visual Classification:

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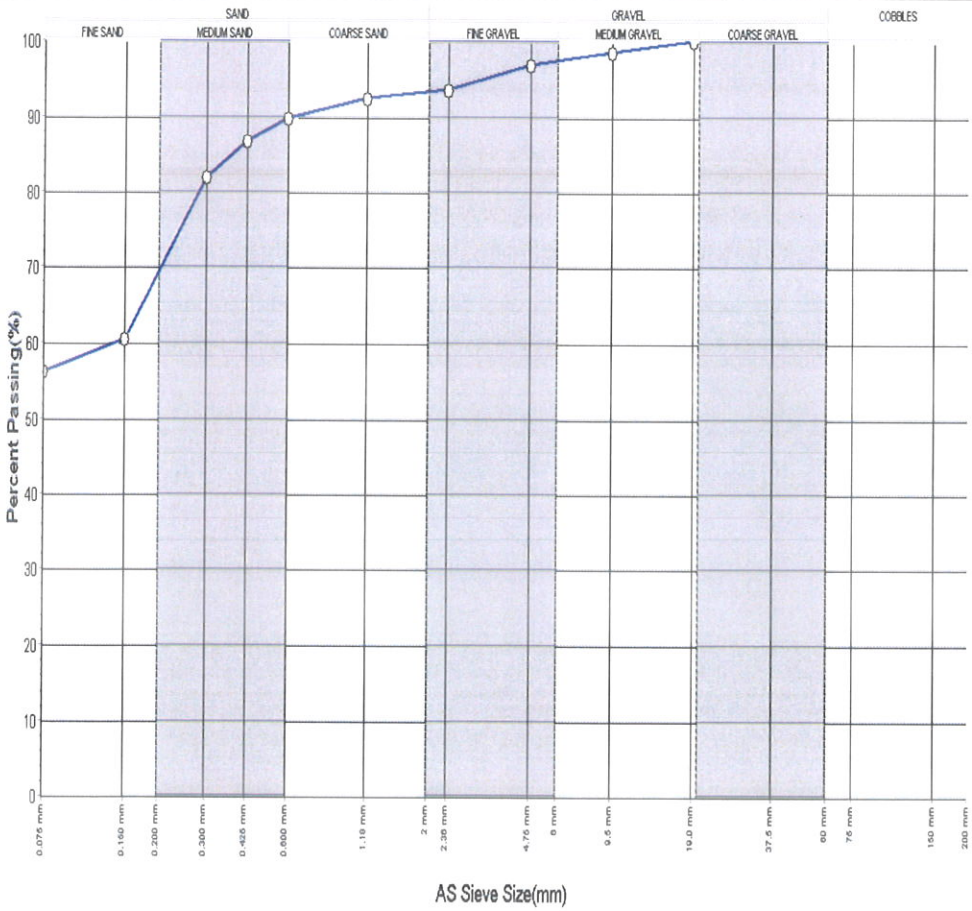
Particle Size Distribution Report

Client:	**Queensland Rail Limited (Toowoomba)**	Job Number:	**137632080-20300**
Client Address:	**PO Box 3357 Toowoomba QLD 4350**	Report Number:	**137632080-20300 - 3**
Project:	**Remedial Slope Design**	Report Date:	**13/04/2015**
Location	**Ch 144.7 km Toowoomba Range Railway ,**		**Page 4 of 14**
Lab No:	**15300792**	Sample Location	
Date Sampled / Received:	**1/04/2015**	CH144-BH03 (4.0-4.45 m)	
Date Tested:	**8/04/2015**	Sample CH144-BH03-003	
Sampled By:	**Client's Rep.**	SPT	
Sample Method:	-		
Material Source:	-		
For Use As:	-		
Remarks:	-		

Test Method: **AS1289.3.6.1**



A.S. Sieve Sizes	Percent Passing
75.00 mm	
53.00 mm	
37.50 mm	
26.50 mm	
19.00 mm	**100**
13.2 mm	-
9.50 mm	**99**
4.75 mm	**97**
2.36 mm	**94**
1.18 mm	**92**
0.600 mm	**90**
0.425 mm	**87**
0.300 mm	**82**
0.150 mm	**60**
0.075 mm	**56**
Moisture Content (%)	**24.6**

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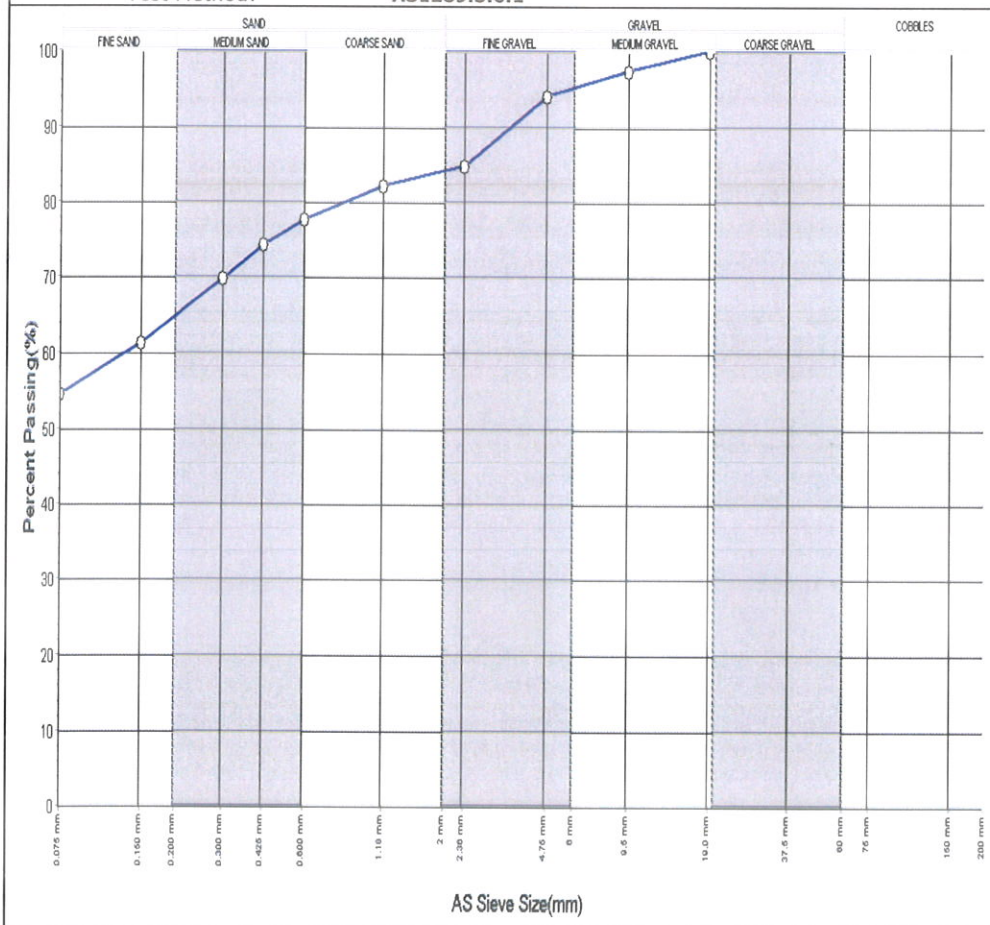
Particle Size Distribution Report

Client:	Queensland Rail Limited (Toowoomba)	Job Number:	137632080-20300
Client Address:	PO Box 3357 Toowoomba QLD 4350	Report Number:	137632080-20300 - 3
Project:	Remedial Slope Design	Report Date:	13/04/2015
Location	Ch 144.7 km Toowoomba Range Railway ,		Page 5 of 14
Lab No:	15300794	Sample Location	
Date Sampled / Received:	1/04/2015	CH144-BH03 (8.5-8.95 m)	
Date Tested:	8/04/2015	Sample CH144-BH03-006	
Sampled By:	Client's Rep.	SPT	
Sample Method:	-		
Material Source:	-		
For Use As:	-		
Remarks:	-		

Test Method: AS1289.3.6.1



A.S. Sieve Sizes	Percent Passing
75.00 mm	
53.00 mm	
37.50 mm	
26.50 mm	
19.00 mm	100
13.2 mm	-
9.50 mm	97
4.75 mm	94
2.36 mm	85
1.18 mm	82
0.600 mm	78
0.425 mm	74
0.300 mm	70
0.150 mm	61
0.075 mm	55
Moisture Content (%)	29.5

Visual Classification:

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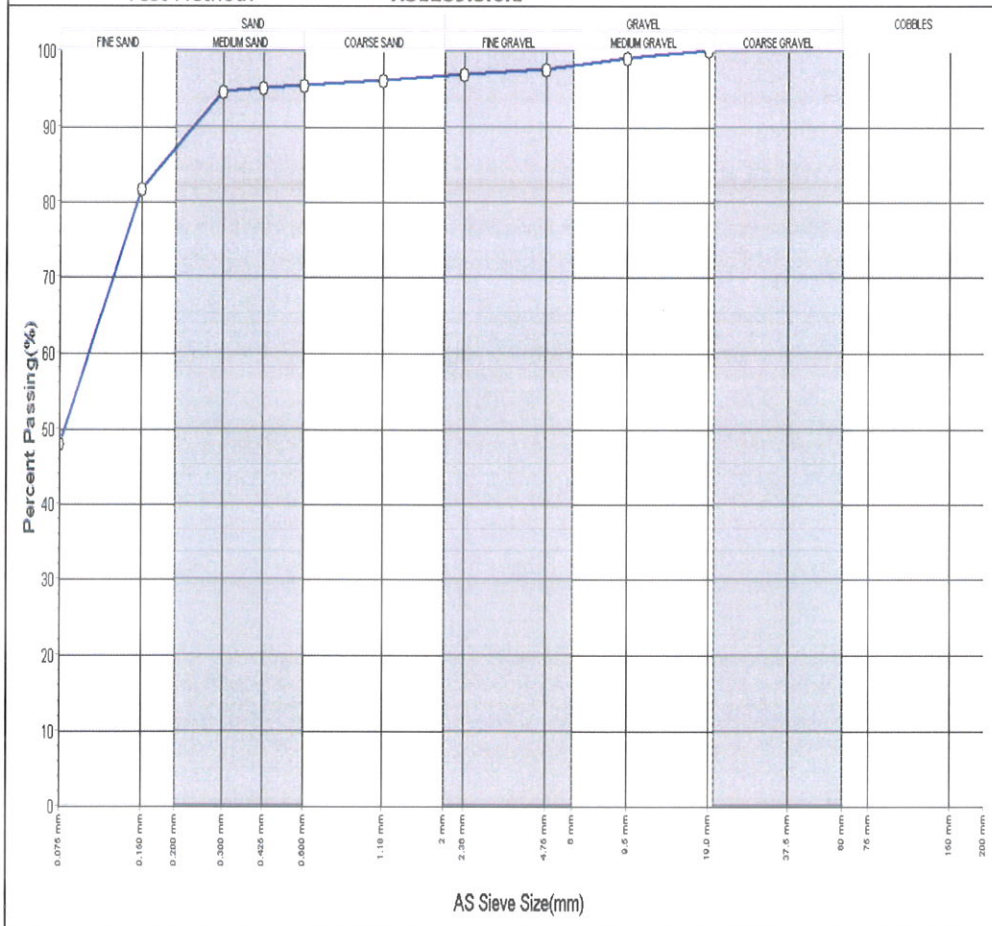
Particle Size Distribution Report

Client:	**Queensland Rail Limited (Toowoomba)**	Job Number:	**137632080-20300**
Client Address:	**PO Box 3357 Toowoomba QLD 4350**	Report Number:	**137632080-20300 - 3**
Project:	**Remedial Slope Design**	Report Date:	**13/04/2015**
Location	**Ch 144.7 km Toowoomba Range Railway ,**		**Page 6 of 14**
Lab No:	**15300795**	Sample Location	
Date Sampled / Received:	**1/04/2015**	CH144-BH03 (11.5-11.95 m)	
Date Tested:	**9/04/2015**	Sample CH144-BH03-008	
Sampled By:	**Client's Rep.**	SPT	
Sample Method:	-		
Material Source:	-		
For Use As:	-		
Remarks:	-		

Test Method: **AS1289.3.6.1**



A.S. Sieve Sizes	Percent Passing
75.00 mm	
53.00 mm	
37.50 mm	
26.50 mm	
19.00 mm	**100**
13.2 mm	-
9.50 mm	**99**
4.75 mm	**98**
2.36 mm	**97**
1.18 mm	**96**
0.600 mm	**95**
0.425 mm	**95**
0.300 mm	**95**
0.150 mm	**82**
0.075 mm	**48**
Moisture Content (%)	**15.5**

Visual Classification:

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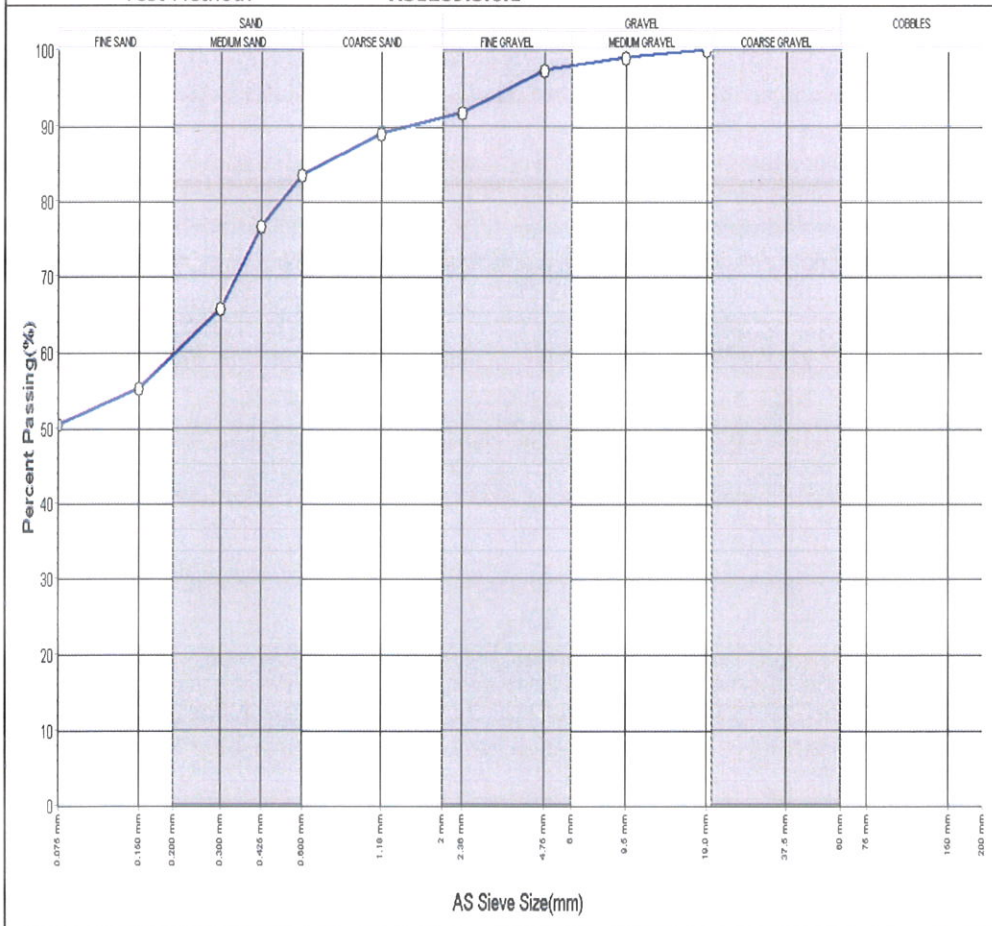
Particle Size Distribution Report

Client:	**Queensland Rail Limited (Toowoomba)**	Job Number:	**137632080-20300**
Client Address:	**PO Box 3357 Toowoomba QLD 4350**	Report Number:	**137632080-20300 - 3**
Project:	**Remedial Slope Design**	Report Date:	**13/04/2015**
Location	**Ch 144.7 km Toowoomba Range Railway ,**		**Page 7 of 14**
Lab No:	**15300797**	Sample Location	
Date Sampled / Received:	**1/04/2015**	CH144-BH04 (5.5-5.95 m)	
Date Tested:	**9/04/2015**	Sample CH144-BH04-004	
Sampled By:	**Client's Rep.**	SPT	
Sample Method:	-		
Material Source:	-		
For Use As:	-		
Remarks:	-		

Test Method: **AS1289.3.6.1**



A.S. Sieve Sizes	Percent Passing
75.00 mm	
53.00 mm	
37.50 mm	
26.50 mm	
19.00 mm	**100**
13.2 mm	-
9.50 mm	**99**
4.75 mm	**97**
2.36 mm	**92**
1.18 mm	**89**
0.600 mm	**83**
0.425 mm	**77**
0.300 mm	**66**
0.150 mm	**55**
0.075 mm	**50**
Moisture Content (%)	**14.9**

Visual Classification:

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Mike Sandilands - Laboratory Manager

NATA Accred No:1961

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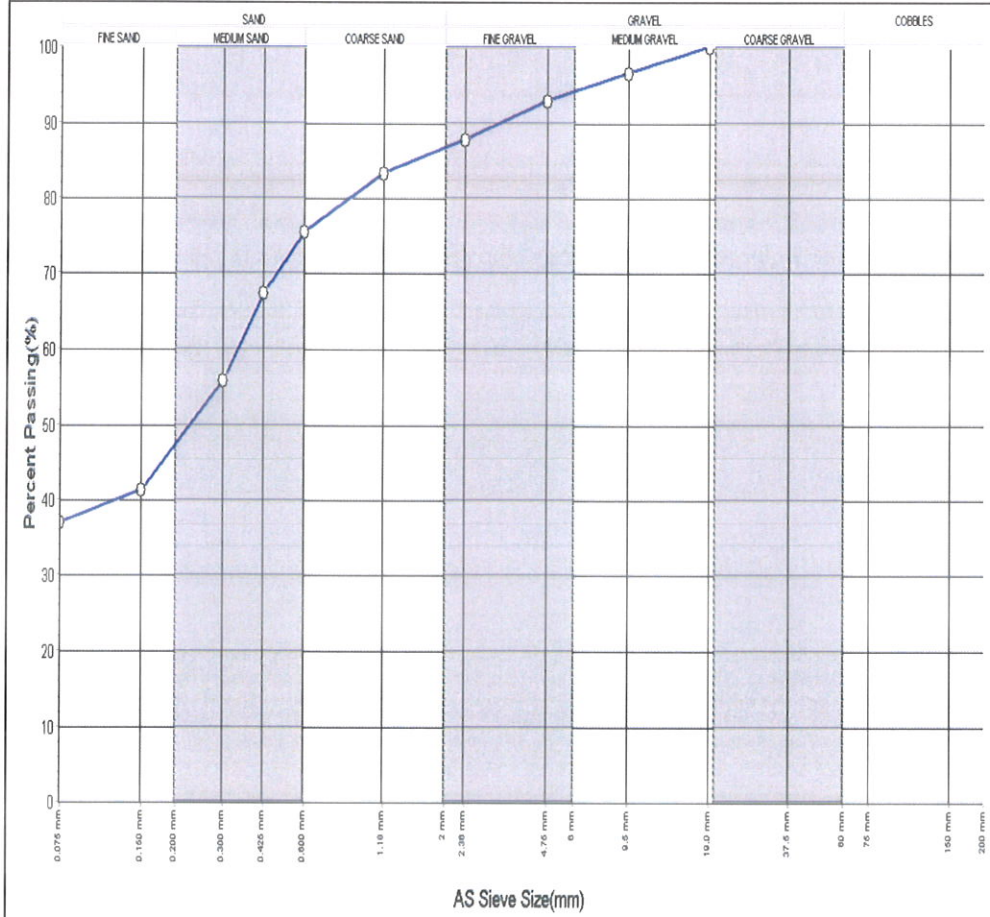
Particle Size Distribution Report

Client:	**Queensland Rail Limited (Toowoomba)**	Job Number:	**137632080-20300**
Client Address:	**PO Box 3357 Toowoomba QLD 4350**	Report Number:	**137632080-20300 - 3**
Project:	**Remedial Slope Design**	Report Date:	**13/04/2015**
Location	**Ch 144.7 km Toowoomba Range Railway ,**		**Page 8 of 14**
Lab No:	**15300798**	Sample Location	
Date Sampled / Received:	**1/04/2015**	CH144-BH04 (8.5-8.95 m)	
Date Tested:	**8/04/2015**	Sample CH144-BH04-006	
Sampled By:	**Client's Rep.**	SPT	
Sample Method:	-		
Material Source:	-		
For Use As:	-		
Remarks:	-		

Test Method: **AS1289.3.6.1**



A.S. Sieve Sizes	Percent Passing
75.00 mm	
53.00 mm	
37.50 mm	
26.50 mm	
19.00 mm	**100**
13.2 mm	**-**
9.50 mm	**97**
4.75 mm	**93**
2.36 mm	**88**
1.18 mm	**83**
0.600 mm	**76**
0.425 mm	**67**
0.300 mm	**56**
0.150 mm	**41**
0.075 mm	**37**
Moisture Content (%)	**12.6**

Visual Classification:

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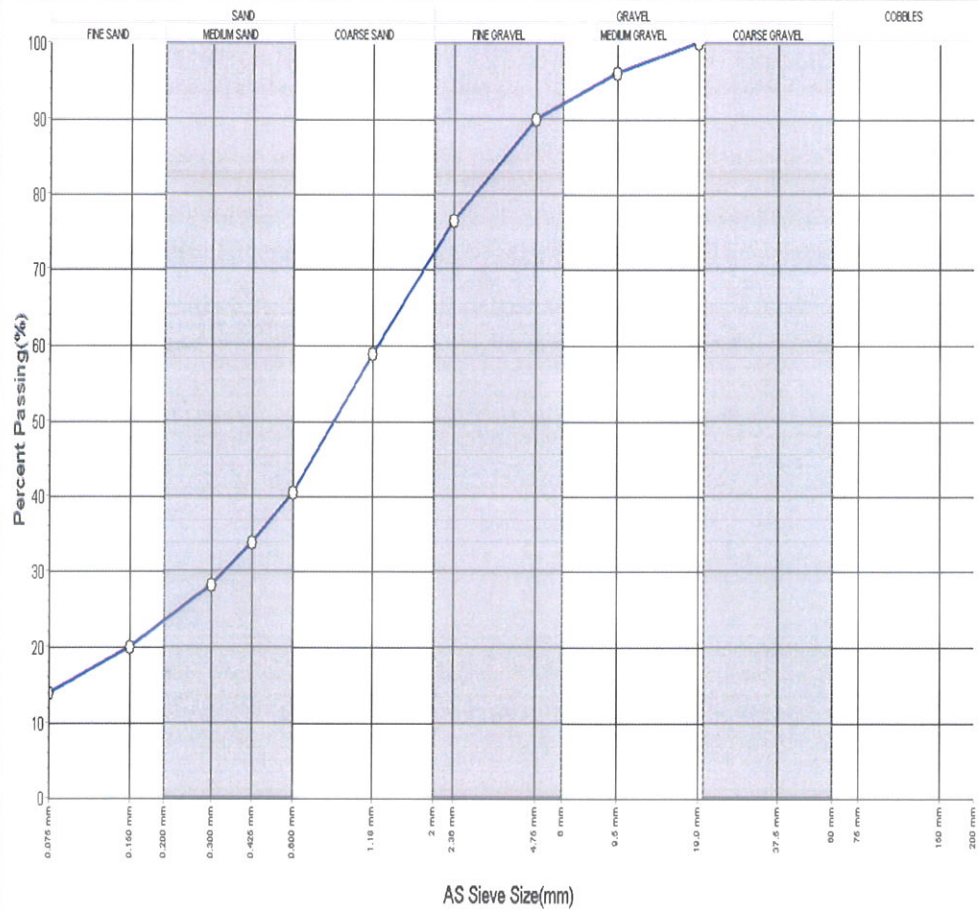
Particle Size Distribution Report

Client:	**Queensland Rail Limited (Toowoomba)**	Job Number:	**137632080-20300**
Client Address:	**PO Box 3357 Toowoomba QLD 4350**	Report Number:	**137632080-20300 - 3**
Project:	**Remedial Slope Design**	Report Date:	**13/04/2015**
Location	**Ch 144.7 km Toowoomba Range Railway ,**		**Page 9 of 14**

Lab No:	**15300800**	Sample Location
Date Sampled / Received:	**1/04/2015**	CH144-BH05 (2.5-2.95 m)
Date Tested:	**8/04/2015**	Sample CH144-BH05-002
Sampled By:	**Client's Rep.**	SPT
Sample Method:	-	
Material Source:	-	
For Use As:	-	
Remarks:	**Sample mass as received does not meet the minimum mass requirements in AS1289.1.1 Table 1.**	

Test Method: **AS1289.3.6.1**



A.S. Sieve Sizes	Percent Passing
75.00 mm	
53.00 mm	
37.50 mm	
26.50 mm	
19.00 mm	**100**
13.2 mm	-
9.50 mm	**96**
4.75 mm	**90**
2.36 mm	**76**
1.18 mm	**59**
0.600 mm	**41**
0.425 mm	**34**
0.300 mm	**28**
0.150 mm	**20**
0.075 mm	**14**
Moisture Content (%)	**17.5**

Visual Classification:

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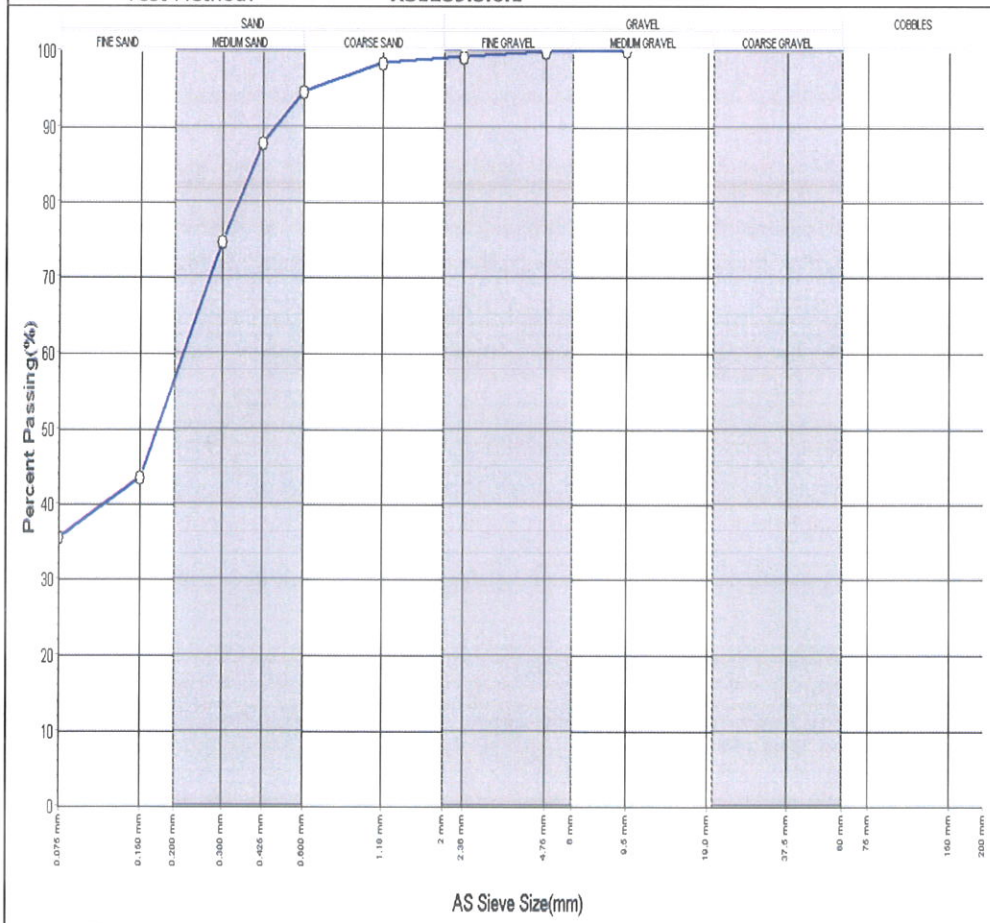
Particle Size Distribution Report

Client:	**Queensland Rail Limited (Toowoomba)**	Job Number:	**137632080-20300**
Client Address:	**PO Box 3357 Toowoomba QLD 4350**	Report Number:	**137632080-20300 - 3**
Project:	**Remedial Slope Design**	Report Date:	**13/04/2015**
Location	**Ch 144.7 km Toowoomba Range Railway ,**		**Page 10 of 14**
Lab No:	**15300801**	Sample Location	
Date Sampled / Received:	**1/04/2015**	CH144-BH05 (5.5-5.93 m)	
Date Tested:	**9/04/2015**	Sample CH144-BH05-004	
Sampled By:	**Client's Rep.**	SPT	
Sample Method:	-		
Material Source:	-		
For Use As:	-		
Remarks:	-		

Test Method: **AS1289.3.6.1**



A.S. Sieve Sizes	Percent Passing
75.00 mm	
53.00 mm	
37.50 mm	
26.50 mm	
19.00 mm	
13.2 mm	
9.50 mm	**100**
4.75 mm	**100**
2.36 mm	**99**
1.18 mm	**98**
0.600 mm	**95**
0.425 mm	**88**
0.300 mm	**75**
0.150 mm	**43**
0.075 mm	**36**
Moisture Content (%)	**22.2**

Visual Classification:

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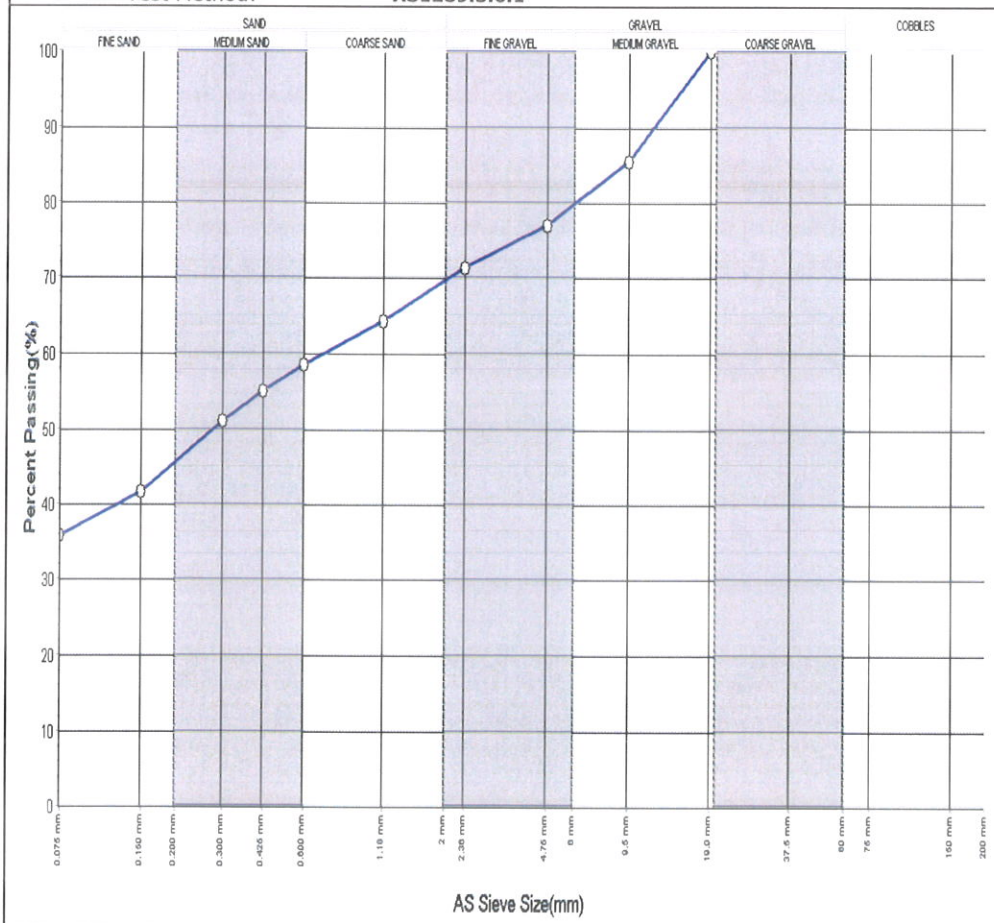
Particle Size Distribution Report

Client:	**Queensland Rail Limited (Toowoomba)**	Job Number:	**137632080-20300**
Client Address:	**PO Box 3357 Toowoomba QLD 4350**	Report Number:	**137632080-20300 - 3**
Project:	**Remedial Slope Design**	Report Date:	**13/04/2015**
Location	**Ch 144.7 km Toowoomba Range Railway ,**		**Page 11 of 14**
Lab No:	**15300802**	Sample Location	
Date Sampled / Received:	**1/04/2015**	CH144-BH06 (1.7-2.15 m)	
Date Tested:	**8/04/2015**	Sample CH144-BH06-002	
Sampled By:	**Client's Rep.**	SPT	
Sample Method:	-		
Material Source:	-		
For Use As:	-		
Remarks:	**Sample mass as received does not meet the minimum mass requirements in AS1289.1.1 Table 1.**		

Test Method: **AS1289.3.6.1**



A.S. Sieve Sizes	Percent Passing
75.00 mm	
53.00 mm	
37.50 mm	
26.50 mm	
19.00 mm	**100**
13.2 mm	-
9.50 mm	**85**
4.75 mm	**77**
2.36 mm	**71**
1.18 mm	**64**
0.600 mm	**59**
0.425 mm	**55**
0.300 mm	**51**
0.150 mm	**42**
0.075 mm	**36**
Moisture Content (%)	**13.1**

Visual Classification:

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Form Number : R77-RL-16

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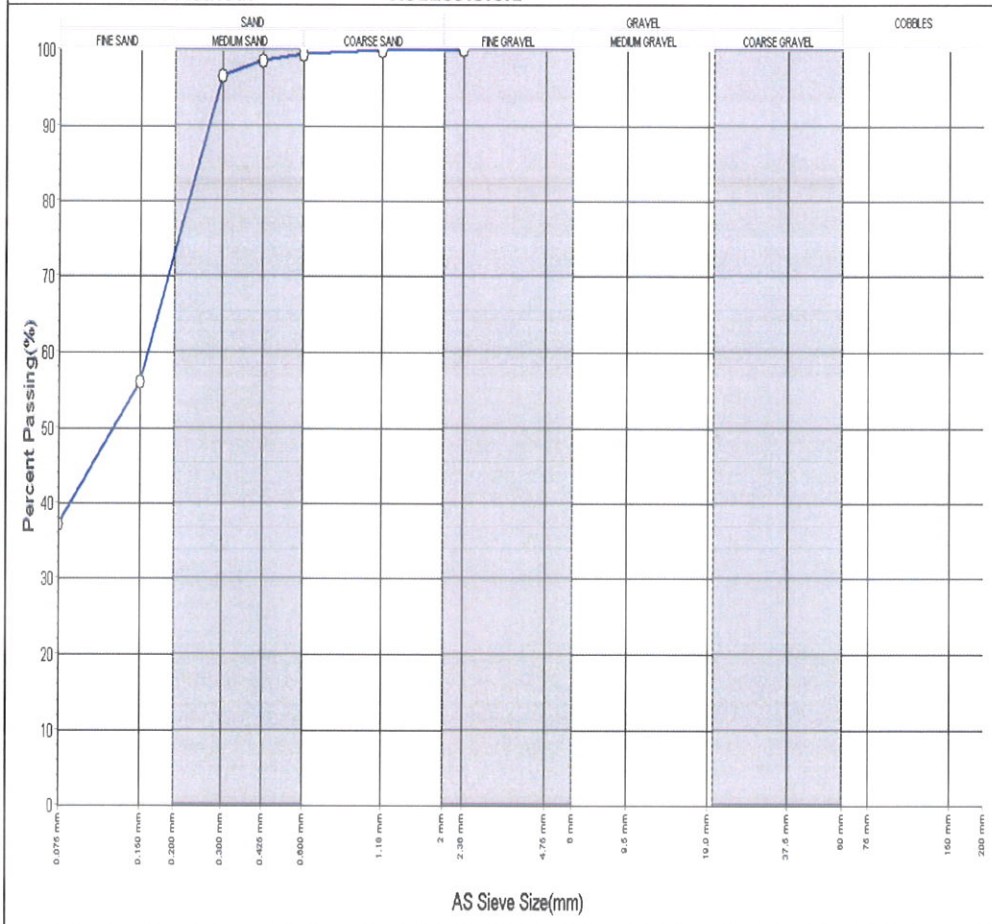
Particle Size Distribution Report

Client:	**Queensland Rail Limited (Toowoomba)**	Job Number:	**137632080-20300**
Client Address:	**PO Box 3357 Toowoomba QLD 4350**	Report Number:	**137632080-20300 - 3**
Project:	**Remedial Slope Design**	Report Date:	**13/04/2015**
Location	**Ch 144.7 km Toowoomba Range Railway ,**		**Page 12 of 14**
Lab No:	**15300804**	Sample Location	
Date Sampled / Received:	**1/04/2015**	CH144-BH06 (7.0-7.45 m)	
Date Tested:	**8/04/2015**	Sample CH144-BH06-006	
Sampled By:	**Client's Rep.**	SPT	
Sample Method:	-		
Material Source:	-		
For Use As:	-		
Remarks:	-		

Test Method: **AS1289.3.6.1**



A.S. Sieve Sizes	Percent Passing
75.00 mm	
53.00 mm	
37.50 mm	
26.50 mm	
19.00 mm	
13.2 mm	
9.50 mm	
4.75 mm	
2.36 mm	**100**
1.18 mm	**100**
0.600 mm	**99**
0.425 mm	**99**
0.300 mm	**97**
0.150 mm	**56**
0.075 mm	**37**
Moisture Content (%)	**13.2**

Visual Classification:

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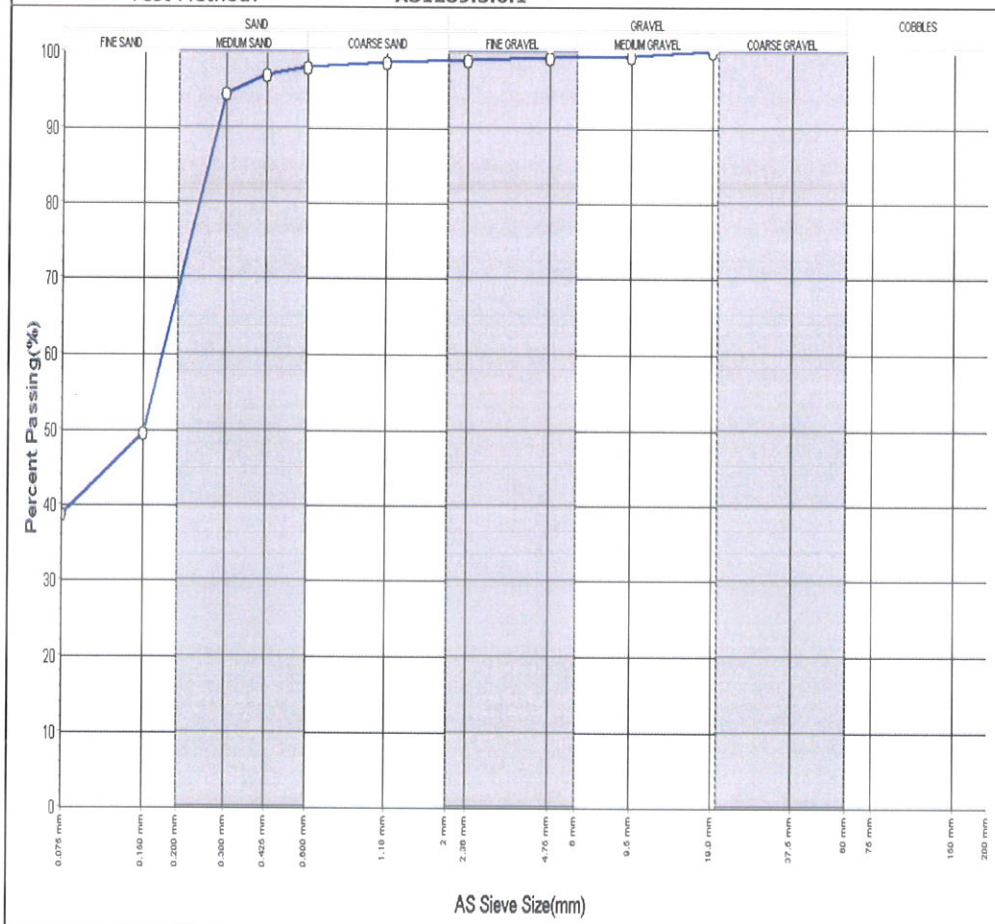
Particle Size Distribution Report

Client:	**Queensland Rail Limited (Toowoomba)**	Job Number:	**137632080-20300**
Client Address:	**PO Box 3357 Toowoomba QLD 4350**	Report Number:	**137632080-20300 - 3**
Project:	**Remedial Slope Design**	Report Date:	**13/04/2015**
Location	**Ch 144.7 km Toowoomba Range Railway ,**		**Page 13 of 14**
Lab No:	**15300806**	Sample Location	
Date Sampled / Received:	**1/04/2015**	CH144-BH07 (4.0-4.45 m)	
Date Tested:	**8/04/2015**	Sample CH144-BH07-003	
Sampled By:	**Client's Rep.**	SPT	
Sample Method:	-		
Material Source:	-		
For Use As:	-		
Remarks:	-		

Test Method: **AS1289.3.6.1**



A.S. Sieve Sizes	Percent Passing
75.00 mm	
53.00 mm	
37.50 mm	
26.50 mm	
19.00 mm	**100**
13.2 mm	-
9.50 mm	**99**
4.75 mm	**99**
2.36 mm	**99**
1.18 mm	**98**
0.600 mm	**98**
0.425 mm	**97**
0.300 mm	**94**
0.150 mm	**49**
0.075 mm	**39**
Moisture Content (%)	**15.1**

Visual Classification:

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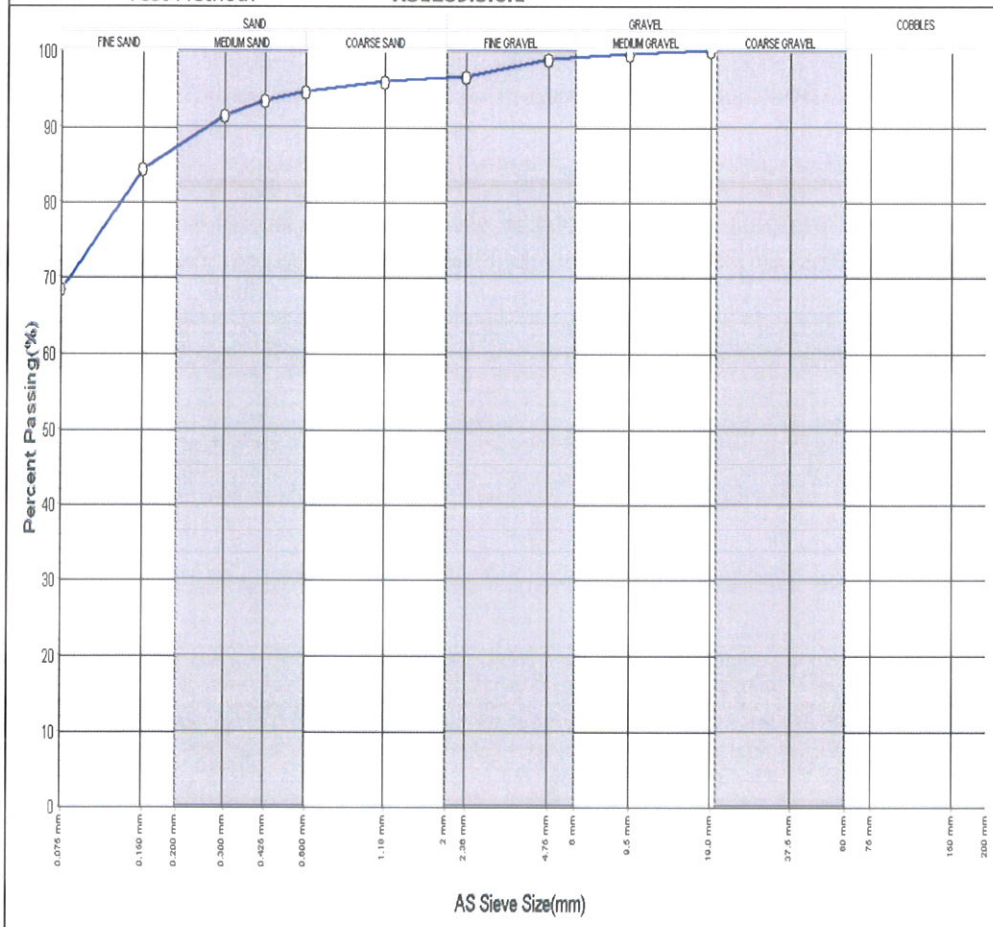
Particle Size Distribution Report

Client:	**Queensland Rail Limited (Toowoomba)**	Job Number:	**137632080-20300**
Client Address:	**PO Box 3357 Toowoomba QLD 4350**	Report Number:	**137632080-20300 - 3**
Project:	**Remedial Slope Design**	Report Date:	**13/04/2015**
Location	**Ch 144.7 km Toowoomba Range Railway ,**		**Page 14 of 14**
Lab No:	**15300807**	Sample Location	
Date Sampled / Received:	**1/04/2015**	CH144-BH08 (5.5-5.95 m)	
Date Tested:	**8/04/2015**	Sample CH144-BH08-004	
Sampled By:	**Client's Rep.**	SPT	
Sample Method:	-		
Material Source:	-		
For Use As:	-		
Remarks:	-		

Test Method: **AS1289.3.6.1**



A.S. Sieve Sizes	Percent Passing
75.00 mm	
53.00 mm	
37.50 mm	
26.50 mm	
19.00 mm	**100**
13.2 mm	-
9.50 mm	**100**
4.75 mm	**99**
2.36 mm	**97**
1.18 mm	**96**
0.600 mm	**95**
0.425 mm	**93**
0.300 mm	**91**
0.150 mm	**84**
0.075 mm	**69**
Moisture Content (%)	**21.4**

Visual Classification:

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Emerson Class Number Report

Client :	**Queensland Rail Limited (Toowoomba)**	Report Number:	**137632080-20300 - 4**
Address :	**PO Box 3357 Toowoomba QLD 4350**	Report Date:	**13/04/2015**
Job Number :	**137632080-20300**	Order Number:	
Project :	**Remedial Slope Design**	Test Method:	**AS1289.3.8.1**
Location :	**Ch 144.7 km Toowoomba Range Railway ,**		

Lab No :	15300789	15300791	15300792	15300793
ID No :	-	-	-	-
Lot No :	-	-	-	-
Item No :	-	-	-	-
Sampling Method :	-	-	-	-
Date Sampled/Received :	1/4/2015	1/4/2015	1/4/2015	1/4/2015
Date Tested :	7/4/2015	7/4/2015	7/4/2015	7/4/2015
Material Source :	-	-	-	-
For Use As :	-	-	-	-
Sample Location :	CH144-BH01 (11.5-11.95 m) Sample CH144-BH01-009 SPT on Silty Clay	CH144-BH02 (7.5-7.95 m) Sample CH144-BH02-004 SPT	CH144-BH03 (4.0-4.45 m) Sample CH144-BH03-003 SPT	CH144-BH03 (7.0-7.45 m) Sample CH144-BH03-005 SPT
Soil Description :	-	-	-	-
Type of Water Used :	**Distilled Water**	**Distilled Water**	**Distilled Water**	**Distilled Water**
Temperature of Water (°C) :	**24**	**24**	**24**	**24**
Emerson Class Number :	**Class 6**	**Class 6**	**Class 3**	**Class 5**
Remarks :				

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Emerson Class Number Report

Client :	**Queensland Rail Limited (Toowoomba)**	Report Number:	**137632080-20300 - 4**
Address :	**PO Box 3357 Toowoomba QLD 4350**	Report Date:	**13/04/2015**
Job Number :	**137632080-20300**	Order Number:	
Project :	**Remedial Slope Design**	Test Method:	**AS1289.3.8.1**
Location :	**Ch 144.7 km Toowoomba Range Railway ,**		

Lab No :	15300795	15300796	15300799	15300801
ID No :	-	-	-	-
Lot No :	-	-	-	-
Item No :	-	-	-	-
Sampling Method :	-	-	-	-
Date Sampled/Received :	1/4/2015	1/4/2015	1/4/2015	1/4/2015
Date Tested :	7/4/2015	7/4/2015	7/4/2015	7/4/2015
Material Source :	-	-	-	-
For Use As :	-	-	-	-
Sample Location :	CH144-BH03 (11.5-11.95 m) Sample CH144-BH03-008 SPT	CH144-BH04 (4.0-4.45 m) Sample CH144-BH04-003 SPT	CH144-BH04 (17.5-17.57 m) Sample CH144-BH04-012 SPT	CH144-BH05 (5.5-5.93 m) Sample CH144-BH05-004 SPT
Soil Description :	-	-	-	-
Type of Water Used :	**Distilled Water**	**Distilled Water**	**Distilled Water**	**Distilled Water**
Temperature of Water (°C) :	**24**	**24**	**24**	**24**
Emerson Class Number :	**Class 5**	**Class 6**	**Class 6**	**Class 5**
Remarks :				

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Emerson Class Number Report

Client :	**Queensland Rail Limited (Toowoomba)**	Report Number:	**137632080-20300 - 4**
Address :	**PO Box 3357 Toowoomba QLD 4350**	Report Date:	**13/04/2015**
Job Number :	**137632080-20300**	Order Number:	
Project :	**Remedial Slope Design**	Test Method:	**AS1289.3.8.1**
Location :	**Ch 144.7 km Toowoomba Range Railway ,**		

Lab No :	15300803	15300805	15300806	
ID No :	-	-	-	
Lot No :	-	-	-	
Item No :	-	-	-	
Sampling Method :	-	-	-	
Date Sampled/Received :	1/4/2015	1/4/2015	1/4/2015	
Date Tested :	7/4/2015	7/4/2015	7/4/2015	
Material Source :	-	-	-	
For Use As :	-	-	-	
Sample Location :	CH144-BH06 (2.5-2.95 m) Sample CH144-BH06-003 SPT	CH144-BH06 (11.5-11.95 m) Sample CH144-BH06-009 SPT	CH144-BH07 (4.0-4.45 m) Sample CH144-BH07-003 SPT	
Soil Description :	-	-	-	
Type of Water Used :	**Distilled Water**	**Distilled Water**	**Distilled Water**	
Temperature of Water (°C) :	**24**	**24**	**24**	
Emerson Class Number :	**Class 3**	**Class 3**	**Class 5**	
Remarks :				

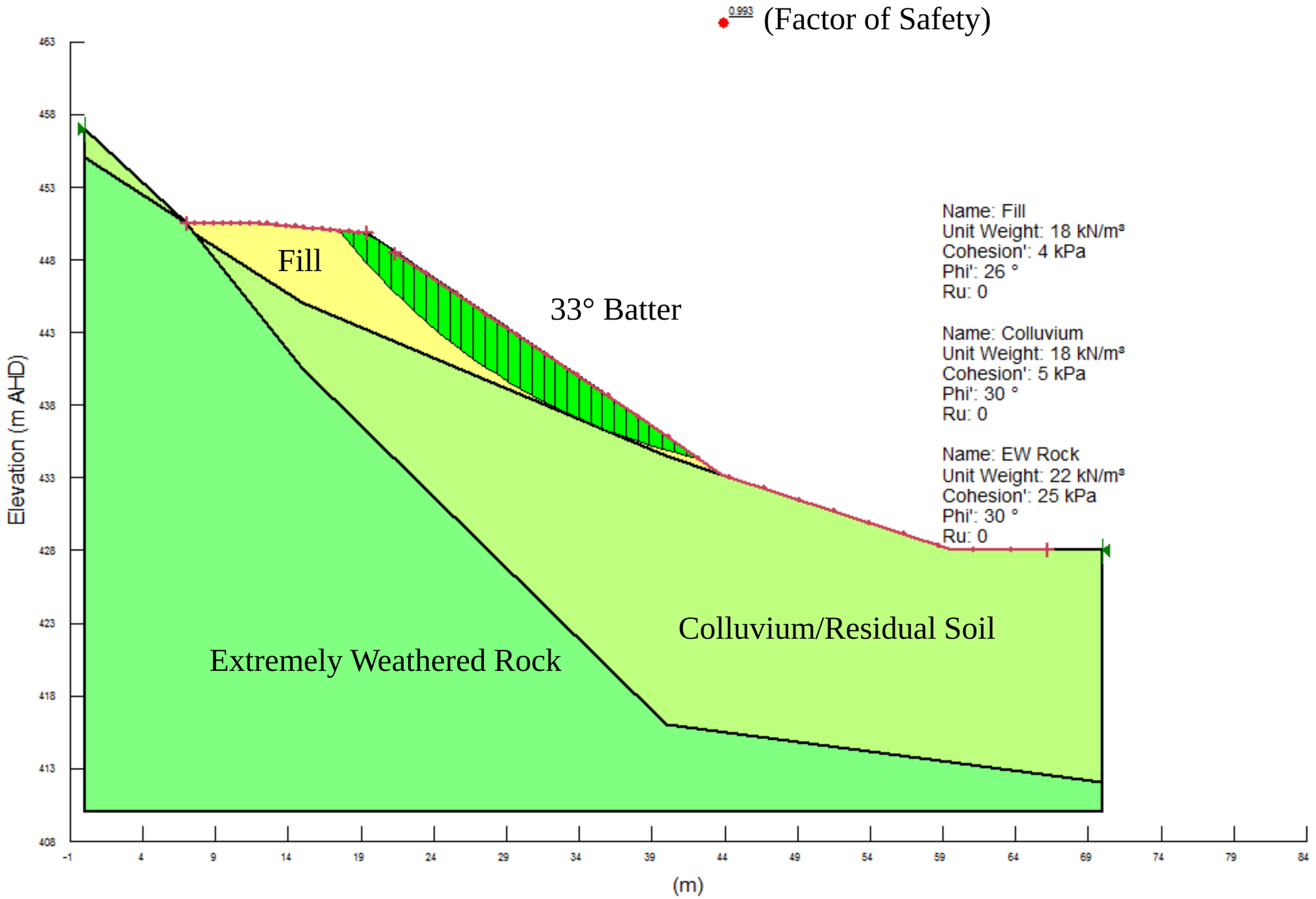
APPROVED SIGNATORY

Mike Sandilands - Laboratory Manager
NATA Accred No:1961

FORM NUMBER : R58-RL-12

APPENDIX C

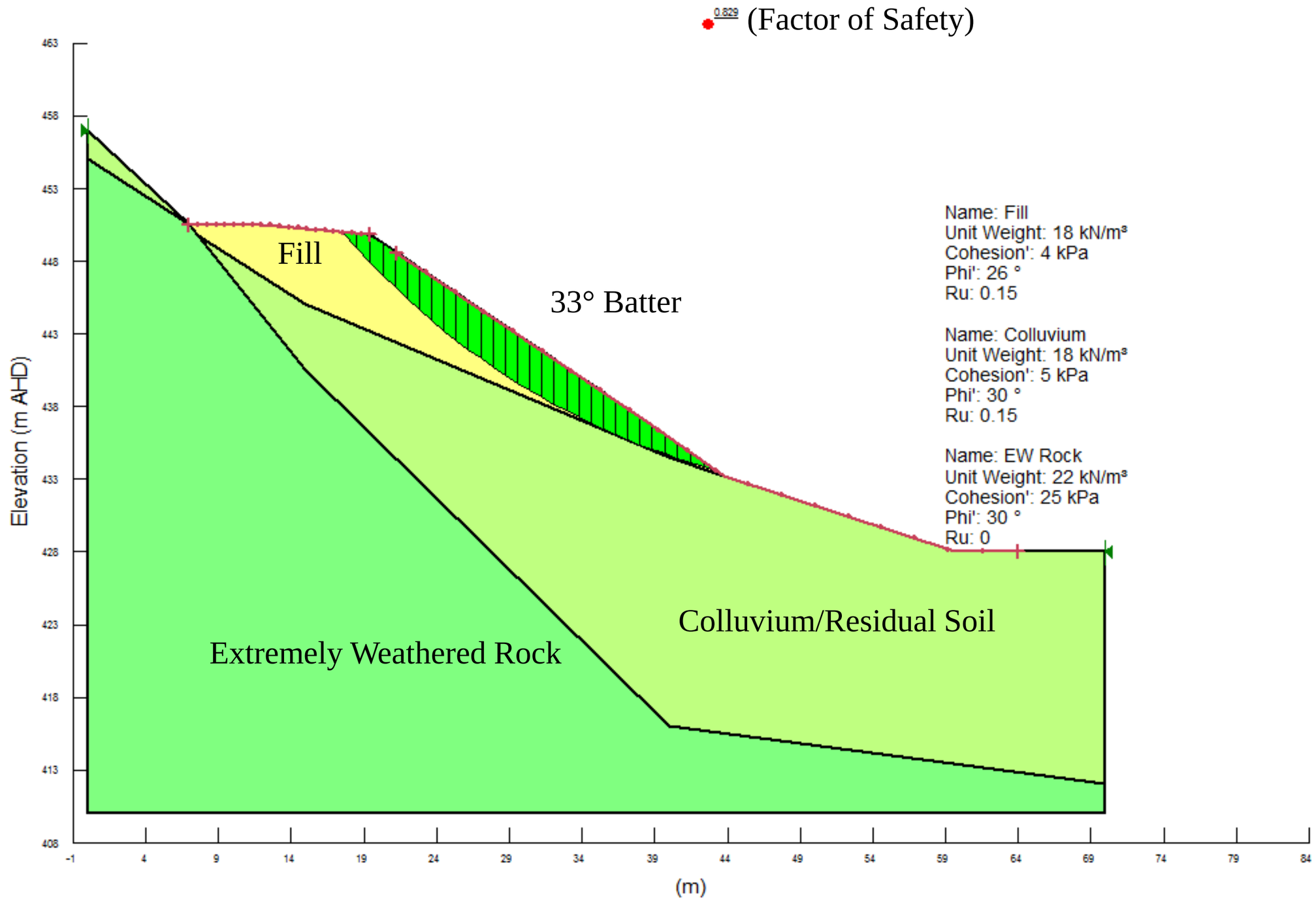
Slope Stability Analysis



Golder Associates

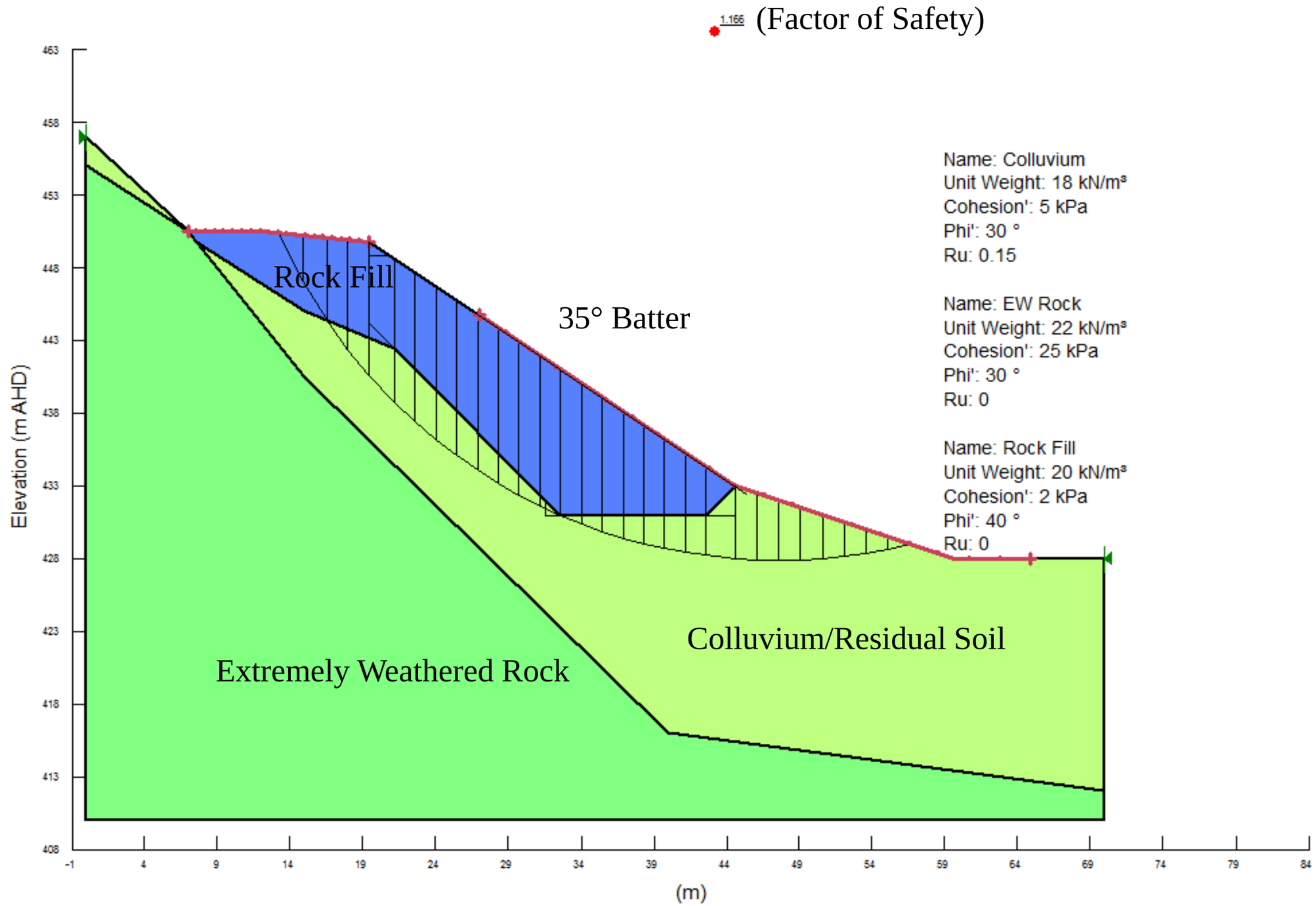
CLIENT	Queensland Rail	PROJECT	Toowoomba Range Railway – Ch 144.7 km
DRAWN SCF	DATE 19/05/2015	TITLE	**Slope Stability Analysis – Section AA Inferred Initial Conditions, Dry**
CHECKED GR	DATE 19/05/2015		
SCALE As Shown		PROJECT No 137632080-012	FIGURE No **C-A1** REV No **0** **A4**

T:\Template\Figure_Templates\Powerpoint\GAP A3L.pot



Golder Associates	CLIENT: Queensland Rail		PROJECT: Toowoomba Range Railway – Ch 144.7 km
	DRAWN: SCF	DATE: 19/05/2015	TITLE: **Slope Stability Analysis – Section AA Inferred Initial Conditions, Ru = 0.15**
	CHECKED: GR	DATE: 19/05/2015	
	SCALE: As Shown		PROJECT No: 137632080-012 · FIGURE No: **C-A2** · REV No: **0** · **A4**

T:\Template\Figure_Templates\Powerpoint\GAP A3L.pot



Golder Associates	CLIENT: Queensland Rail		PROJECT: Toowoomba Range Railway – Ch 144.7 km		
	DRAWN: SCF	DATE: 19/05/2015	TITLE: **Slope Stability Analysis – Section AA Rock Fill Remediation – Model 1**		
	CHECKED: GR	DATE: 19/05/2015			
	SCALE: As Shown		PROJECT No: 137632080-012	FIGURE No: **C-A3**	REV No: **0** **A4**

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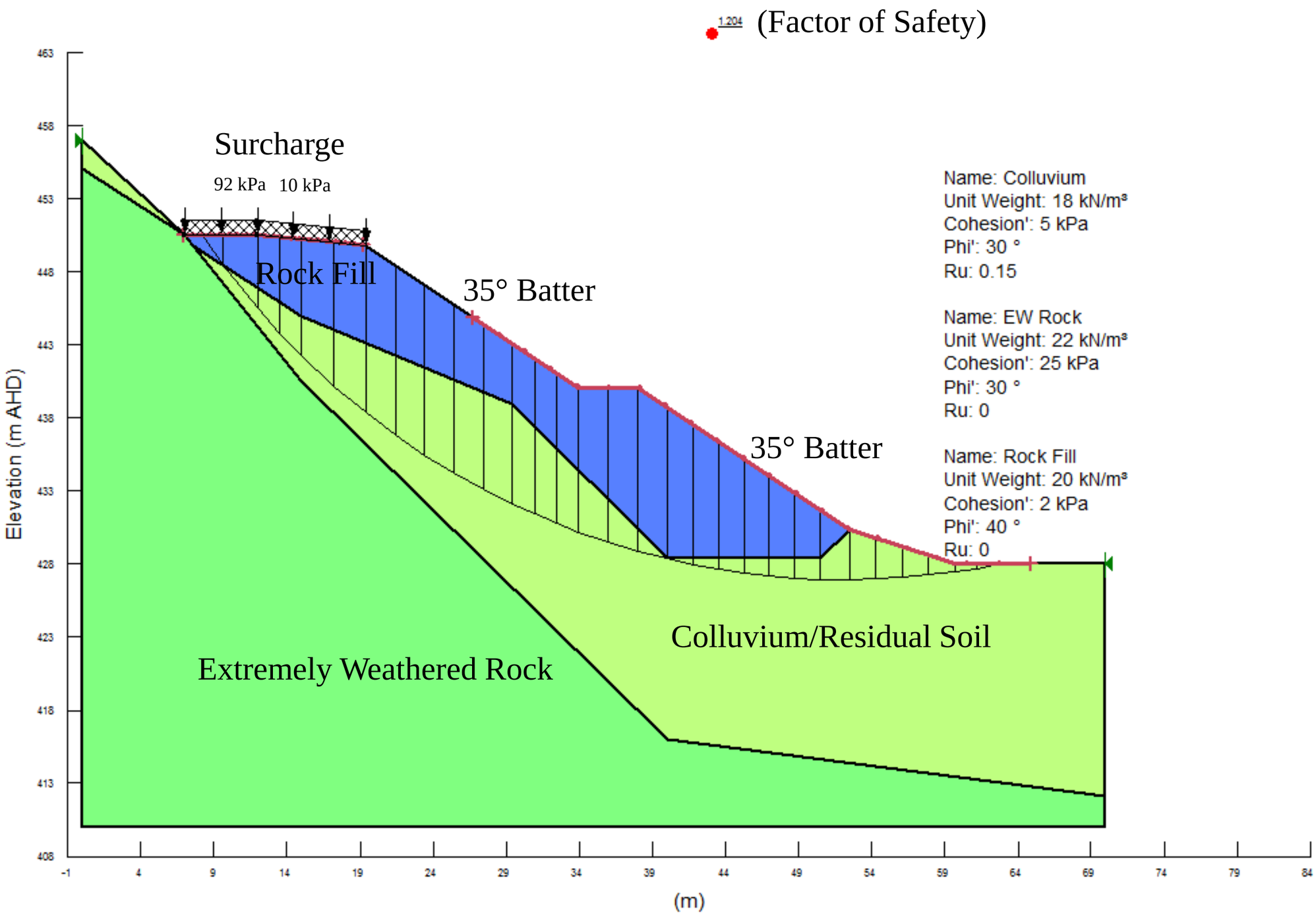

Golder Associates	CLIENT Queensland Rail		PROJECT Toowoomba Range Railway – Ch 144.7 km		
	DRAWN SCF	DATE 19/05/2015	TITLE **Slope Stability Analysis – Section AA Rock Fill Remediation – Model 2**		
	CHECKED GR	DATE 19/05/2015			
	SCALE As Shown		PROJECT No 137632080-012	FIGURE No **C-A4**	REV No **0** **A4**

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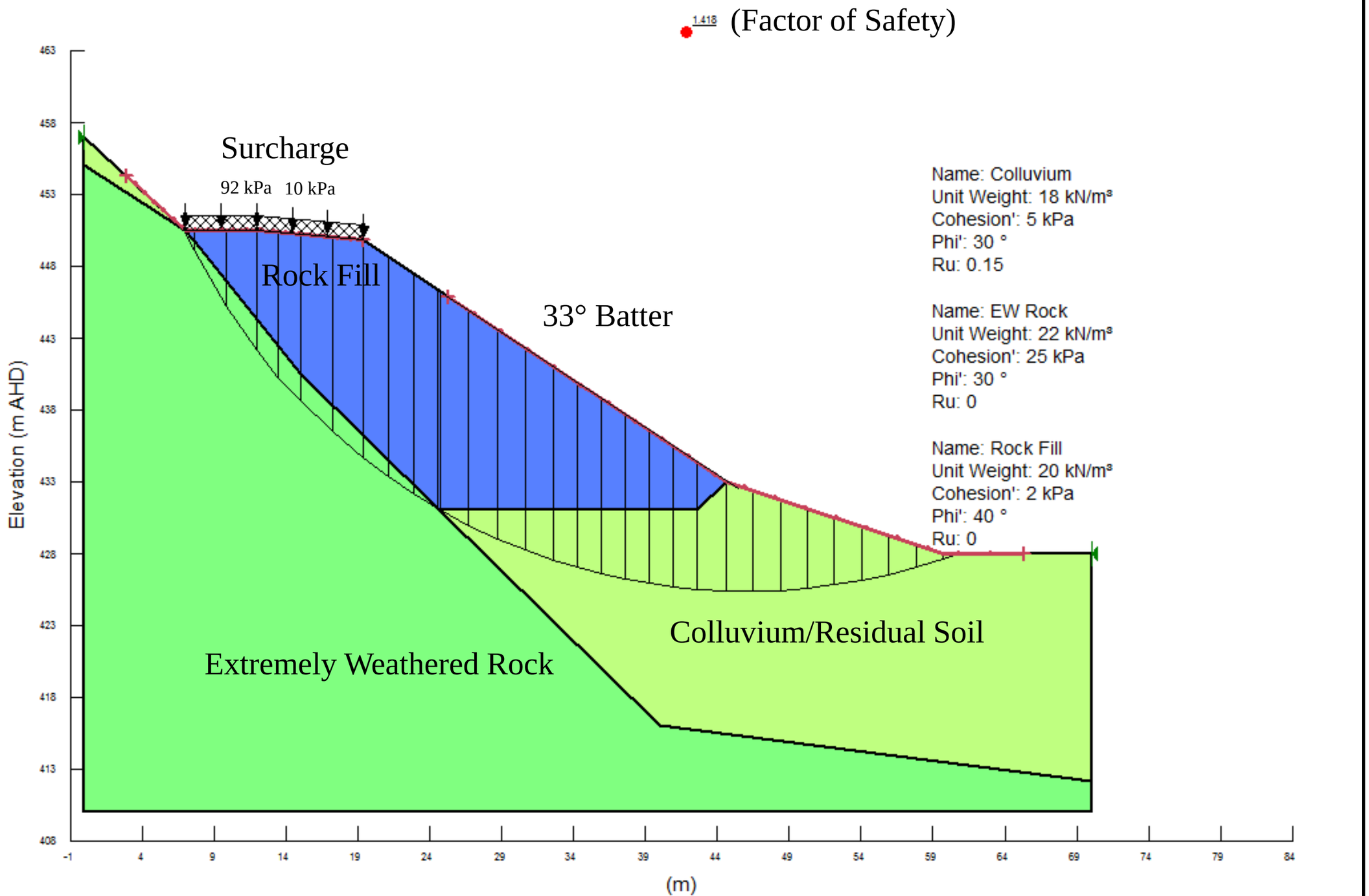

Golder Associates	CLIENT: Queensland Rail		PROJECT: Toowoomba Range Railway – Ch 144.7 km		
	DRAWN: SCF	DATE: 19/05/2015	TITLE: **Slope Stability Analysis – Section AA Rock Fill Remediation – Model 3**		
	CHECKED: GR	DATE: 19/05/2015			
	SCALE: As Shown		PROJECT No: 137632080-012	FIGURE No: **C-A5**	REV No: **0** **A4**

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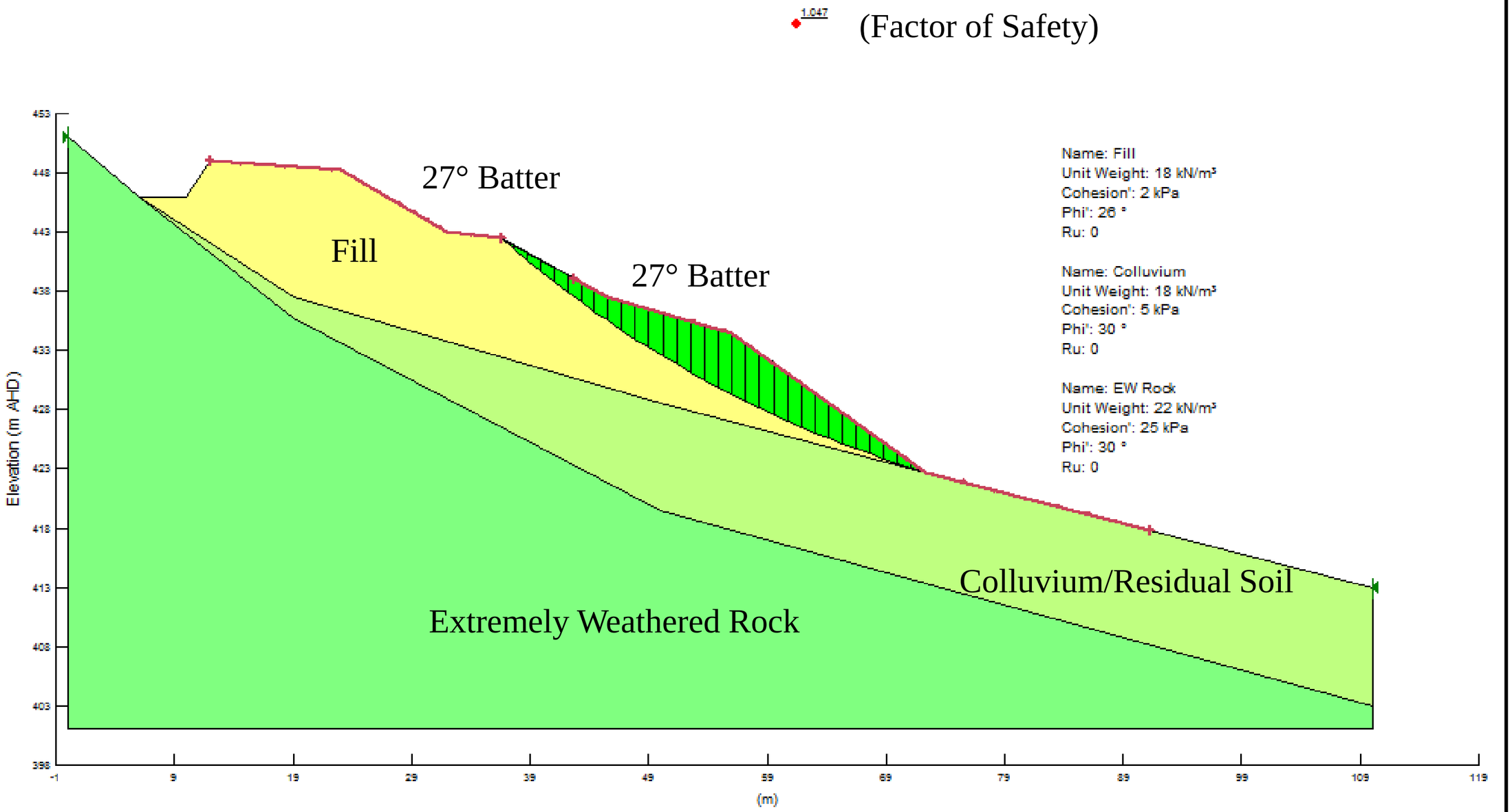

Golder Associates	CLIENT: Queensland Rail		PROJECT: Toowoomba Range Railway – Ch 144.7 km
	DRAWN: SCF	DATE: 19/05/2015	TITLE: **Slope Stability Analysis – Section BB Inferred Initial Conditions, Dry**
	CHECKED: GR	DATE: 19/05/2015	
	SCALE: As Shown	PROJECT No: 137632080-012	FIGURE No: **C-B1** REV No: **0** **A4**

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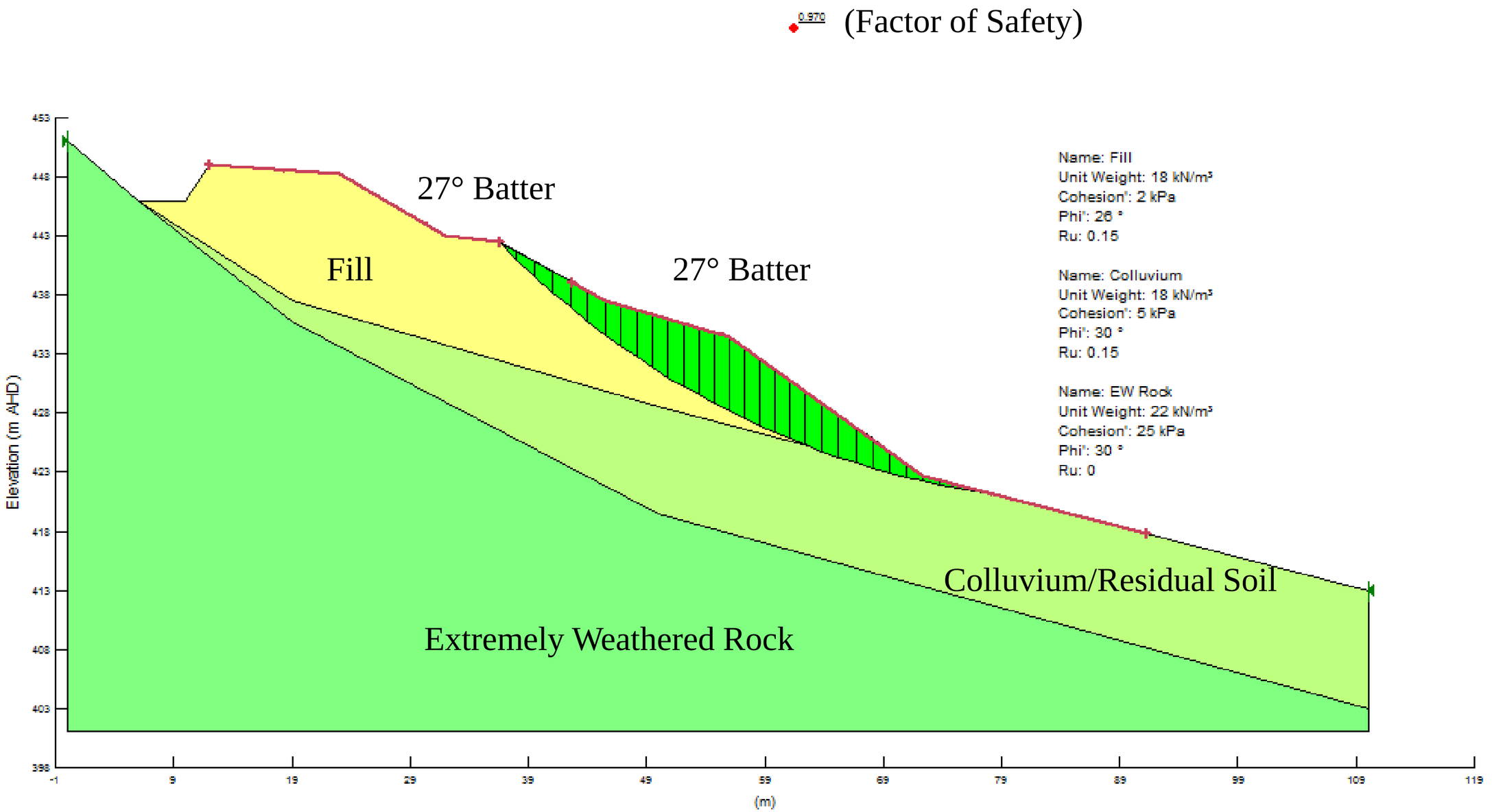

Golder Associates	CLIENT: Queensland Rail		PROJECT: Toowoomba Range Railway – Ch 144.7 km	
	DRAWN: SCF	DATE: 19/05/2015	TITLE: **Slope Stability Analysis – Section BB Inferred Initial Conditions, Ru = 0.15**	
	CHECKED: GR	DATE: 19/05/2015		
	SCALE: As Shown		PROJECT No: 137632080-012	FIGURE No: **C-B2** REV No: **0** **A4**

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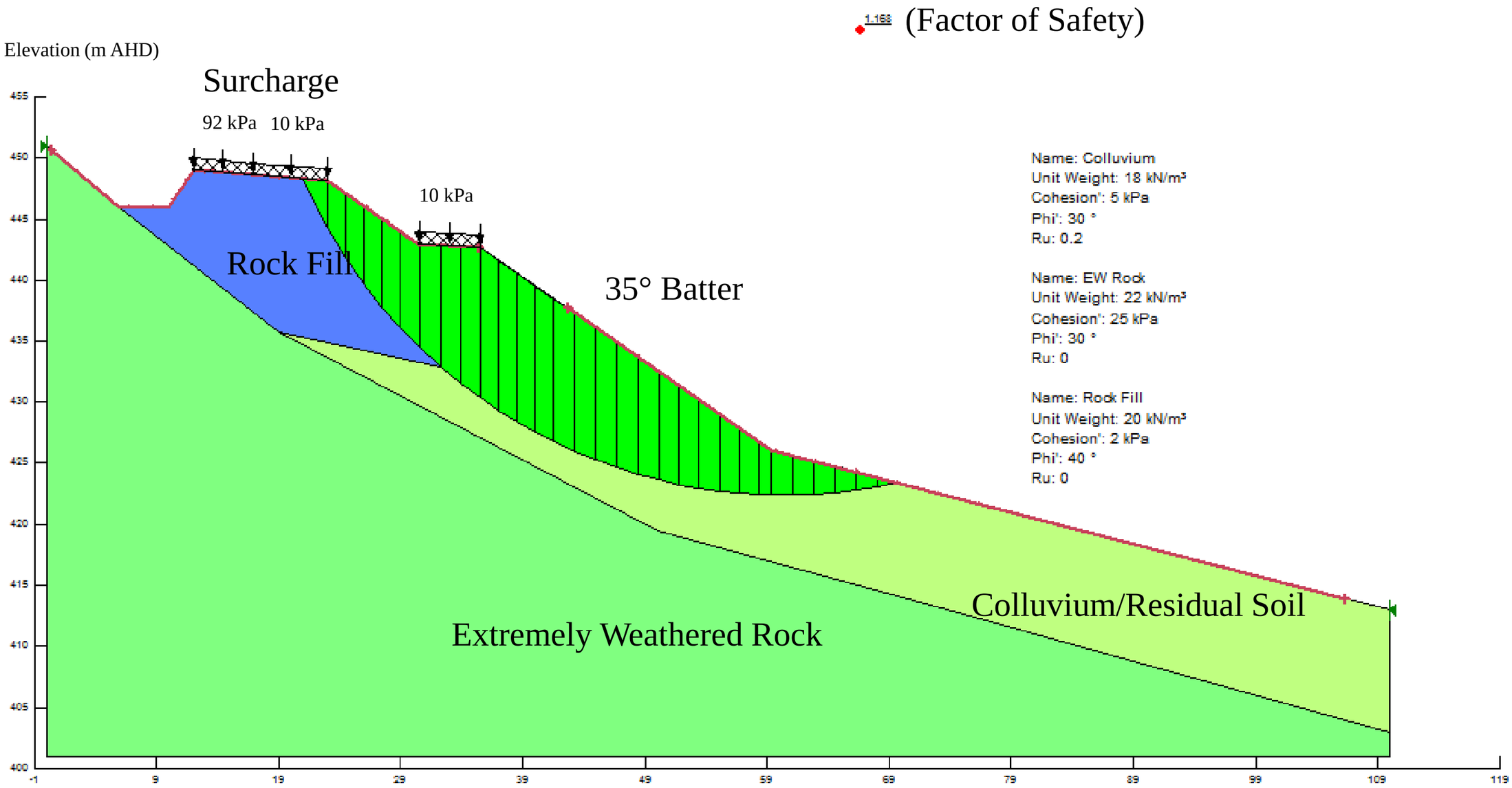

Name: Colluvium
Unit Weight: 18 kN/m³
Cohesion': 5 kPa
Phi': 30 °
Ru: 0.2

Name: EW Rock
Unit Weight: 22 kN/m³
Cohesion': 25 kPa
Phi': 30 °
Ru: 0

Name: Rock Fill
Unit Weight: 20 kN/m³
Cohesion': 2 kPa
Phi': 40 °
Ru: 0

Golder Associates	CLIENT: Queensland Rail		PROJECT: Toowoomba Range Railway – Ch 144.7 km
	DRAWN: SCF	DATE: 19/05/2015	TITLE: **Slope Stability Analysis – Section BB Rock Fill Remediation – Model 1**
	CHECKED: GR	DATE: 19/05/2015	
	SCALE: As Shown		PROJECT No: 137632080-012 · FIGURE No: **C-B3** · REV No: **0** · **A4**

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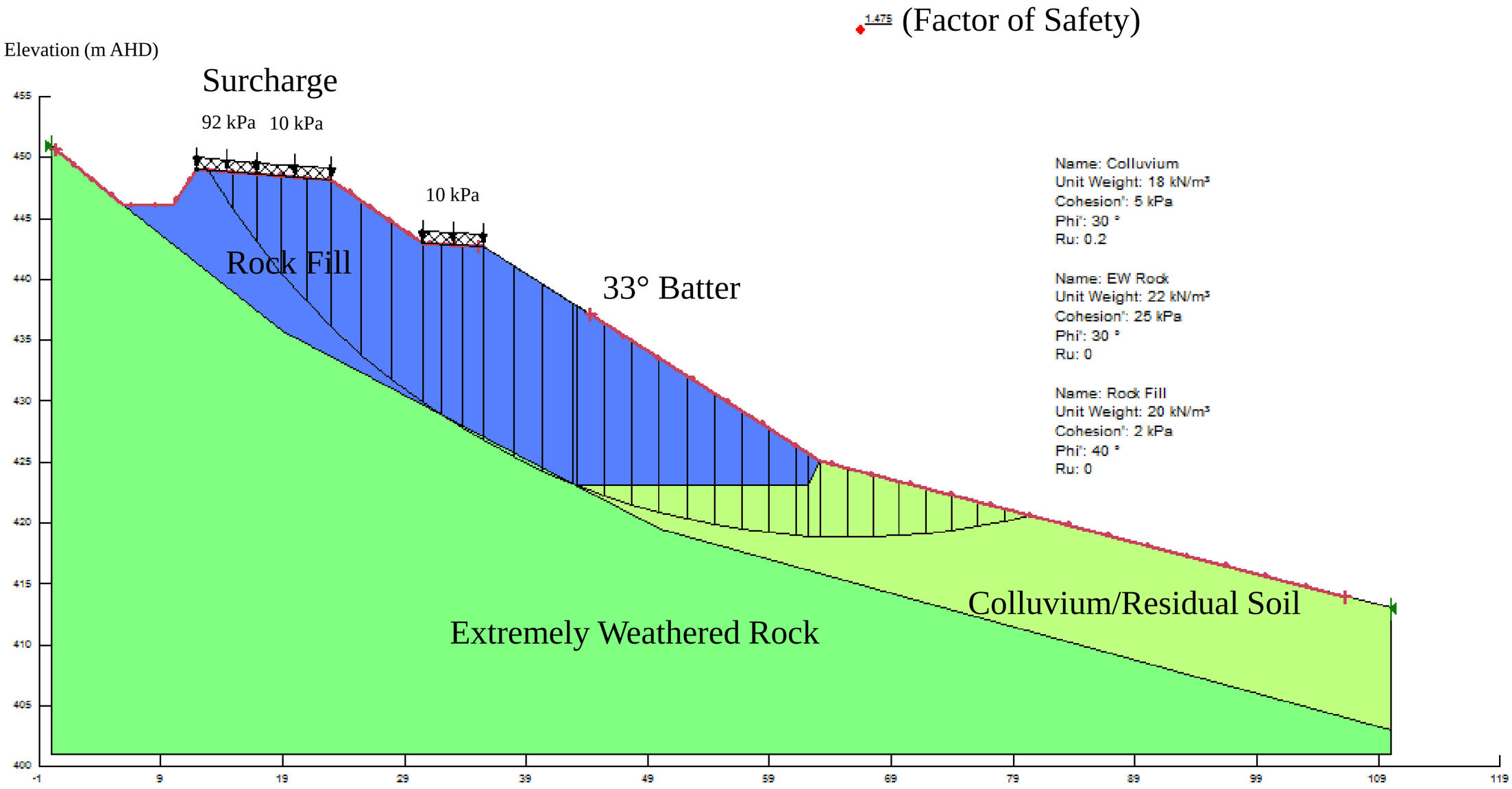

Name: Colluvium
Unit Weight: 18 kN/m³
Cohesion': 5 kPa
Phi': 30 °
Ru: 0.2

Name: EW Rock
Unit Weight: 22 kN/m³
Cohesion': 25 kPa
Phi': 30 °
Ru: 0

Name: Rock Fill
Unit Weight: 20 kN/m³
Cohesion': 2 kPa
Phi': 40 °
Ru: 0

Golder Associates	CLIENT: Queensland Rail		PROJECT: Toowoomba Range Railway – Ch 144.7 km
	DRAWN: SCF	DATE: 19/05/2015	TITLE: **Slope Stability Analysis – Section BB Rock Fill Remediation – Model 2**
	CHECKED: GR	DATE: 19/05/2015	
	SCALE: As Shown	PROJECT No: 137632080-012	FIGURE No: **C-B4** REV No: **0** **A4**

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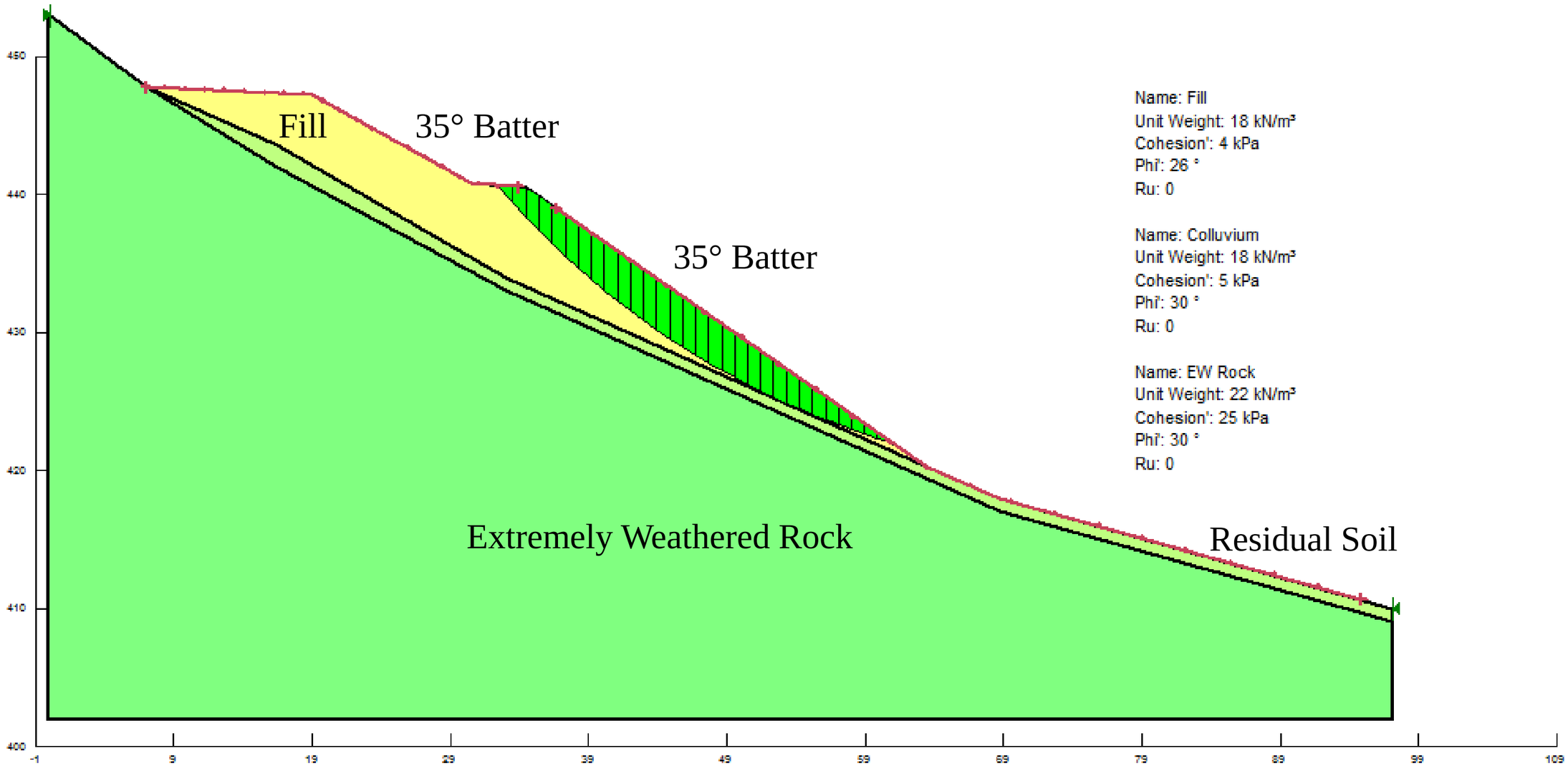
0.945 (Factor of Safety)

Elevation (m AHD)



Name: Fill
Unit Weight: 18 kN/m³
Cohesion': 4 kPa
Phi': 26 °
Ru: 0

Name: Colluvium
Unit Weight: 18 kN/m³
Cohesion': 5 kPa
Phi': 30 °
Ru: 0

Name: EW Rock
Unit Weight: 22 kN/m³
Cohesion': 25 kPa
Phi': 30 °
Ru: 0

CLIENT	Queensland Rail	PROJECT	Toowoomba Range Railway – Ch 144.7 km
DRAWN SCF / DATE 19/05/2015		TITLE	**Slope Stability Analysis – Section CC Inferred Initial Conditions, Dry**
CHECKED GR / DATE 19/05/2015			
SCALE As Shown		PROJECT No 137632080-012 / FIGURE No **C-C1** / REV No **0** / **A4**	

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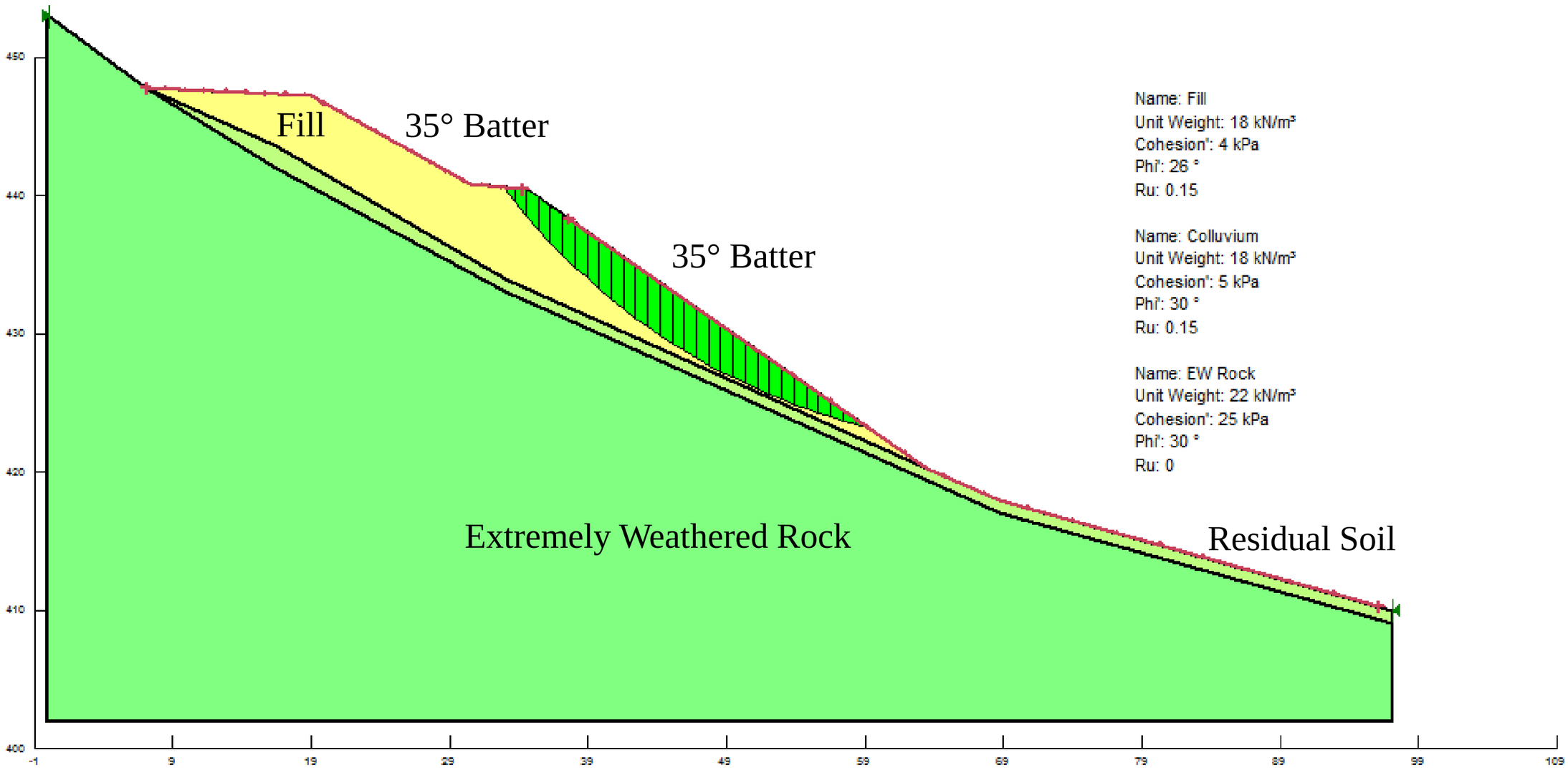
0.789 (Factor of Safety)

Elevation (m AHD)



Name: Fill
Unit Weight: 18 kN/m³
Cohesion': 4 kPa
Phi': 26 °
Ru: 0.15

Name: Colluvium
Unit Weight: 18 kN/m³
Cohesion': 5 kPa
Phi': 30 °
Ru: 0.15

Name: EW Rock
Unit Weight: 22 kN/m³
Cohesion': 25 kPa
Phi': 30 °
Ru: 0

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CLIENT	Queensland Rail	PROJECT	Toowoomba Range Railway – Ch 144.7 km
DRAWN SCF	DATE 19/05/2015	TITLE	**Slope Stability Analysis – Section CC Inferred Initial Conditions, Ru = 0.15**
CHECKED GR	DATE 19/05/2015		
SCALE As Shown		PROJECT No 137632080-012	FIGURE No **C-C2** REV No **0** **A4**

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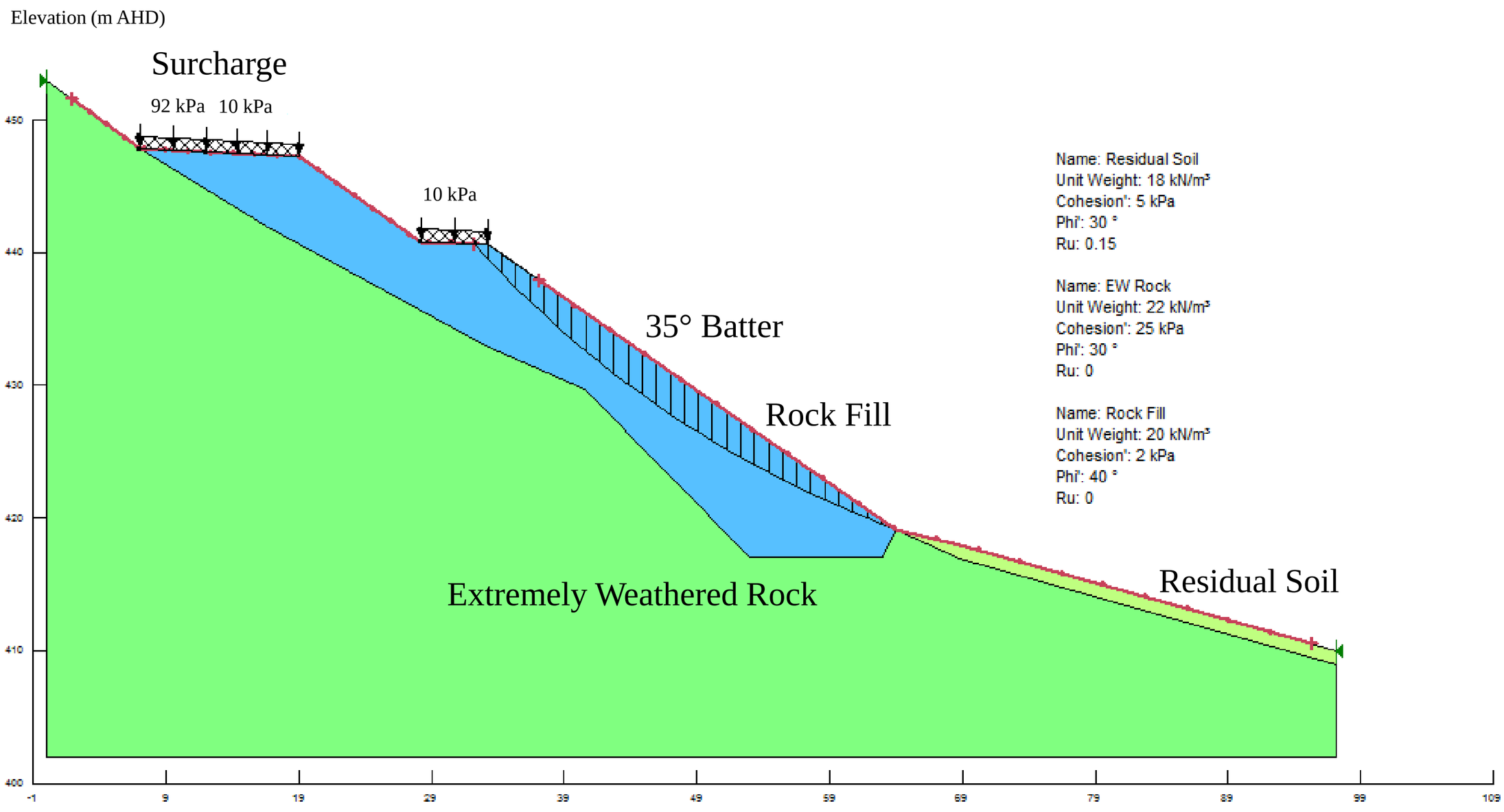
1.363 (Factor of Safety)



Name: Residual Soil
Unit Weight: 18 kN/m³
Cohesion': 5 kPa
Phi': 30 °
Ru: 0.15

Name: EW Rock
Unit Weight: 22 kN/m³
Cohesion': 25 kPa
Phi': 30 °
Ru: 0

Name: Rock Fill
Unit Weight: 20 kN/m³
Cohesion': 2 kPa
Phi': 40 °
Ru: 0

Golder Associates

CLIENT: Queensland Rail		PROJECT: Toowoomba Range Railway – Ch 144.7 km	
DRAWN: SCF	DATE: 19/05/2015	TITLE: **Slope Stability Analysis – Section CC Rock Fill Remediation – Model 1**	
CHECKED: GR	DATE: 19/05/2015		
SCALE: As Shown		PROJECT No: 137632080-012	FIGURE No: C-C3 / REV No: 0 / A4

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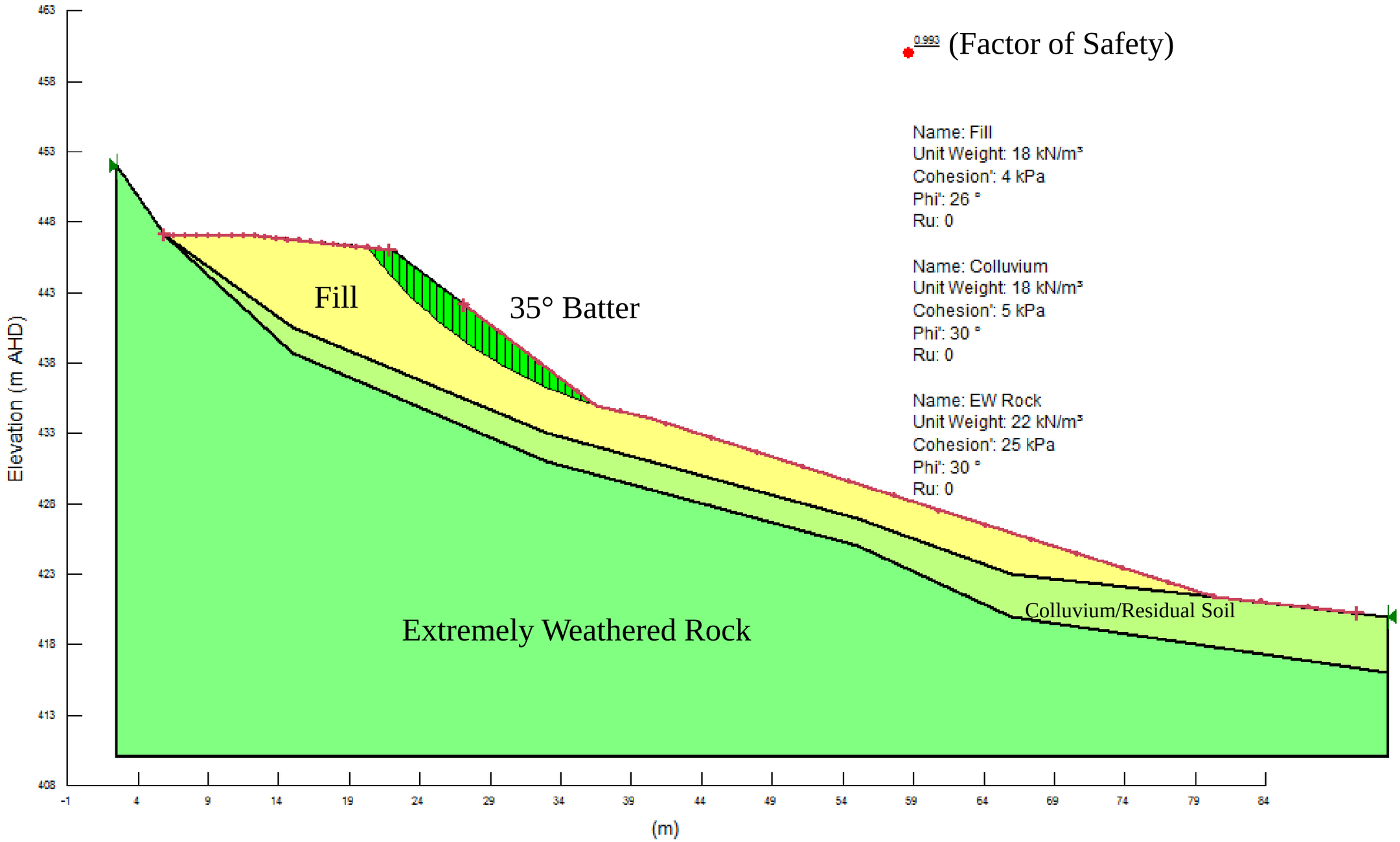

Golder Associates	CLIENT: Queensland Rail		PROJECT: Toowoomba Range Railway – Ch 144.7 km		
	DRAWN: SCF	DATE: 19/05/2015	TITLE: **Slope Stability Analysis – Section DD Inferred Initial Conditions, Dry**		
	CHECKED: GR	DATE: 19/05/2015			
	SCALE: As Shown		PROJECT No: 137632080-012	FIGURE No: **C-D1**	REV No: **0** / **A4**

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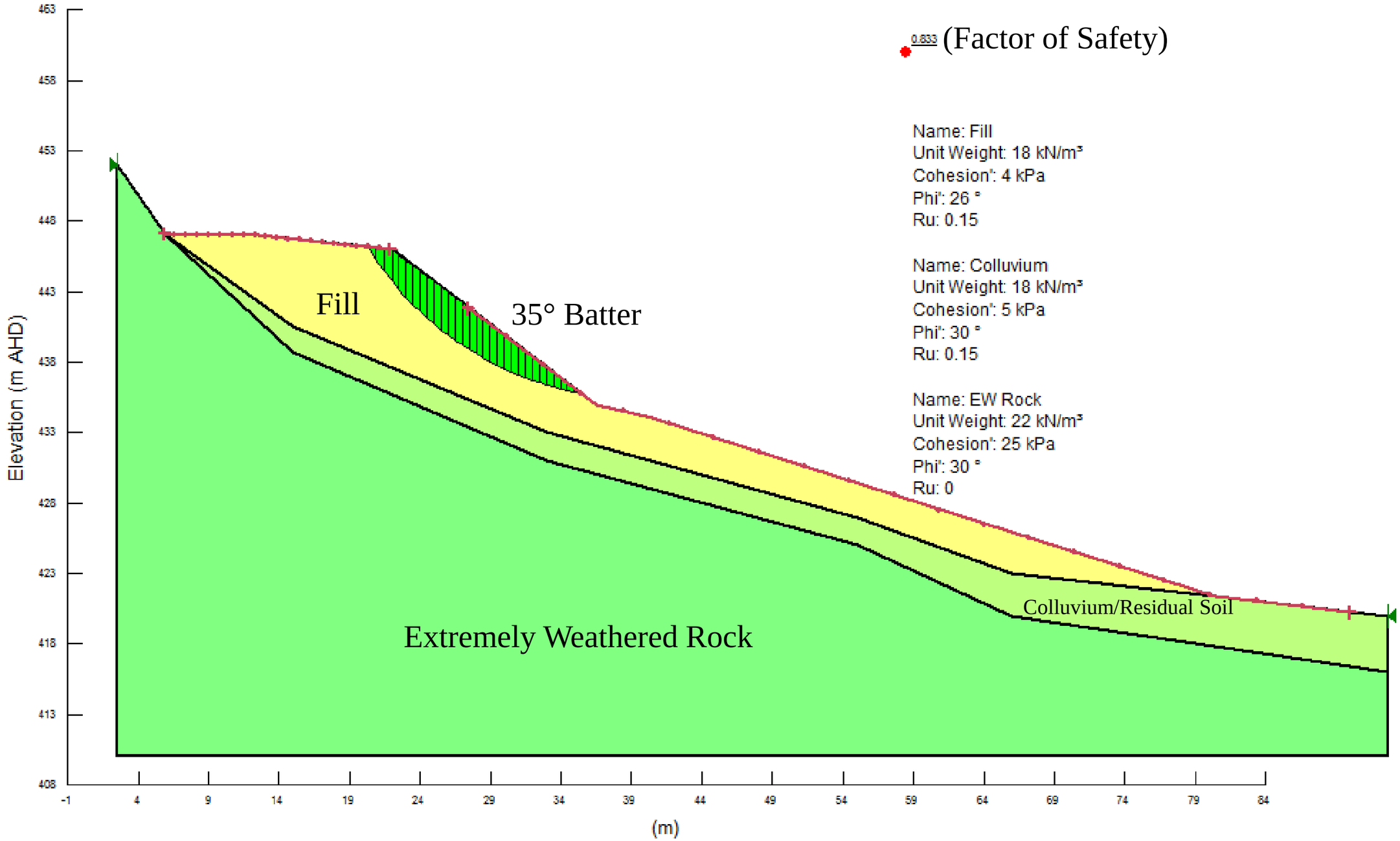

Golder Associates	CLIENT: Queensland Rail		PROJECT: Toowoomba Range Railway – Ch 144.7 km		
	DRAWN: SCF	DATE: 19/05/2015	TITLE: **Slope Stability Analysis – Section DD Inferred Initial Conditions, Ru = 0.15**		
	CHECKED: GR	DATE: 19/05/2015			
	SCALE: As Shown		PROJECT No: 137632080-012	FIGURE No: **C-D2**	REV No: **0** **A4**

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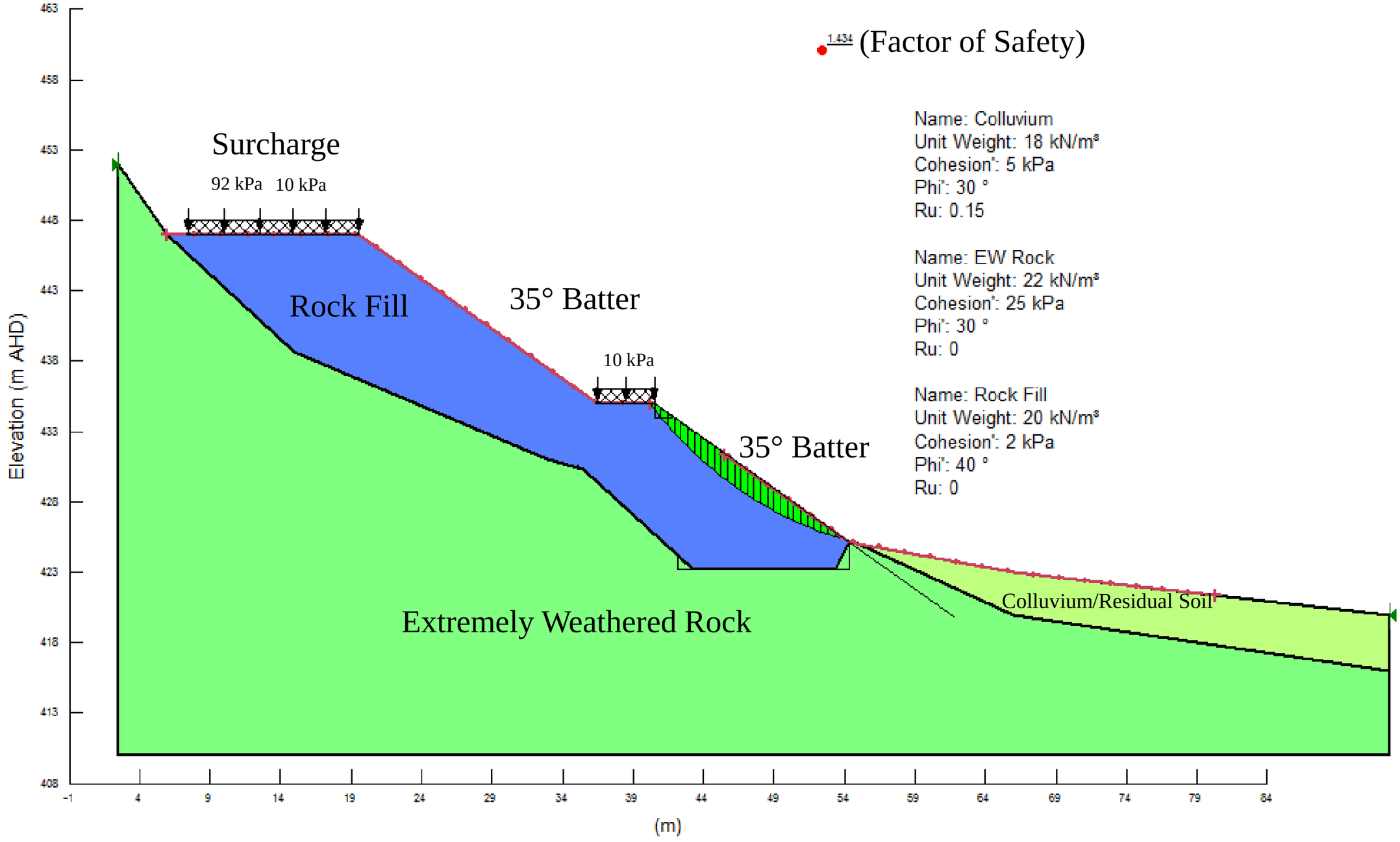

Name: Colluvium
Unit Weight: 18 kN/m³
Cohesion': 5 kPa
Phi': 30 °
Ru: 0.15

Name: EW Rock
Unit Weight: 22 kN/m³
Cohesion': 25 kPa
Phi': 30 °
Ru: 0

Name: Rock Fill
Unit Weight: 20 kN/m³
Cohesion': 2 kPa
Phi': 40 °
Ru: 0

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CLIENT	Queensland Rail	PROJECT	Toowoomba Range Railway – Ch 144.7 km
DRAWN SCF	DATE 19/05/2015	TITLE	**Slope Stability Analysis – Section DD Rock Fill Remediation – Model 1**
CHECKED GR	DATE 19/05/2015		
SCALE As Shown		PROJECT No 137632080-012	FIGURE No **C-D3** REV No **0** **A4**

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APPENDIX D

Limitations

LIMITATIONS

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