2 December 2025
Job No: 1101614.0000-LET-ENG-001.v1

Bass Coast Shire Council
76 McBride Avenue
Wonthaggi 3995

Attention: Luke Bryant

Dear Luke

Nyora-Wonthaggi Rail Trail Erosion
Stability and Risk Assessment

1 Introduction

Tonkin & Taylor Pty Ltd (T+T) has been engaged to complete an initial walkover and preliminary risk assessment of a section of the Nyora-Wonthaggi rail trail in Kilcunda, for you as our client.

The scope of work was completed in accordance with our letter of engagement dated 6 November 2025 (1101614.0000-LOE-ENG-001.v1) for our client Bass Coast Shire Council.

This letter report summarises our findings and recommendations based on our site walkover, and a risk assessment for the rail trail in this location.

2 Project Background

2.1 Project understanding

The subject area of this assessment is the section of Nyora-Wonthaggi rail trail which runs along Kilcunda surf beach, accessed from the Lionel Rose carpark, Kilcunda.

This trail was originally a railway line which was opened in 1910, constructed to transport coal from the Wonthaggi State Coal mine. In this location, the railway was constructed on the top of the natural coastal dunes with rail operations closing in 1978.

The rail trail is a popular tourist attraction, utilised by walkers, bikers and horse riders year around, with increased usage in the summer months with more favourable weather.

There has been a recent landslide near the Lionel Rose carpark in Kilcunda which has resulted in damage to a beach access staircase. This landslide is likely to have resulted from erosion of material from the toe of the slope in this location, during a high storm surge event.

The rail trail is located near the crest of the slope in this location and is prone to ongoing erosion and landslide during high tide and weather events shown on a marked up aerial photo taken during our site visit (Figure 1 below).

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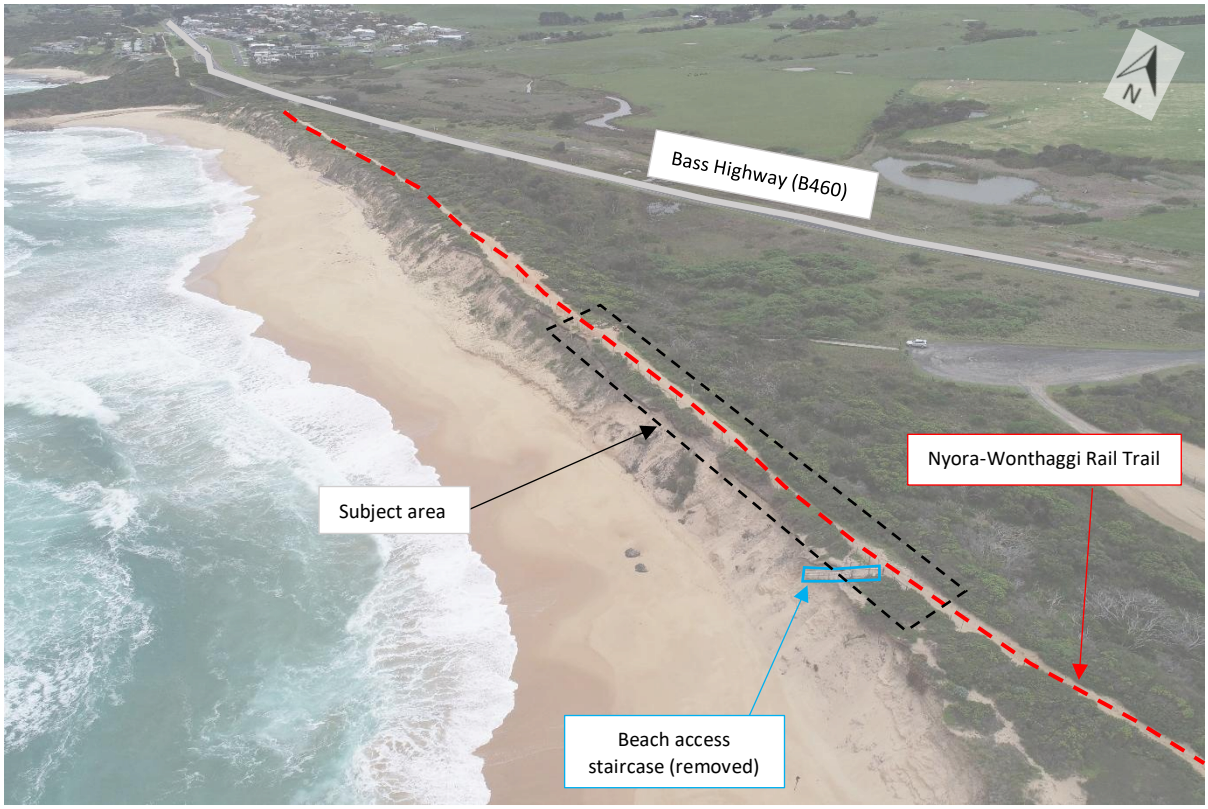


Figure 1 *Markup of section of rail trail considered (oblique aerial photograph taken with UAV by T+T during site visit)*

2.2 Geology

2.3 Regional Geology

As previously identified, the geological map[1] of the area shows the site to be typically underlain by Quaternary age Coastal Lagoon and Coastal Dune deposits.

The Coastal Lagoon soils are expected to comprise silts and clays which are often dark grey/black and variably consolidated.

The Coastal Dune deposits are typically encountered as poorly to moderately consolidated rounded sands with minor clay in some locations.

Fill associated with the construction of the historic railway (rail trail) is present at the crest of the dune along the subject alignment. This comprises typically granular soils or variable sizes with some minor proportion of fines (clay and silt).

[1] Department of Economic Development, Jobs, Transport and Resources (2016) Online 1:250,000 scale geological map (http://er-info.dpi.vic.gov.au/sd_weave/registered.htm). State Government of Victoria.

3 Existing information

3.1 Previous reports

Two previous reports have been provided by the client, one completed by BMT Commercial Australia Pty Ltd[2] (BMT) and one by Range Consulting Pty Ltd[3] (FSC Range).

The BMT report was completed in 2021 and is a coastal process study of this section of coastline to inform an options assessment for coastal adaptation with particular consideration of the rail trail and maintaining the community and recreational values of the area. This report highlights that the presence of the historic seawall to the west has protected the dune behind this structure, but diverted and concentrated wave energy to the area without the seawall protection which is the area of our current study. This report also references the loss of multiple beach access stairs from the surf beach and nearby cemetery in the previous decade before the report (2011 to 2021). The BMT report further noted that in the year prior to the report, the erosion had begun to impact the rail trail (2020 to 2021). The BMT report also noted that the dune is situated in the current erosion hazard zone and that use of the rail trail was hazardous and likely to continue to deteriorate, with the net erosion trend and future sea level rise expected to increase regression/collapse.

A number of options were investigated as part of this report including non-intervention, consistent with public safety, retreat of the rail trail with the dune crest regression, rerouting of the trail behind the dune, beach/dune nourishment, short term and long term protective measures with engineered solutions.

The second report, completed in 2024 by Range Consulting Pty Ltd (the FSC Range report), presents the findings of a coastal processes and risk assessment for the historic seawall located to the west of the subject area. The findings of the FSC Range report determined that the condition of this seawall asset was rated as very poor, however it still continued to provide erosion protection and dune support where it is present. The FSC Range report also states that failure of this structure could expose the rail trail in this location to erosion risk in the next five to ten years. The FSC Range report also noted that this area is unlikely to be subject to permanent inundation in the next five to ten years, however storm surge and storm tide (including flooding of Bourne Creek further landward) could impact this area.

The beach along this section of coast is noted by FSC Range to have undergone cycles of erosion and accretion, with erosion evident currently. Event driven recession values of up to 5m were stipulated in this report, associated with a 1 in 10 year recurrence event if the seawall were to fully fail, which could be used as a proxy for the area without seawall protection (our subject area).

3.2 Historic aerial comparison

A comparison of changes to this section of coastline was completed by reviewing historic aerial images, supplied by the client, from 2006, 2015 and January 2025 and November 2025. Minor landward regression of the crest was noted from 2006 to January 2025. Crest regression in the critical section is noted to be around 0.5m during this period. A larger change is noted between the January 2025 and November 2025 crest locations, with a landward retreat of around 3m of the crest during this period.

[2] Report by BMT Commercial Australia Pty Ltd, *Kilcunda Foreshore Erosion: Options Assessment*, dated 13/09/2021, revision B – Final.

[3] Report by Range Consulting Pty Ltd, *Kilcunda Coastal Protection Structures,* dated 07/06/2024, revision 0.

This erosion was driven by a storm surge event which increased wave energy and erosion of the toe. This is in line with the findings of the previous reports summarised above which consider that regression here is likely to be episodic as a result of storms.

3.3 Site walkover

A site visit was conducted by a T+T engineering geologist on 12 November 2025. This included a walkover of the rail trail alignment in the study area and capture of aerial imagery using our in house unmanned aerial vehicle (UAV, drone).

Key observations and notes for this walkover include:

- A small, informal drainage swale was observed running along the southern (beach side) edge of the rail trail. This was dry during our site visit but is very shallow and is not expected to convey large amounts of water without being overwhelmed.
- The rail trail is constructed of granular fill material which is overhanging in a number of locations as a result of toe erosion removing loose sand from beach level. The horizontal alignment of the crest of the slope is not straight, with a number of arcuate features along the crest edge, which is evidence of landslide collapse where the overhanging rail trail fill collapses.
- No tension cracks were noted in the rail trail along the subject area alignment or along the crest.
- There is a fence along this section of rail trail to limit access across the dunes down to the beach. The distance from this fence to the crest of the slope is variable along the alignment, with the minimum distance measured as 1.6m, as shown in the 'worst case section' included as Figure 2, Appendix A.
- The dune beneath the rail trail is made up of loose/very loose sand with the foreshore noted as soft underfoot. This was confirmed with a Dynamic Cone Penetrometer (DCP) completed at the base of the previous stair location which returns results of less than 1 blow per 100mm in the upper 0.5m.
- An old seawall structure is located adjacent to the subject area, along the coast to the west. This structure appears to have provided some protection to the dune above this location, however, it is in poor condition. These structures can often increase erosion of unprotected areas where their extent ends, which also appears to have occurred in this area.
- The overhang in some sections of the rail trail is up to 1m horizontal over the slope and imminent collapse of the rail trail should be expected in these locations.
- The area between the dune crest and the fence is typically vegetated, however there are some locations where the vegetation is sparser along the section of interest.

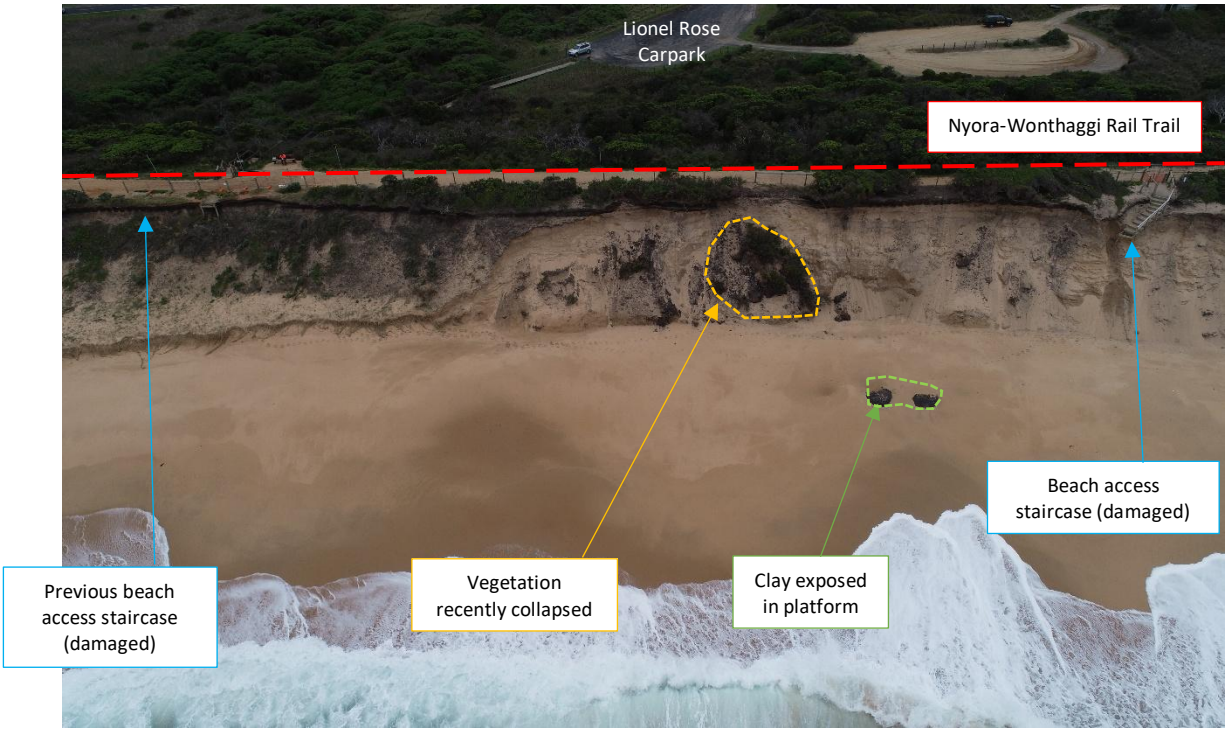


Figure 3.1: Annotated aerial showing rail trail alignment and previous stair locations.

A site plan (Figure 1) with observations above annotated is included in Appendix A, along with a cross section (Figure 2) in the worst case location. This location is defined as the location where the overall slope grade of the dune is steepest and the slope is highest.

4 Stability Analysis

4.1 Model profile

T+T has carried out a slope stability assessment based on limit equilibrium methods using commercial software package SlopeW by GeoStudio. One cross section has been modelled for this area, Cross section A-A', using contour information supplied by the client. This section was selected as a critical section for this area based on the following criteria:

- Steepest overall slope grade (~40°).
- Highest slope section (~8.6m).

The following assumptions have been made in the stability analysis:

- A minimum depth of slip surface of 0.5 m has been considered in the analysis.

4.2 Geotechnical model

The coastal dune deposits which make up the coast in this location are highly susceptible to erosion from strong waves and are continuously eroding (erosion of toe and landward regression of crest). This affects the dune toe and reduces the slope stability.

Concentrated runoff and water saturation can increase potential for slope instability, which could occur from overflow of the shallow swale drains. Erosion and instability can be also accelerated by lack of vegetation, which was observed with erosion of the toe and continued collapse.

Vegetation assists in preventing surface erosion, creating a tensile strength within the root zone (increasing the resistance of the soil) and reducing water in the soil horizon.

4.3 Geotechnical design parameters

A summary of the geotechnical parameters is provided in Table 4.1 below. The parameters were selected based on our local experience and verified through back analysis of the known slowly regressing crest.

Table 4.1 Geotechnical parameters used in slope stability analyses

Unit	Description	Unit weight (kN/m^3)	Effective cohesion c' (kPa)	Effective angle of friction ϕ' (°)
Unit 1	Rail Trail FILL	19	3	38
Unit 2	SAND	17	1	35
Unit 3	CLAY (with sand)	17	5	27

4.4 Slope stability analysis

Limit equilibrium slope stability analysis using GeoStudio Slope W was undertaken considering the following scenarios:

- Modelling of the slip surface (i.e. lowest Factor of Safety (FoS)) using the calculated soil parameters.
- Modelling different slip surfaces to estimate minimum setback distances to achieve a FoS of 1.2.

The groundwater table was assumed to flow from RL 8 m AHD, from the carpark level where boggy ground was identified, to the toe of the slope at high tide/erosional sequence. The results of the slope stability analyses are presented in **Error! Reference source not found.**B.

The Factor of Safety (FoS) under existing conditions is close to 1.0. Typically, a slope with a FoS of between 1 and 1.1 would be considered marginally stable. For most civil engineering cases, a FoS of 1.3 is considered to be acceptable for short-term conditions.

This has been reduced to 1.2 for this study which is considered appropriate when considering the intermittent occupancy and providing that the recommendations in section 6.1 below are implemented.

5 Risk assessment of existing conditions

A risk assessment of the rail trail and a mobile (not stationary) site user has been completed in general accordance with the methodology included in the Australian Geotechnical Society (AGS) 2007 guidelines[4]. We consider that the coastal slopes along this section of alignment are susceptible to rotational earth slides up to approximately 500m^3 in volume. A short travel distance and slow to moderate velocity are expected in these landslides. It is also expected that there would be some evidence/warning of imminent collapse with formation of tension cracking in the rail trail.

[4] Australian Geomechanics Society, *Practice Note Guidelines for Landslide Risk Management 2007,* reference AGS (2007c*)* dated 2007.

A landslide risk assessment has been undertaken for an itinerant rail trail user. The following assumptions have been considered based on the site observations and data collected:

- It is estimated that the annual probability of a landslide which reaches the edge of the rail trail (current fence line) is 0.5. (i.e. likely within the 2 years).
- We estimate that the person most at risk (i.e. a frequent user) could have a 10% chance of being present at the time of a landslide. This is based on an assumption that traffic (public users) along the rail trail is expected to be lower during poor weather events which would be removing sufficient material from the toe of the slope to cause significant crest regression.
- The vulnerability value for the person most at risk was adopted based on the Appendix F of the Australian Geomechanics Society (AGS) Practice Note Guidelines for Landslide Risk Management 2007c.
- We estimate that a landslide resulting from an episodic removal of toe material (storm surge event) could impact up to 30% width of the rail trail.

Table 5.1 and Table 5.2 present the risk assessment results.

Table 5.1: Risk to life under existing conditions

Hazard	Annual probability of the landslide	Probability of spatial impact of the landslide	Temporal spatial probability	Vulnerability of the individual	Annual probability of loss of life
Rotational Earth Slide	$5x10^{-1}$	30%	10%	10%	$1.5x10^{-3}$

Table 5.2: Risk to asset (rail trail) under existing conditions

Hazard	Annual probability of the landslide	Probability of spatial impact of the landslide	Consequences to property	Qualitative Risk
Rotational Earth Slide	$5x10^{-1}$	30%	Minor	High

Assuming that this project does not have a defined risk criteria, the risk to life and property are evaluated against the tolerable limits recommended by the AGS 2007 guidelines, which are $1x10^{-4}$ / annum for the person most at risk, and moderate for existing slopes. Implementation of the fencing at the set-back distances discussed in section 6.1 below would reduce temporal spatial risk to zero in the calculation of risk to life above which will reduce this value to below this tolerable limit.

Our risk to property assessment is above tolerable limits which is expected given that the asset (rail trail) is being actively eroded and undermined. Protection or realignment works should be conducted for this section of slope in the near future (within the next few years).

As mentioned in both the FSC Range and BMT reports, if it is desirable to maintain the rail trail at its current location, a robust engineering solution (revetment/seawall) will be required at the toe of the slope to protect the current dune. This structure would need to consider the high susceptibility of this coastal sand to both wind and wave action and is expected to be relatively expensive. In addition, it is likely to be required in a timely manner.

Alternatively, the rail trail could be relocated back from the slope (as discussed further by BMT), with access to the beach by positioning future staircases in a more sheltered location.

6 Public Access Considerations

6.1 Short term access

We recommend that Bass Coast Shire consider the implementation of the following risk mitigation options for the rail trail to maintain access for the short term (access for between 6 months to 1 year). These are based on our stability analysis, which have adopted a FoS of 1.2 as a suitable factor when considering risk for an itinerant rail trail user. The outputs of this analysis are included as Appendix B. These mitigation measures include:

- Set up fencing at a setback from the crest of at least 3.5 m (based on the modelled 1.2 FoS line in the worst case section).
- Implementation of signage along this section to inform rail trail users of potential risk and not to linger in the area with safety fencing in place.
- Ongoing regular inspections should be conducted by a suitably experienced Bass Coast Shire representative to confirm no cracking/collapse extending into the safety fence zone. We recommend these are completed monthly and after any storm or large surge event.

If the ongoing monthly safety inspections identify regression of the crest of the slope into the area covered by the safety fencing or development of tension cracks in the rail trail, an additional site visit should be completed by a geotechnical practitioner to confirm ongoing short term stability for rail trail in this location.

7 Discussion

It is expected that ongoing removal of the material at the toe of the landslide and continued landward regression of the dune will continue if no remediation measures are conducted at the site.

Implementation of a setback zone of at least 3.5m from the current crest and ongoing monthly (and following storm events) inspections is expected to provide sufficient safety for short term public access (6 months to 1 year).

Normal tidal fluctuations are not expected to be removing significant amounts of sand from the toe of the slope and would have minor impacts on crest regression. High weather/wave surge events are expected to remove larger amounts of sand from the toe which will result in episodic collapse and erosion/regression of the crest.

The recommendations above should provide continued safe access of the site in the short term but ongoing regression of the crest will continue. Longer term solutions like toe protection or rail trail realignment should be considered as a priority for this site to provide ongoing longer term use of the rail trail.

8 Applicability

This report has been prepared for the exclusive use of our client Bass Coast Shire Council, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

Tonkin & Taylor Pty Ltd

Report prepared by:	Authorised for Tonkin & Taylor Pty Ltd by:
	
.....	.....
Wendy Greatbatch	Trevor Smith
Associate Engineering Geologist	Project Director

2-Dec-25
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Appendix A Site Plan and Cross Section

- **Figure 1 – Site Plan**
- **Figure 2 – Cross Section**

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NOTES:
1. ALL DIMENSIONS IN MILLIMETRES UNLESS NOTED OTHERWISE.

A3 SCALE 1:400

0 4 8 12 16 20 (m)

ORIGINAL IN COLOUR

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PROJECT No.	1101614		
DESIGNED	WDG	Nov.25	
DRAWN	KMJA	Nov.25	
CHECKED			
APPROVED	DATE		

CLIENT **BASS COAST SHIRE COUNCIL**

PROJECT **NYORA-WONTHAGGI TRAIL, KILCUNDA**

TITLE GEOTECHNICAL ASSESSMENT
SITE PLAN

UNDER REVISION 1

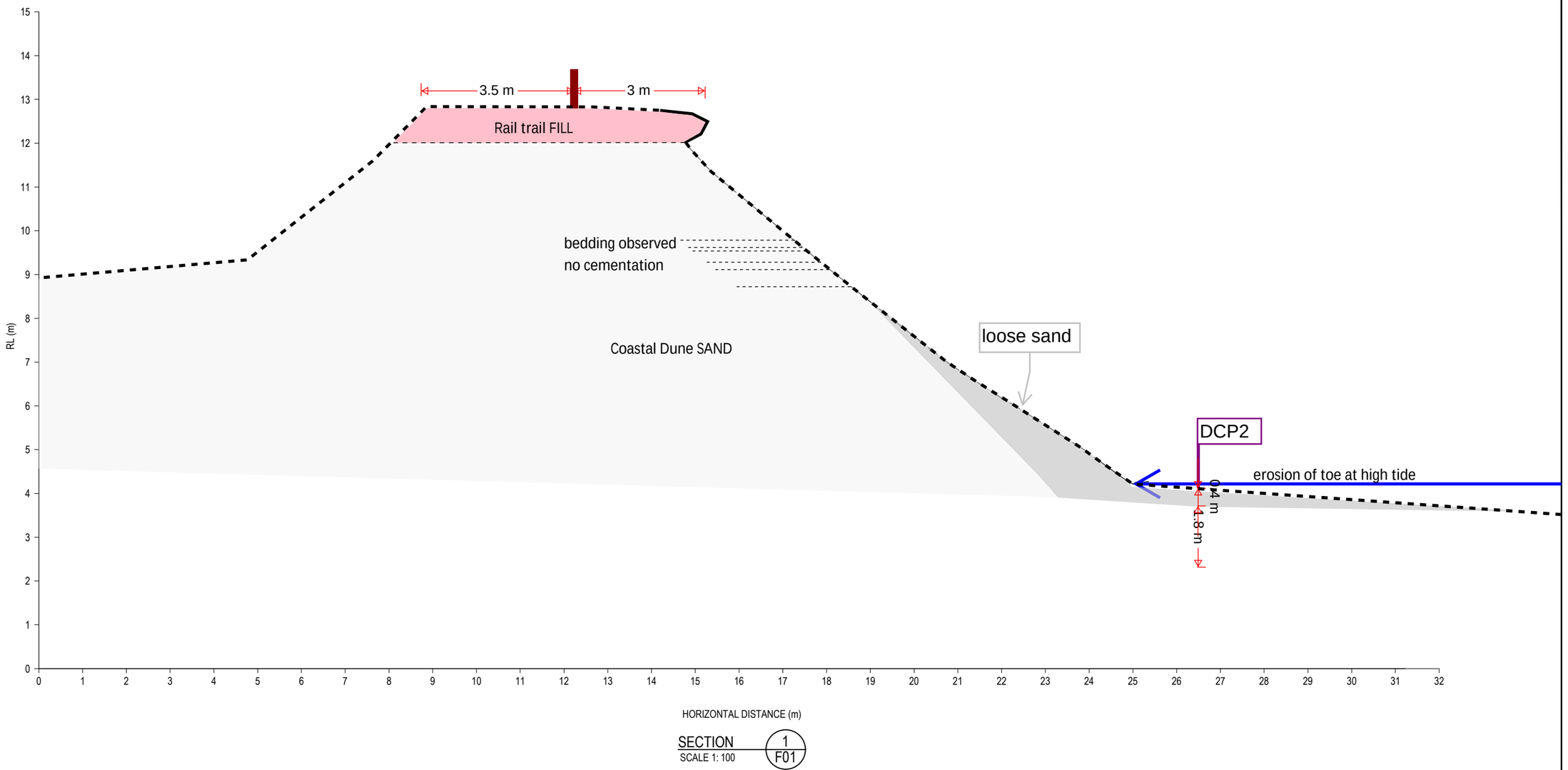
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LEGEND

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SECTION 1 / F01
SCALE 1: 100

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NOTES:
1. ALL DIMENSIONS IN METRES UNLESS NOTED OTHERWISE.

A3 SCALE 1:100

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PROJECT No.	1101614	
DESIGNED	WDG	Nov.25
DRAWN	KMJA	Nov.25
CHECKED		
APPROVED		DATE

CLIENT **BASS COAST SHIRE COUNCIL**

PROJECT **NYORA-WONTHAGGI TRAIL, KILCUNDA**

TITLE GEOTECHNICAL ASSESSMENT
SECTION

UNDER REVISION 1

SCALE (A3) 1:100 FIG No. 1101614-F02 REV 1

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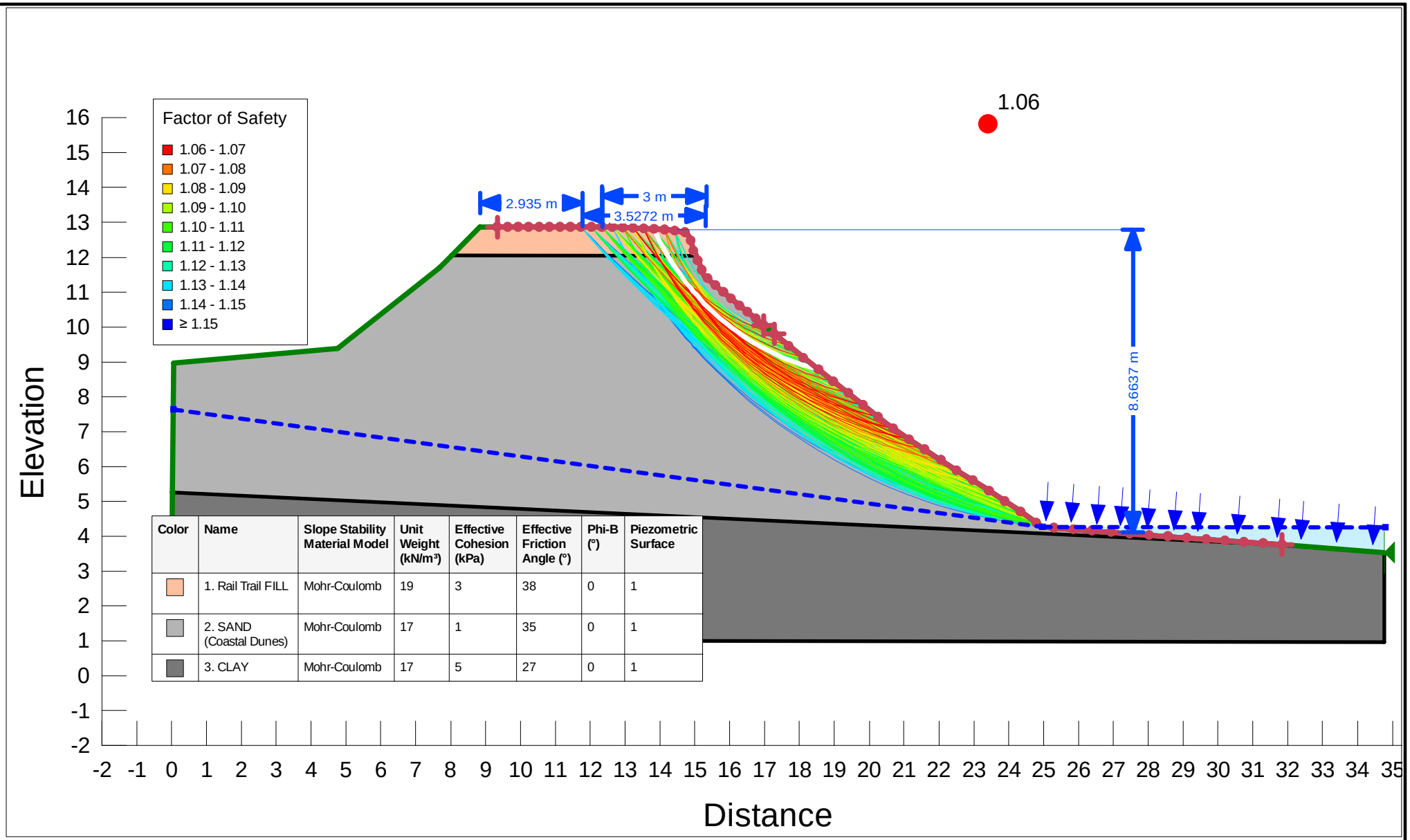
Client: **Bass Coast Shire Council**
Site Address: **Nyorra-Wonthaggi Rail Trail**
Project: **Risk Assessment and Walkover**

Report Number: **1101614.0000**
Report Date: **26.11.2025**
Operator: **WDG**

DCP TEST RESULTS
AS1289.6.3.2

Test No.:	**1**	**2**	**3**					
Test Date:	12.11.25	12.11.25	12.11.25					
Location:	Refer Site Plan	Refer Site Plan	Refer Site Plan					
Starting Depth (mm) :	EGL*	EGL*	EGL*					
Penetration (mm)	**No. Blows**	**No. Blows**	**No. Blows**					
100	1	0.5	7					
200	1	0.5	15					
300	2	1	25+					
400	1	1						
500	2	1.5						
600	3	1.5						
700	3	3						
800	4	3						
900	5	4						
1000	6	4						
1100	7	2						
1200	8	2						
1300	10	2						
1400	10	4						
1500	11	4						
1600	13	3						
1700	14	4						
1800	14	5						
1900	15							
2000	16							
						* EGL = existing ground level		

Appendix B Slope Stability Ananlysis



Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
	1. Rail Trail FILL	Mohr-Coulomb	19	3	38	0	1
	2. SAND (Coastal Dunes)	Mohr-Coulomb	17	1	35	0	1
	3. CLAY	Mohr-Coulomb	17	5	27	0	1

Tonkin+Taylor	**Current Condition**	Title: 1101614 - Kilcunda Landslide, Section A- A'	Date: 25/11/2025
		File name: 1101614_X-Section A-A'.gsz	Analysed by: WDG
		Scale: 1:150 @ A4	Checked by: TWSM

Directory: C:\Users\wdg\Desktop\My Projects\Slope Stability Models\