TECHNICAL MEMORANDUM

To	[redacted] Mornington Peninsula Shire	**From**	[redacted] Stantec
Project	Beleura Cliff Path, Mornington	**Date**	22 December 2023
Subject	Executive Summary for Landslide Risk Assessment	**Ref No.**	304400705Report05.1

1 INTRODUCTION

The Beleura Cliff Path has been impacted by significant landslide activity in two locations within the last two years, resulting in the temporary closure of the path. Mornington Peninsula Shire Council engaged Stantec to carry out a detailed site inspection and a landslide risk assessment for the full length of the Beleura Cliff Path ("the path"), from Caraar Creek Lane to Mills Beach in Mornington. The scope of work included:

- A meeting with the Friends of Beleura Cliff Path community group and a council lead community meeting to collect anecdotal information relating to landslide activity along the path. Both meetings were attended by Stantec Representatives.
- A desktop study of the area immediately surrounding the path, including consideration of geology, water (natural groundwater, pipes and irrigation as well as climate) and historic reports relating to assessments of the path.
- A detailed site inspection of the full length of the path by Stantec representatives.
- Light Detection and Ranging (LiDAR) survey.
- A landslide risk assessment for the full length of the path.
- Provision of options for remediation in both locations as well as a comparative options assessment.

2 DESKTOP STUDY

The desktop study details the available history of the path, including recent closures, changes to the alignment, surface upgrades, revegetation of the area and structures built as a result of landslide activity.

The LiDAR survey carried out enabled a contour map and hill shade map to be created for the cliff along the full length of the path. The combination of contours and shading provides a visual indication of specific areas where landslides have possibly occurred, as well as identifying the locations of naturally formed gullies which pre-date human inhabitation in the area and their associated catchment areas upslope of the crest of the cliff.

The surface geology of the cliffs changes over the length of the path, with Tertiary aged Brighton Group to the north and Devonian aged Granodiorite to the south. Areas of colluvium were identified during the site inspection, indicating historic landslide activity within the area. The path has been constructed on whichever material is present in each location.

Stantec Australia
Level 4, 501
Swanston Street
Melbourne, VIC
Australia

Ironstone boulders can be observed on Mills Beach towards the southern end of the path. These boulders on the beach are likely to have originated from a layer that was originally located within the Brighton Group at the top of the cliff. As the underlying Brighton Group has been eroded, the ironstone becomes unsupported and eventually falls down to the beach at the base of the cliff.

Blocked and broken drainage pipes are identified as a significant concern along the length of the path. Irrigation pipes can be observed along the length of the path with some controlled systems (ie used when needed and drained when not in use) and some uncontrolled systems (ie set on a time to run every day even when not needed, and left charged with water).

In years where rainfalls are greater than average, such as in La Niña year, there is a naturally higher groundwater flow within gullies as well as a higher volume of groundwater run off in the drainage network. As such, climate events are considered likely to have an impact on the stability of the cliff.

3 OBSERVATIONS FROM SITE INSPECTION

The site inspection involved walking the accessible sections of the path from Caraar Creek Lane to Mills Beach, as well as walking along the beach at the base of the cliff from Mills Beach to the northern end of the path alignment. The path was split into 24 sections based on the features observed along the length of the path. These are presented in the figures below.

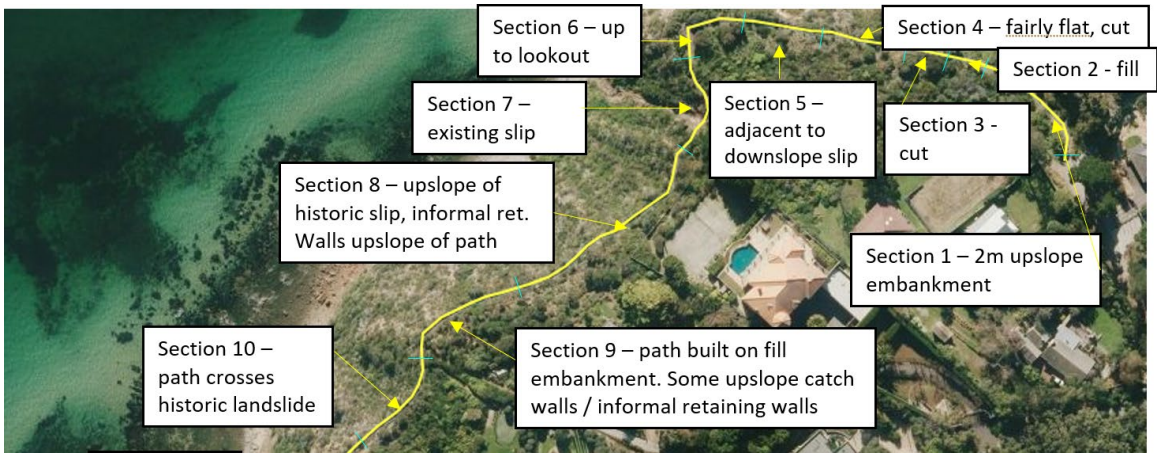

Figure 3-1 - Section Extents Part 1 of 3

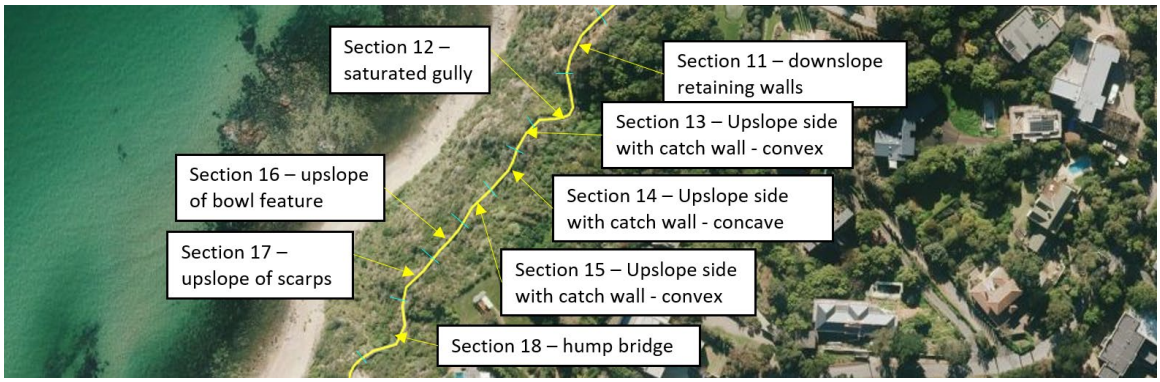

Figure 3-2 - Section Extents Part 2 of 3

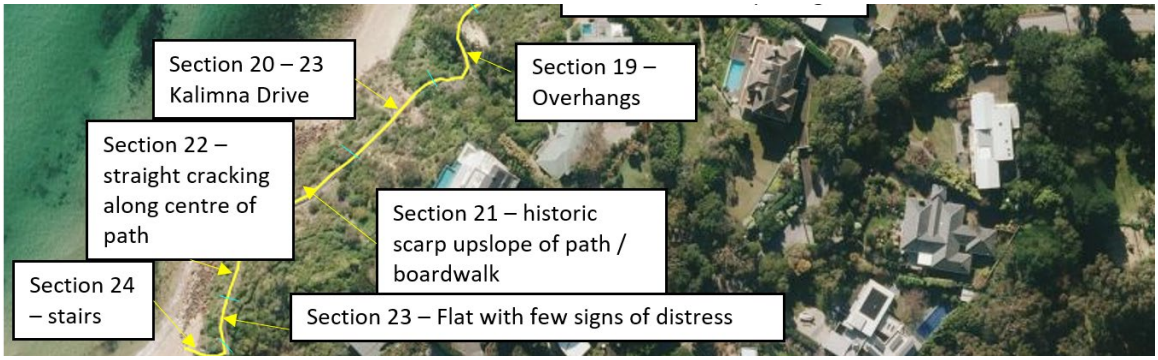

Figure 3-3 - Section Extents Part 3 of 3

Key observations made on site include:

- The construction of the path has resulted in some sections of path being built cut into the cliff and in other areas built on fill embankments.
- The path crosses areas of historic landslide activity in multiple locations.
- Cracking in the path was observed in multiple locations. Straight cracking was observed in sections of path constructed on fill and arcuate cracking was observed in sections of the path where landslide activity is occurring. Cracks have mostly been sealed but in some locations it was noted at the time of the inspection that sealing or resealing needed to be done.
- In multiple locations, informal retaining walls were observed adjacent to the path. In some instances the walls were originally built to catch debris from minor upslope slips but are now full and have been planted.
- Two active landslides have impacted the path in recent times. Section 7 has a debris flow that has been reactivated. Section 20, downslope of 23 Kalimna Drive, is a small reactivation of a much larger historic landslide.
- The “hump bridge” in Section 18 was constructed following damage to the original path by a landslide.
- Section 21 comprises a section of boardwalk built after the original path was damaged by a landslide.
- In Section 19, informal remediation works comprising timber boards nailed to the cliff face, have been implemented to reduce future landslide material impacting the path.
- Surface drainage pipes and systems were observed. Some drains appeared to be in poor condition.
- At the locations of the active landslides, water was observed seeping through the scarps.

- Surface water run off is washing soil material onto the path in some locations.
- Drainage pipe outfalls on the beach were observed. Some had water coming out of them, others did not, indicating the presence of breakages or blockages in the pipes.
- Small landslides at the toe of the cliff were observed. These are thought to result from wave action. At present they do not impact on the stability of the path higher up the cliff.

4 LANDSLIDE RISK ASSESSMENT

A landslide risk assessment (LRA) was carried out for each of the 24 sections of path identified, to determine whether it is appropriate for people to use the path. The LRAs were completed in accordance with the guidance presented in the Australian Geomechanics Society Practice Note Guideline for Landslide Risk Management 2007 (AGS 2007).

The report provides detailed assessments for each of the 24 sections.

Multiple criteria were assessed to determine an overall risk to life for each section of the path. For existing slopes, AGS (2007) suggests that 'tolerable' risk should be less than or equal to $1x10^{-4}$ therefore this has been adopted for the purposes of this report.

The assessment shows that for each individual section of the path, the risk to life to the individual most at risk is considered 'tolerable', primarily as a result of the short transit time for each hazard compared to the length of a year. However, as the path is used by a number of people and individual people may use the path multiple times a year, it is important to consider the societal risk. The societal risk is the cumulative risk that builds up over time as each person uses the path and takes into account the number of people that use the path.

The societal risk has been determined based on approximately 100 people using the path per day, noting that this is an estimate as no traffic count has been carried out to obtain actual user numbers for the path. The number is based on anecdotal information provided by the Shire and Friends groups.

The analysis indicates that the societal risk is 'not tolerable' for Sections 7 and 20. Elsewhere the societal risk is assessed as 'tolerable' or 'acceptable'. A summary societal risk map is provided in Figure 4-1.

Figure 4-1 – Societal risk map

As all of the sections are aligned one after the other along the path, meaning that a person using the path will walk through all of the different sections identified instead of accessing discrete sections, the Societal Risk of all of the sections combined needs to be considered as well. Based on the societal risk for individual hazards, the combined risk for the full length of the path is **1.42E-02**. This indicates that the Societal Risk to Life is not tolerable for people walking from one end of the path to the other.

It has been identified that the critical sections of the path include Sections 5, 7, 19 and 20. If the Societal Risk to Life in all four of these sections can be brought up to a 'Tolerable' level, then the combined Societal Risk to Life for the full length of the path would also become 'Tolerable'.

5 RISK MITIGATION MEASURES

The current risk mitigation measures include fencing at the start and end of the cliff path, as well as on both sides of each of the areas where active landslides are located. Observations made during the site inspection indicate the fences either side of the active landslide have limited effectiveness in preventing people from accessing the high-risk areas.

The societal risk to life obtained from the LRA has been assessed to identify the most critical sections of the path to be targeted for remedial measures, such that the combined societal risk for life for the full path can be reduced to a 'tolerable' level. This assessment indicated that there are two areas along the path that, if

both remediated, would improve the Societal Risk to Life of using the full length of the path to a ‘Tolerable’ level. These two areas include one length along the north of the path including Sections 5, 6 and 7 (Area A). The other length is along the south of the path and includes Sections 19 and 20 (Area B).

The solutions proposed in the report are assessed for suitability and include consideration of the Marine and Coastal Policy (2020).

Towards the Caraar Creek Lane end of the path, the hazards within Area A could be addressed by re-routing the path inland and further away from the hazards presented by Section 5 (downslope scarp) and Section 7 (active landslide).

An options assessment was not considered for Area A as the solution was discussed with MSPC representatives during the site inspection and was understood to be the most feasible remedial option for this area.

Four remedial options have been presented for Area B:

- A bridge
- A path to the beach,
- A gabion supported path and grading
- Drainage and grading

A detailed options assessment for all of the Area B options is presented in the report. The findings are presented in the options assessment matrix, reproduced below.

Table 5-1 – Option Assessment Matrix

	Safety in construction	Medium Term Residual Risk	Long Term Residual Risk	Difficulty in Design	Difficulty in Construction	Relative Cost Ranking	Environmental Impact	Ongoing Amenity	Will the option provide open pedestrian access?	Administrative Difficulty
Option 1 - Bridge	High	Low	Low	High	High	High	High	Low	Yes	Medium
Option 2 - Steps to beach	Low	Low	Medium	Low	Low	Low	Low	High	Yes	Medium
Option 3 – Gabion supported path and grading	Medium	Medium	High	Medium	Medium	Medium	Medium	Low	Yes	Medium
Option 4 – Drainage and grading	High	Low	Medium	High	High	High	High	Low	Yes	High

Stantec Australia
Level 4, 501
Swanston Street
Melbourne, VIC
Australia

6 CONCLUSIONS AND RECOMMENDATIONS

Ongoing landslide activity has been observed along the cliffs on which the Beleura Cliff Path has been constructed. Evidence indicates that this has been occurring for thousands of years. The landslide activity is likely a result of multiple factors, including but not exclusively the geology of the cliffs, rainfall, and water (from natural and manmade sources).

Based on the assessment, it has been concluded that Area A and Area B identified in Section 5 of this summary have a 'Not Tolerable' risk to life and remediation of both of these areas are required to open the path.

Such that the path can reopen with a tolerable level of Societal Risk to Life, remedial works are required in Area A and Area B, with options presented above.

In addition to this, an audit of all drainage and irrigation systems should be undertaken along the full length of the path, with upgrades implemented where breaks or blockages are identified to prevent the uncontrolled discharge of water over the cliff face.

It is also recommended that community education programs relating to the correct use of irrigation systems are rolled out, with specific focus on residents immediately adjacent to the cliff. Periodic audits of irrigation practices should be conducted by council staff to verify that recommended practices are being followed. Any irrigation systems need to be changed to be non-automated and such that they can be depressurised once manual watering is complete.

Ongoing engagement and liaison with property owners is encouraged. The local community groups provide valuable feedback relating to the condition of the path and any issues with drainage or irrigation within the area.

Following the remedial works in the areas identified, it is recommended that the path is inspected at regular intervals by a council officer (i.e. once every 3 months) to monitor areas of interest and identify if any significant changes are occurring. Should significant changes be identified then further geotechnical advice should be sought.

In addition to this, any cracks in the asphalt path must be sealed periodically (i.e. once every 6-12 months).

Yours sincerely,

[redacted]

[redacted]

Stantec Australia
Level 4, 501
Swanston Street
Melbourne, VIC
Australia

The conclusions in the Report are Stantec's professional opinion, as of the time of the Report, and concerning the scope described in the Report. The opinions in the document are based on conditions and information existing at the time the document was published and do not take into account any subsequent changes. The Report relates solely to the specific project for which Stantec was retained and the stated purpose for which the Report was prepared. The Report is not to be used or relied on for any variation or extension of the project, or for any other project or purpose, and any unauthorized use or reliance is at the recipient's own risk.

Stantec has assumed all information received from the Client and third parties in the preparation of the Report to be correct. While Stantec has exercised a customary level of judgment or due diligence in the use of such information, Stantec assumes no responsibility for the consequences of any error or omission contained therein.

This Report is intended solely for use by the Client in accordance with Stantec's contract with the Client. While the Report may be provided to applicable authorities having jurisdiction and others for whom the Client is responsible, Stantec does not warrant the services to any third party. The report may not be relied upon by any other party without the express written consent of Stantec, which may be withheld at Stantec's discretion.