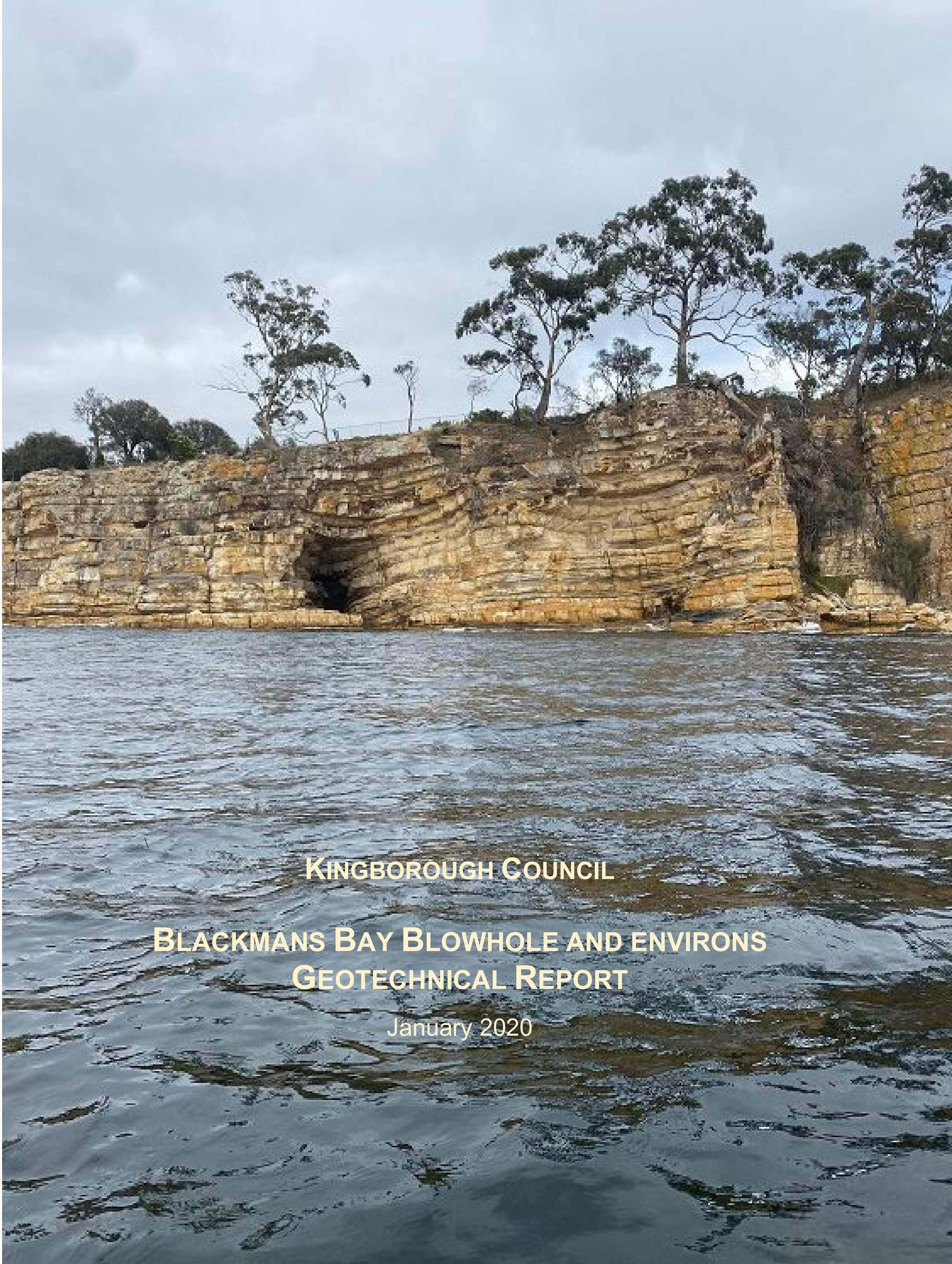

KINGBOROUGH COUNCIL

BLACKMANS BAY BLOWHOLE AND ENVIRONS GEOTECHNICAL REPORT

January 2020

Cover image

View west towards the coastal opening of the Blackmans Bay Blowhole (centre left), 24 December 2019. The cliff is composed of Permian-age siltstone, sandstone and mudstone dipping approximately 12^0 WSW.

Refer to this report as

Cromer, W. C. (2020). *Geotechnical Report, Blackmans Bay Blowhole and Environs.* Unpublished report for Kingborough Council by William C. Cromer Pty. Ltd., 21 January 2020.

Warning
Printed copies of this report must be in colour, and in full.
No responsibility is otherwise taken for its contents.

SUMMARY

In recent geotechnical investigations commissioned by Kingborough Council, three types of geotechnical hazards are recognised at and near Blackmans Bay Blowhole. They are rockfalls/topples of a range of sizes, small landslides, and tree falls.

The hazards present no unacceptable risks to infrastructure (the cliff top fence and Talone Road: no houses are at credible risk), and no management is required.

The hazards present varying (mostly low) risks to life. In this report, these are compared to acceptability criteria recommended by the Australian Geomechanics Society *Landslide Risk Management* 2007c, but Kingborough Council as regulator should assess acceptability for these risks against its own organisational criteria. If risk treatment is contemplated, reducing the likelihood of the hazards occurring is impracticable. Treatment (if any) should focus on reducing consequences of the hazards, which in turn may mean regulating public access to parts of the area.

1 INTRODUCTION

1.1 Background, scope and personnel

1.1.1 Background

In December 2019, William C. Cromer Pty. Ltd. (WCC) was commissioned by Kingborough Council (KC) to conduct geotechnical investigations at the northern end of Blackmans Bay Beach, including the sea cliffs and Blackmans Bay Blowhole, and the land seawards of Talone Road as far north as 36 Talone Road.

Council's background notes, instructions and the study area are in Attachment 1.

Relevant background observations are:

- In January 2017 a fatality occurred from a cliff-top fall near the Blackmans Bay Blowhole.
- Following a coroner's report into the fatality, KC acquired land adjacent to the site of the fatality, and commissioned a Public Safety Risk Assessment by IPM Consulting Services.
- IPM reviewed the public safety risks, the existing risk management, and any additional improvements to risk management which might be appropriate.
- IPM noted the known activities in the area were sightseeing, general recreational use, abseiling (by tourist operators, community groups and schools) and cliff jumping.
- The most significant hazards associated with these activities were identified as falls from the edges of the cliff and blowhole, injury from rockfalls and falling tree limbs, injuries from pedestrian-traffic interaction, and slips and trips on uneven and unofficial paths.
- Collectively, the public safety risk was regarded by IPM as significant.
- IPM made several recommendations, including:
    - upgraded fencing along the cliff top,
    - engineered and certified anchors for abseiling,
    - warning signage,
    - public education, and
    - a "Geotechnical review of the blowhole and cliffs in accordance with the Landslide Risk Management standard released by the Australian Geomechanics Society in 2007."

1.1.2 Scope, personnel and dates

WCC's scope of investigations paraphrased from Attachment 1 was to:

- describe the relevant geological conditions in the study area,
- identify and characterise geological/geotechnical risks, suggest (as required) risk management measures, and
- where appropriate, provide geotechnical specifications for the control measures recommended by IPM.

To address this scope, the following investigations were conducted:

Desk-top study

A review was done of on-line geotechnical and geological information relating to the study area and environs. Most is presented in Attachment 2.

Field work

Field work included:

- an initial inspection and photography on 4 December 2019
- off-shore (kayaking) site inspection and photography on 24 December 2019
- mapping, drone photography, and informal doorknocking to meet local residents on Talone Road on 2 January 2020,
- dynamic cone penetrometer (DCP) profiling at 16 locations along the existing and proposed extended fenceline in the study area on 2 January 2020, and
- separate on-site discussions about abseiling with Mr. P. Harris of Aardvark Adventures (AA), and Mr. Luke Hamilton of the Tasmanian Climbing Instructors Association (TCIA) on 2 January 2020.

The geological and geotechnical inspections, drone photography and abseiling meetings were conducted by engineering geologist Bill Cromer. Consulting geologist Genevieve Bremner and field assistant Richard Mackintosh carried out the DCP profiling.

1.2 Presentation of results

Most of the results of investigation are presented in the six Attachments accompanying this report.

1.3 Previous geotechnical inspection

At the request of KC, I conducted a brief geotechnical inspection of the Blackmans Bay Blowhole in April 1999, and in a one-page report[1] made some minor suggestions in relation to fencing and stormwater control.

[1] Cromer, W. C. (1999). *Re: Blackmans Bay Blowhole – geotechnical inspection*. Letter/report to Mr. S. Kaczmarski, Program Engineer, Technical Services, Kingborough Council. Environmental & Technical Services Pty. Ltd., 4 May 1999.

2 RESULTS

2.1 Geology

2.1.1 Published geology

The published[2] bedrock geology of the district (Attachment 2) shows Permian-age sedimentary rocks underlie the whole area, with the exception of beach and dune sand at and near sea level on Blackmans Bay Beach. The Permian rocks are described as unfossiliferous glaciomarine[3] interbedded mudstone, siltstone and sandstone of the Abels Bay Formation.

2.1.2 Observed geology

Site observations support the published geology. Relevant ones are:

Excellent exposures of well-bedded siltstone, sandstone and mudstone occur on the sea cliffs in the study area. The cliffs range from less than a few metres high at the northern end of Blackmans Bay Beach, to about 15 – 17m high at the entrance to the blowhole, to about 40m high at the northern end of the study area (Figures 1 and 2).

Figure 1. View west towards the southern part of the study area, showing well-bedded Permian-age siltstone, sandstone and mudstone dipping approximately 12^0 southwest.

Bed thickness ranges from about 0.1m to almost one metre, and dips approximately 12^0 to the southwest.

[2] Calver, C. R. (compiler). 2007. Digital Geological Atlas 1:25,000 Scale Series. Sheet 5223. Blackmans Bay. Mineral Resources Tasmania

[3] Glaciomarine sediments are deposited in a marine environment fed by glacial meltwater and/or glaciers and icebergs.

Jointing is well developed in the sedimentary rocks. Most is subvertical, with the major joint direction, including that of the mouth to the blowhole, approximately striking (trending) 70 – 250^{0}T. A set of similar joints strikes at roughly right angles and is subparallel to the bedding strike (Figure 3). Joint spacing varies from less than 0.1m, to more than a metre.

The main joint set creating the blowhole and its mouth extends further to the west southwest towards Blowhole Road, and the blowhole itself tends to preferentially erode in the same direction.

Figure 2. View northwest to the sea cliffs in the northern half of the study area, showing well-bedded Permian-age siltstone, sandstone and mudstone dipping approximately 12^0 southwest

Weathering of the bedrock is variable, ranging from slight to extreme. Slight weathering results in little mineralogical change and a relatively high strength rock. Extreme weathering results in chemical breakdown (typically of binding cement between grains) which produces a highly erodible material usually exhibiting soil properties[4].

At the base of the cliffs is a shore platform of variable width (depending on tides), which dips inland at the same angle as the bedding. Platform width ranges from as little as a few metres, up to 40m or so at low tide. In places, the platform is absent, and has either been cut through by marine erosion along the major joint direction (Figure 3) or is locally replaced by a cobble beach (eg at the northern end of the study area). The platform permits pedestrian access, particularly at low tide, but access is difficult where it is disrupted along the major eroded joint set (eg the blowhole mouth).

Slow retreat of the sea cliffs is continually occurring via erosion by waves at its base, and wind. The mechanism of retreat is mostly rockfalls and topples, and very small scale landsliding. The sizes of the falls and topples is controlled by joint directions and spacings, and ranges from individual joint blocks less than 0.1m in diameter, up to major falls involving hundreds of tonnes (Attachments 3 and 4).

[4]Material with soil properties can be remoulded in the hand, with or without adding water.

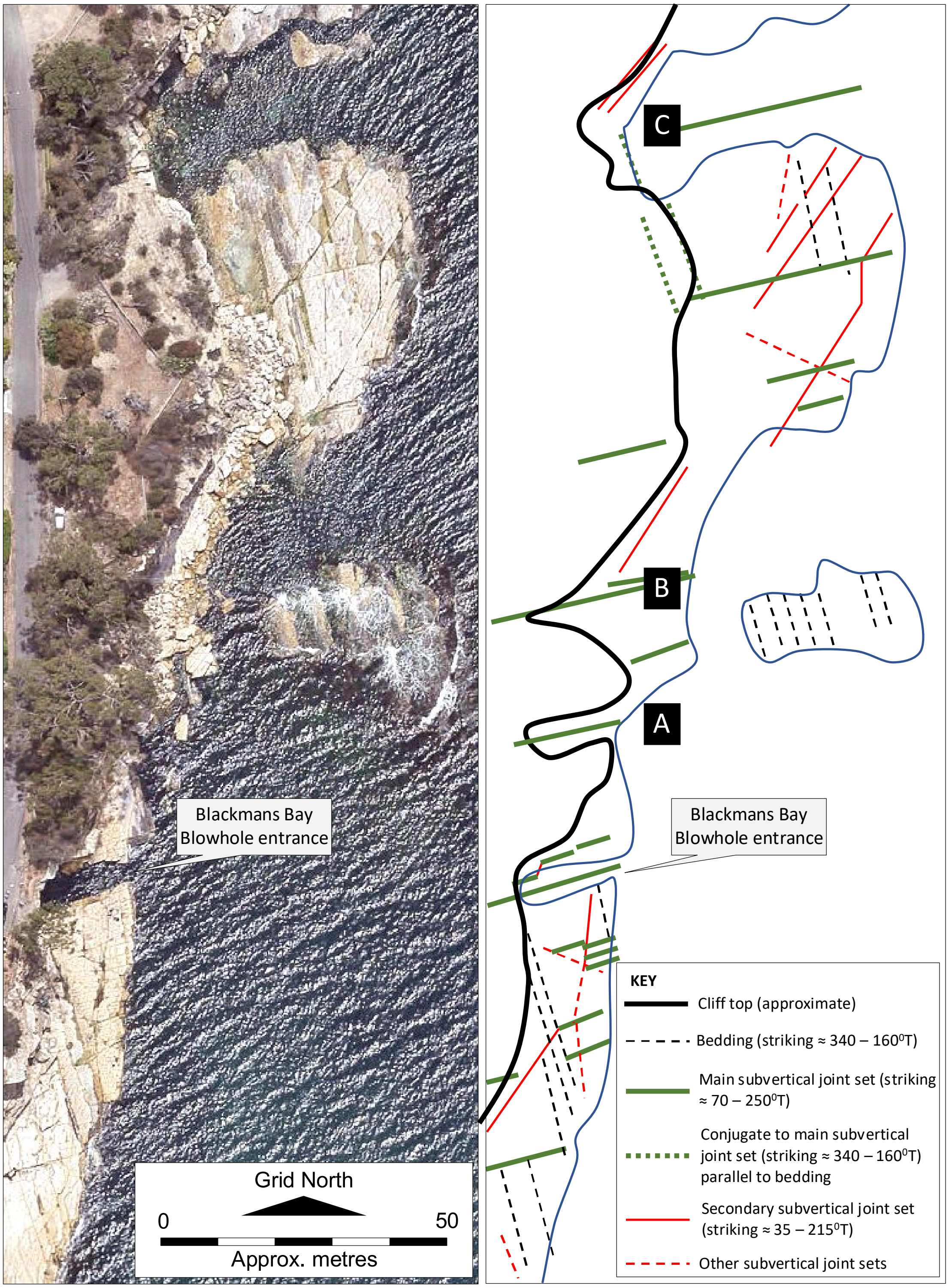

Figure 3. The dominant joint direction along the sea cliffs in the study area is approximately 70 – 250^{0}T. These are subvertical, and marine erosion along some of them has produced the blowhole and its mouth, and re-entrants A, B and C shown here. See also the photographs in Attachment 3.

Soils developed in-situ on bedrock are mostly light-coloured silty clay and clayey silt, usually with siltstone and sandstone rock fragments, and with a stiff to very stiff consistency.

Along the cliff top, soil thickness ranges from about 0.2m to 1.6m, based on DCP profiling (Attachment 5). Soil properties based on the DCP results (Figure 5.1 in Attachment 5) are also variable:

- Allowable bearing capacity typically (but not always) increases with depth, from about 200kPa near-surface to more than 400kPa at depths below about 0.5m. Corresponding CBR values range from about 10% near-surface, to over 25% below about 0.5m.
- At DCP1, 2, 9 and 11, strength decreased with depth down to bedrock.

Soil interpreted as transported (colluvial) and containing angular rock fragments was observed on south-facing slopes at the southern end of the study area.

2.1.3 Formation and age of Blackmans Bay Blowhole

Blackmans Bay Blowhole has been formed – and continues to be enlarged – by wave action preferentially eroding along a major set of subvertical joints trending in a west southwest direction in the Permian-age sedimentary rocks.

There are many other examples of similar erosion along adjacent coasts.

We are currently in an interglacial period, and have been for the past 10,000 years or so, when sea level has been roughly the same as at present (Figure 4). It is possible that the blowhole developed during this period, but it is also possible it is much older: There was a period of over a hundred thousand years during the Last Glacial spanning about 6000 – 120,000 years ago when sea level was 30 – 130m lower than at present, and blowhole formation was not possible. But at around 120,000 – 130,000 years ago, sea level is thought to be up to 10m or so higher than current levels, and blowhole formation might have been active then as well.

3 DISCUSSION

3.1 Geotechnical hazards

3.1.1 Conceptual geological models

Figures 5 and 6 are conceptual geological cross sections ("models"), at natural scale, through the sea cliffs in the study area, at the locations shown in Figure 7.

The detail in the sections is consistent with site observations.

Cross section A – B depicts interpreted geological conditions through the blowhole and its mouth. Cross section C – D is located some 120m further north, where the cliff is higher and the shore platform wider.

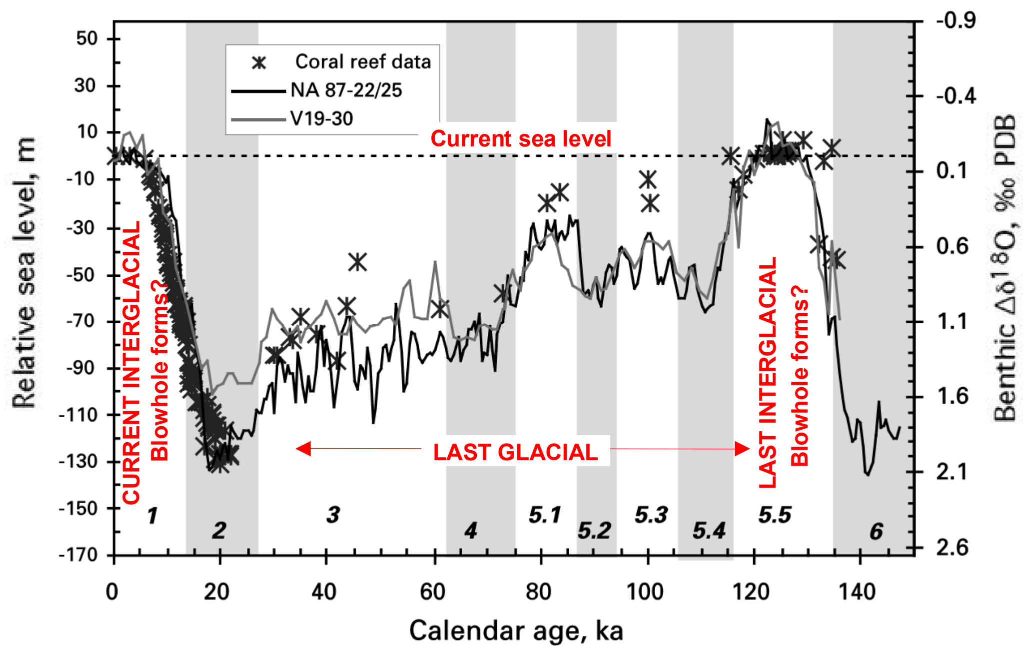

Figure 4. Relative global sea level changes since the Last Interglacial, based on corals and other evidence. (Figure 1 of Waelbroek *et. al*. (2002)). ka = thousands of years ago.
Reference: Waelbroek, C. *et. al*. (2002). Sea-level and deep water temperature changes derived from benthic foraminifers isotopic records. Quaternary Science Reviews 21 pp 295 – 305.

3.1.2 Identified geotechnical hazards

Three types of geotechnical hazards[5] are identified in the study area, and are shown in Figures 5 and 6:

- Hazards 1 – 6 are rockfalls/topples involving different volumes of material – from failures of hundreds of tonnes (Hazards 1 and 2), to individual small boulders weighing a few kilograms (Hazard 6)[6]. Examples of these hazards are depicted in Plates 2 – 6 in Attachment 3, and in Attachment 4.
- Hazard 7 are very small landslides (earthslides[7]) from at or near the top of the sea cliffs, involving failure of the soil profile. Examples are shown in Plates 2, 3 and 5 in Attachment 3.
- Hazard 8 are tree and limb falls. Examples are depicted in Plates 2, 3 and 5 in Attachment 3.

[5] Injuries from pedestrian-traffic interaction, and slips and trips on uneven and unofficial paths, as identified by IPM, are not considered to be geotechnical hazards, and are therefore not discussed further in this report.
[6] The inset Tables on Figures 5 and 6 define landslide size and speed. Even rockfalls of hundreds of tonnes are "small".
[7] Earthslides are landslides involving mostly soil, with only minor proportions of rock.

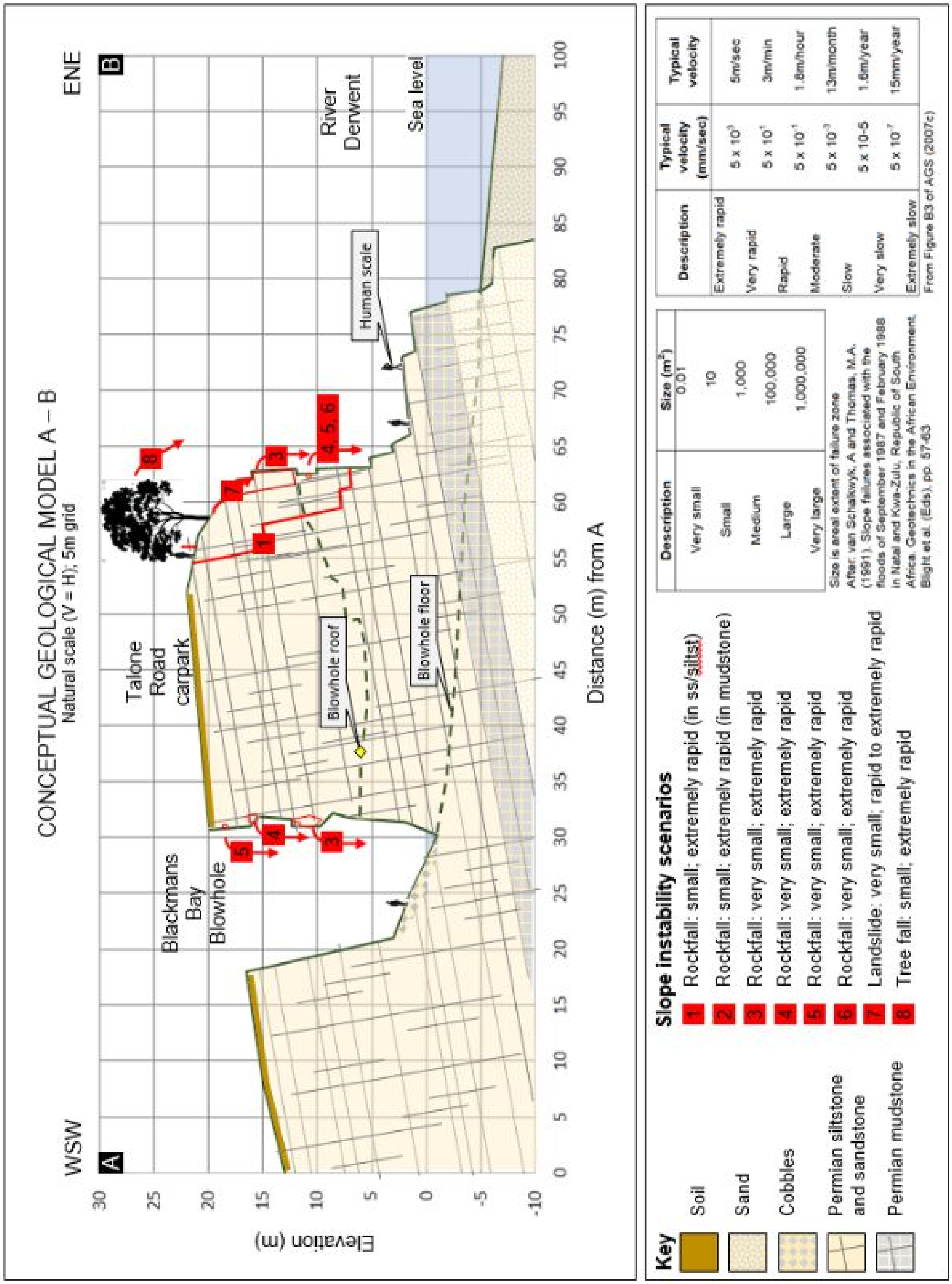

Figure 5. Conceptual geological cross section A – B through the Blackmans Bay Blowhole, showing the types, and nominal sizes and speeds, of identified geotechnical hazards. Note the human scale, which is different to that in Figure 6. See Figure 7 for the location of the cross section.

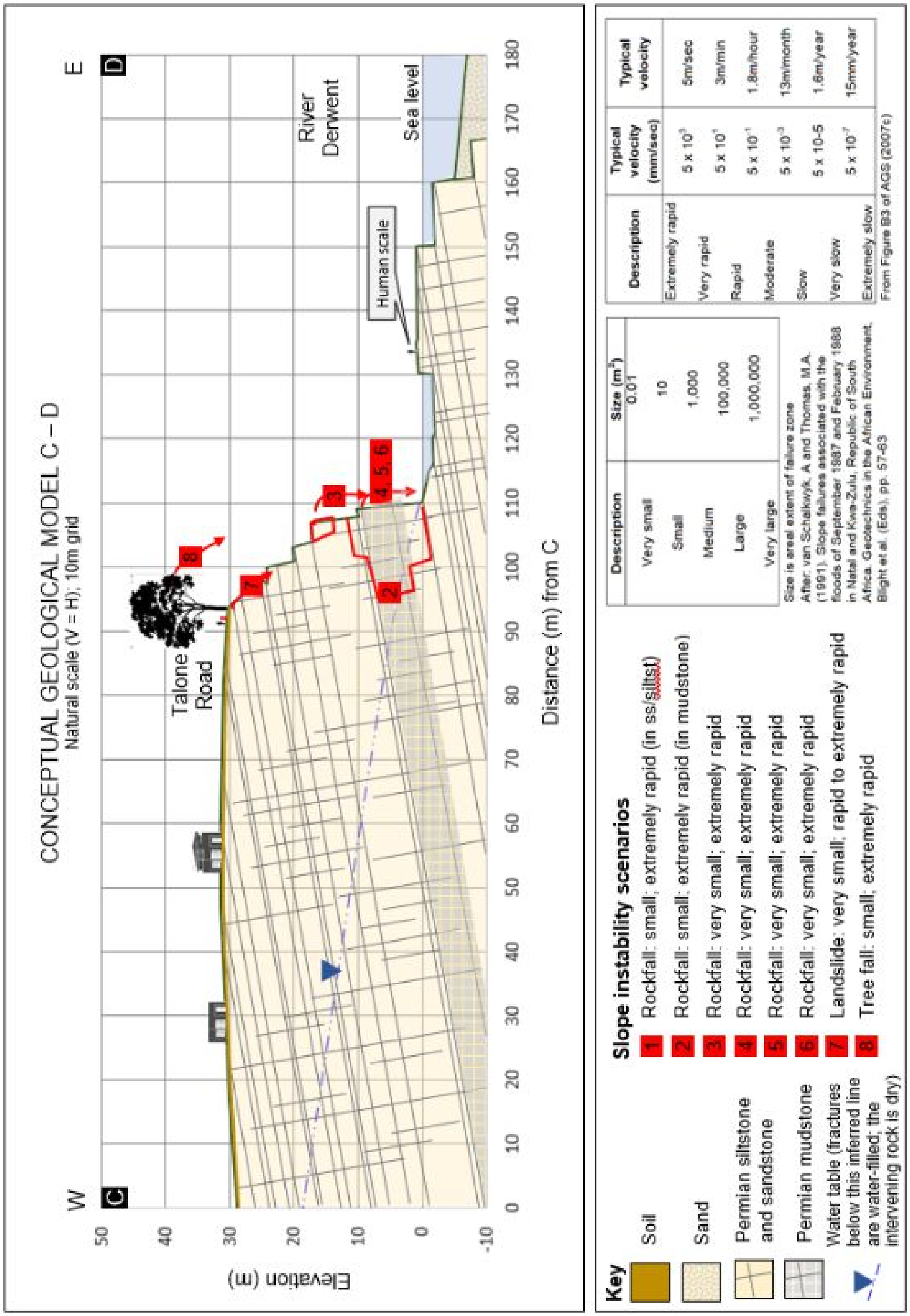

Figure 6. Conceptual geological cross section C – D roughly through the centre of the study area, showing the types, and nominal sizes and speeds, of identified geotechnical hazards. Note the human scale, which is different to that in Figure 5. See Figure 7 for the location of the cross section.

Figure 7. Location of section lines A – B and C – D. Source: www.thelist.tas.gov.au

3.1.3 Landslide risk management

Attachment 6 is a landslide risk management (LRM) assessment[8] of Hazards 1 – 8, in accordance with the Australian Geomechanics Society *Landslide Risk Management* 2007 (AGS2007).

Qualitative risks to property

Property in this context is considered to be infrastructure – Talone Road and the cyclone fence along the cliff edge.

It is regarded that houses along the western side of Talone Road are not at credible risk from any of the hazards 1 – 8.

Table 1 (reproduced from Attachment 6) shows that hazards 1 – 8 present Low risk to identified infrastructure in the study area, and no risk treatment is required.

Quantitative risks to life

Risk to life have been considered for four examples of activities which are judged to be reasonably representative of those taking place in the study area:

Example 1. A mobile recreational individual walking on the shore platform, subject to hazards 1 – 8. Risk to life for an individual most at risk is the sum of all risks and is estimated to be 6 x 10^{-6}.

Example 2. Static sightseers (3 people at a time) at the fenceline at the Talone Street carpark, subject to hazard 1 only. Risk to life for an individual most at risk is estimated to be 3 x 10^{-9}.

Risk to life for all 3 people is 4 x 10^{-5}, which as an F-N pair plots in the ALARP (As Low as Reasonably Practicable) region of the societal risk graph.

Example 3. A small static abseiling group (5 people) at the base of the cliff near the blowhole mouth, subject to hazards 1, 3 and 4. Risk to life for an individual most at risk is estimated to be 7 x 10^{-8}, 1 x 10^{-5} and 3.5 x 10^{-4} for hazards 1, 3 and 4 respectively.

Risk to life for all 5 people is 3.5 x 10^{-7} for hazard 1, which as an F-N pair plots in the Acceptable region of the societal risk graph. The risk is 7 x 10^{-5} for hazard 3, which plots on the ALARP region of the societal risk graph.

Example 4. An individual mobile kayaker or swimmer entering the blowhole via its mouth (calm seas are presumed), subject to hazards 3 and 4. Risk to life for an individual most at risk is estimated to be 2 x 10^{-5} and 5 x 10^{-4} for hazards 3 and 4 respectively.

[8] **Important notes.** 1. LRM, and particularly the assessment of hazard likelihood, is a subjective process. Likelihoods for hazards 1 – 8 are shown qualitatively in Table 1, and are listed qualitatively as $P_{(H)}$ values in Table 6.4 in Attachment 4. Temporal and spatial probabilities are also subjective inputs, and risk to life in particular is sensitive to these. As far as can be judged from available evidence, it is thought that the inputs are reasonable. However, it is understood and readily acknowledged that other LRM assessors might adopt different inputs, and hence estimate different risks to property and life. 2. It must also be understood that the acceptance criteria for any risk shall be determined by regulators, not LRM risk assessors. Some guidance in this regard is offered in Attachment 6.

Table 1. Likelihood, consequence and qualitative risk analysis of Scenarios 1 – 8. Risks to infrastructure are Low for all hazards.

	1	2	3	4	5	6
	Scenario	**Likelihood of occurrence**	**Consequence to assets**	**Level of risk to assets above and behind**	**Level of risk to assets below**	**Recommended risk treatment**
1	Rockfall/rock topple Small scale; in siltstone and sandstone, from any part of the cliff face; extremely rapid; involving a width of cliff face of at least 20m.	Unlikely	Medium to road	Low	Not applicable (no assets below)	None
2	Rockfall/rock topple Small scale; in mudstone, from the lower parts of the cliff face; extremely rapid; involving a width of cliff face of at least 20m.	Likely	Insignificant			
3	Rockfall/rock topple Very small scale; in siltstone, sandstone or mudstone, from any part of the cliff face; extremely rapid; involving one or more boulders over a width of cliff face of at least 5m.	Almost Certain to Likely				
4	Rockfall/rock topple Very small scale; in siltstone, sandstone or mudstone, from any part of the cliff face; extremely rapid; involving one or more boulders over a width of cliff face of at least 1m.	Almost Certain				
5	Rockfall/rock topple Very small scale; in siltstone, sandstone or mudstone, from any part of the cliff face; extremely rapid; involving one or more boulders over a width of cliff face of at least 0.5m.					
6	Rockfall/rock topple Very small scale; in siltstone, sandstone or mudstone, from any part of the cliff face; extremely rapid; involving a single boulder (joint fragment) up to 0.1m in diameter.					
7	Earthslide Very small scale landslide, from at or near cliff top, up to 5m wide and less than about 2m3 in volume; extremely rapid, moist to wet, suspended to active					
8	Tree or tree limb fall Very small scale fallen tree and/or limb, from at or near cliff top, with a downslope affected zone up to about 5m wide; extremely rapid.		Insignificant			

Notes

Column 1: refer to cross sections (Figures 4 and 5 in report) for explanations of size and speed.
Note definition of size is not from AGS2007c.

Column 2: refer to Attachment 7 for an explanation of Likelihood terms.

Column 3: refer to Attachment 7 for an explanation of Consequence terms.
Assets(ie property, infrastructure) in this instance = Talone Road and fence

Column 4: refer to Attachment 7 for an explanation of Risk terms.

3.2 Clifftop fencing

3.2.1 Location and variable height

Cyclone fencing extends close to the cliff edge on the seaward side of Talone Road the full length of the study area. Its height ranges from 1.1m and 1.4m from the northern end south to the large eucalypts opposite 53/55 Talone Road. From this point for a short distance south it is about 0.8m high. It increases in height to about 1.3 – 1.4m, and then decreases again to about 0.8m opposite the blowhole (Figure 8).

Figure 8. Different heights of the cyclone fence at the Talone Road carpark opposite the Blackmans Bay Blowhole (at DCP11). At left, the fence is 1.4m high; at right, about 0.9m. Abseilers anchor from this location. Anecdotally, an old couch was positioned at one time over the fence at left.

3.2.2 Age and condition

Local residents say the fence is several decades old. Some of the posts are slightly loose. Apart from its variable height, its condition is fair.

3.2.3 Fence upgrading

IPM has recommended the fence be upgraded. It is suggested here that if it is replaced, it should be of uniform height and material type. A minimum height of 1.2m is suggested as reasonable (there are likely to be objections from local residents if it any higher, and height is not a serious deterrent to people intent on scaling it).

There is very limited opportunity to change its location – except perhaps at the Talone Road carpark, where it could be moved a short distance into the carpark to move sightseers further away from the risk of hazard 1. However, any slight reduction in risk to life would perhaps be offset by a larger number of people attempting to climb over the fence if it offered a wider area on the seaward side.

3.2.4 Fence footing design

Footing design for a new fence is an engineering issue, but it could be informed by the DCP results (Attachment 5) showing soil thickness and strength.

3.2.5 Blowhole fence

The existing metal fence is about 1.8m high and in good condition. In my view it requires no upgrading apart from where it has been damaged by a leaning casuarina. The tree should also be removed.

3.3 Abseiling

3.3.1 Abseiling activities

Mr. L. Hamilton of TCIA, and Mr. P. Harris of AA, both conduct abseiling activities. The former runs school groups, and the latter school and other groups of all ages.

Other competent groups probably also use the site, and it is known that some experienced individuals abseil alone. Mr. Hamilton noted that he has observed inexperienced people also abseil alone or in small groups.

The abseiling sites are in the Talone Road car park, and one or two locations about 40m to the south where the cliff is lower.

It is estimated that about 30 or more visits are made annually by abseiling groups. Group size range from one or two people, up to about 20.

Only one person abseils at a time from an anchor point.

3.3.2 Abseiling anchor points

All groups apparently use existing anchor points: eg trees in front of or behind the fence, the fence itself, and presumably any point able to safely cope with the weight of a single person. Several anchors might be used for each abseil.

There are no formal, recognised anchor points.

Both TCIA and AA agreed that formal, engineered anchor points would be beneficial. Typically, they would be just on the seaward side of the fence, and might be eye bolts attached to a vertical rod or column cemented into demonstrable bedrock. All or some could also be located on the landward side of the fence, although these would be more likely to be vandalised.

Typically, the installed anchors would be between about 0.8m and 1.2m apart, and an installed depth of about 0.3m into bedrock would probably suffice.

Installing engineered anchor points on either or both sides of an upgraded fence might perversely increase rather than decrease the risk of abseiling incidents. While they would benefit all abseilers, they might encourage increased abseiling by inexperienced people.

3.4 Warning signs

IPM recommended warning signs be erected in the study area. From a geotechnical perspective, signs probably do little to address risks to life occasioned by hazards 1 – 8. But from a duty-of-care perspective, signage along the cliff edge and shore platform is appropriate.

The main elements at risk are cliff jumpers and other thrill seekers, and people intent on suicide, and it is difficult to regulate against these activities.

3.4 Public education

IPM recommended a public education program to raise awareness of public risk in the area.

This is likely to be beneficial in a general sense, but is unlikely to reduce geotechnical risk to life.

4 CONCLUSIONS

The following conclusions arise from this report.

The sea cliffs in the study area comprise Permian-age siltstone, sandstone and mudstone dipping at approximately 12^0 to the west southwest. The rocks are or relatively high strength, and show prominent subvertical jointing at various directions and spacings. The Blackmans Bay Blowhole has formed from marine erosion along a major joint direction at least 6,000 years or so ago, but possibly 120,000 – 130,000 years ago, and perhaps older.

Three types of geotechnical hazards exist at and near the Blackmans Bay Blowhole: rockfalls/topples, landslides and tree falls. Various volumes and sizes of rockfalls/topples are considered separately in this report. The hazards are:

1. Rockfall at least 20m wide (multiple boulders) in sandstone/siltstone
2. Rockfall at least 20m wide (multiple boulders) in mudstone
3. Rockfall/topple up to 5m wide (one or more boulders)
4. Rockfall/topple at least 1m diameter
5. Rockfall/topple 0.5m in diameter
6. Rockfall/topple 0.1m in diameter
7. Landslide (earthslide) up to 5m wide
8. Tree fall/topple

Risk to property (ie assets such as Talone Road and the cliff top fence, but no houses) from all hazards is regarded as Low and no risk treatment is required.

Risk to Life for individuals and groups has been considered for four kinds of activities exposed to all or some of the hazards:

1. walking on the shore platform at and near the base of the cliffs,
2. sightseers at the top of the cliff at the Talone Road carpark,
3. abseiling parties, and
4. kayakers and swimmers entering the blowhole via its mouth.

For these examples, risk to life to individuals and ranges from about 3 x 10^{-9} to 6 x 10^{-6} for the first two examples, from about 7 x 10^{-8} to 3.5 x 10^{-4} for the third activity, and from 2 x 10^{-5} to 5 x 10^{-4} for the last activity.

From a group perspective, risks to life for two of the activities plots in the ALARP region of the societal risk graph. The remaining risks to life plot in the Acceptable region of the graph.

The highest risk to life (5 x 10^{-4}) is to individuals in the blowhole itself, occasioned by hazard 4.

The regulator determines risk acceptability criteria. If risks to life are required to be treated, reducing the likelihood of hazards 1 – 8 is not considered practicable. Reducing the consequences should be the focus. Some consequence-reducing actions could include:

- moving the existing fence a metre or two inland at the Talone Road carpark, and at the same time limiting the number of sightseers able to stand close to the edge of the cliff (eg by constructing a narrow, partly enclosed walkway) to no more than (say) 2 people, and
- preventing or discouraging access to the base of the blowhole by kayakers and swimmers.

In relation to fence upgrades, abseiling anchors, signage and public education, no specific geotechnical risk treatments are required.

W. C. Cromer

Principal

This report is and must remain accompanied by the following Attachments

Attachment 1. Kingborough Council Request for Quote for this job (3 pages)

Attachment 2. Location, cadastre, contours, aerial imagery, hill shading, published geology, and landslide, coastal erosion and coastal inundation hazard areas (8 pages)

Attachment 3. Site photography (3 pages)

Attachment 4. Comparative satellite imagery showing aspects of slope instability over 9.5 year (3 pages)

Attachment 5. Dynamic cone penetrometer (DCP) results (7 pages)

Attachment 6. Landslide Risk Management (13 pages)

Attachment 7. Qualitative terminology used in assessing risk to property (2 pages)

Attachment 1
(3 pages)
Kingborough Council Request for Quote for this job

Kingborough

19 November 2019

Our Ref: Talone Road, Blackmans Bay

William C Cromer Pty Ltd
Attn: William Cromer
74A Channel highway
Taroona TAS 7053

billcromer@bigpond.com

Dear Mr Cromer,

RE. REQUEST FOR QUOTE

You are hereby invited to submit a quote for provision of the following services:

Geotechnical Investigation

01. Subject Site

The geotechnical investigation is to encompass the area east of Talone Road (south of 36 Talone Road), the Blowhole & Blackmans Bay Headland Reserve, and the northern extremity of Blackmans Bay Beach, Blackmans Bay.

The subject site encompasses the eastern edge of the Talone Road streetscape, including publicly accessible areas located between the Talone Road carriageway and the adjacent clifftops, locations that provide attractive prospect over the River Derwent at Blackmans Bay, the Blackmans Bay Headland Reserve, cliff edge, cliffs and marine shelf (to base of cliffs).

The subject site includes: undulating topography; sharp, and often concealed, cliff edges; significant vertical relief; rocky outcrops; the Blackmans Bay Blowhole 'rim' and 'inlet', the shoreline marine shelf (to base of cliffs); established coastal vegetation (including large trees); a bitumen carriageway and turnaround; footpaths; and limited park furniture.

Please refer to Figure 1 (over page) for more information relating to the extents of the subject site.

kingborough.tas.gov.au
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T: (03) 6211 8200 F: (03) 6211 8211 E: kc@kingborough.tas.gov.au

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Figure 1: Extent of Subject Site (illustrated here within the magenta Study Area boundary)

02. Context

Council is in receipt of a Record of Investigation into Death (Without Inquest) relating to the accidental death of Margaret Mary Lore at the subject site on 28 January 2017.

Pursuant to the Coroner's recommendations, Council has recently acquired the land directly south of the Talone Road turnaround and north of Blackmans Bay Beach.

Please note that ownership of the land (north of the Talone Road turnaround), located directly east of Talone Road, is held under freehold titles associated with the lots opposite and is subject to the Environmental Management Zone Code under the Kingborough Interim Planning Scheme (2015).

Council has recently taken receipt of a Public Safety Risk Assessment (undertaken by IPM Consulting Services). Please refer to the Assessment (attached) for detailed information relating to known activities that occur within the investigation area. The Report also outlines recommendations relating to the installation of control measures within the investigation area. The geotechnical investigation will inform the planning and design of proposed control measures and should make specific reference to these in the deliverables (report).

kingborough.tas.gov.au
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Environmental, engineering and groundwater geologists
M 0408 122 127 E billcromer@bigpond.com W www.williamccromer.com

03. Outputs

A geotechnical investigation is to be undertaken in accordance with

- *Australian Standard 1726-1993 Geotechnical Site Investigations;*
- *Geomechanics Society 2007, Landslide Risk Management Standard.*

A report shall be delivered to Council addressing (but not limited to) the following:

1. Description of the relevant geological conditions within the investigation area;
2. Geological / geotechnical risks identified by location and likelihood;
3. Stabilisation measures (as required) and other interventions (where appropriate);
4. Specifications relating to the control measures outlined in the IPM Public Safety Risk Assessment (ie. minimum setbacks and/or preferred locations for fencing, footings, footing depths, etc., and more as required).

04. Methodology

Please include an outline of your proposed methodology, including intended survey techniques and preferred method of reporting, in your response (quote) to Council.

05. Timing

Please provide a response within 5 business days of the date of this RFQ with an outline of your proposed project plan (including timelines for the investigation and deliverables, and a methodology).

The first draft of the report should be submitted to Council by 9am on Monday, 6 January 2020.

Please do not hesitate to contact me directly should you wish to discuss or require any additional information.

Yours sincerely,

PAUL DONNELLY
URBAN DESIGN OFFICER

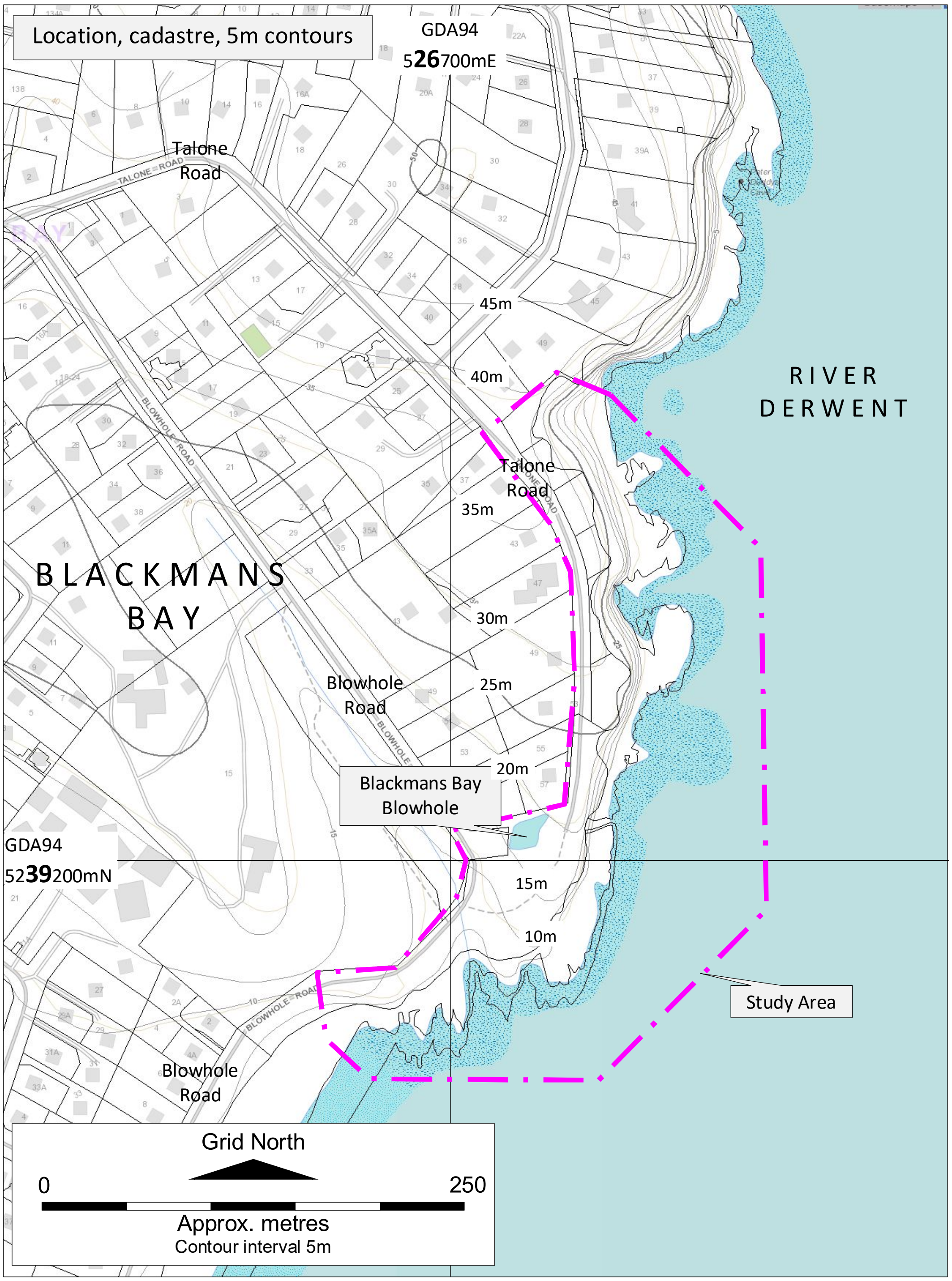
Phone: (03) 6211 8124
Email: pdonnelly@kingborough.tas.gov.au

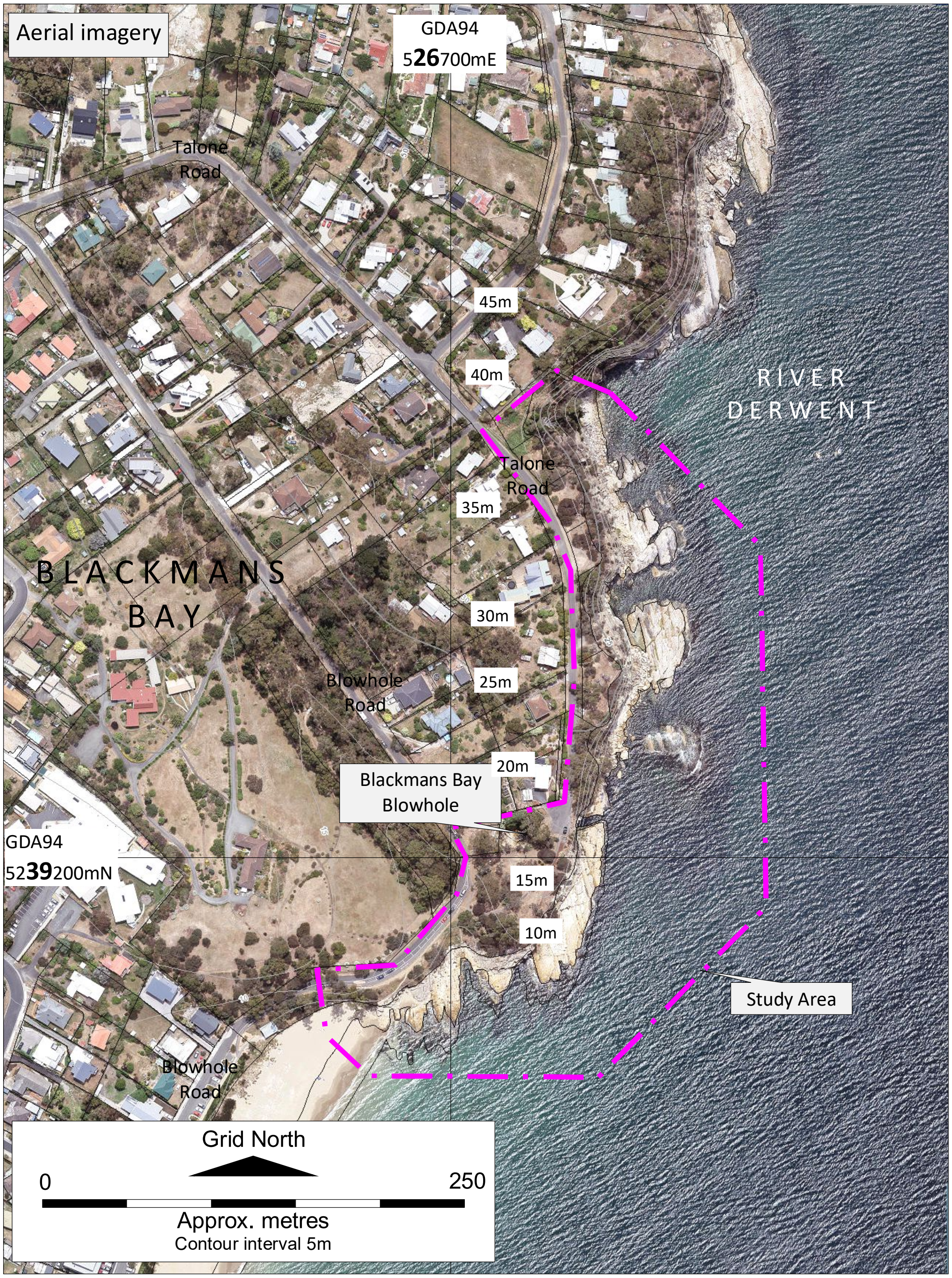
Attachment 2

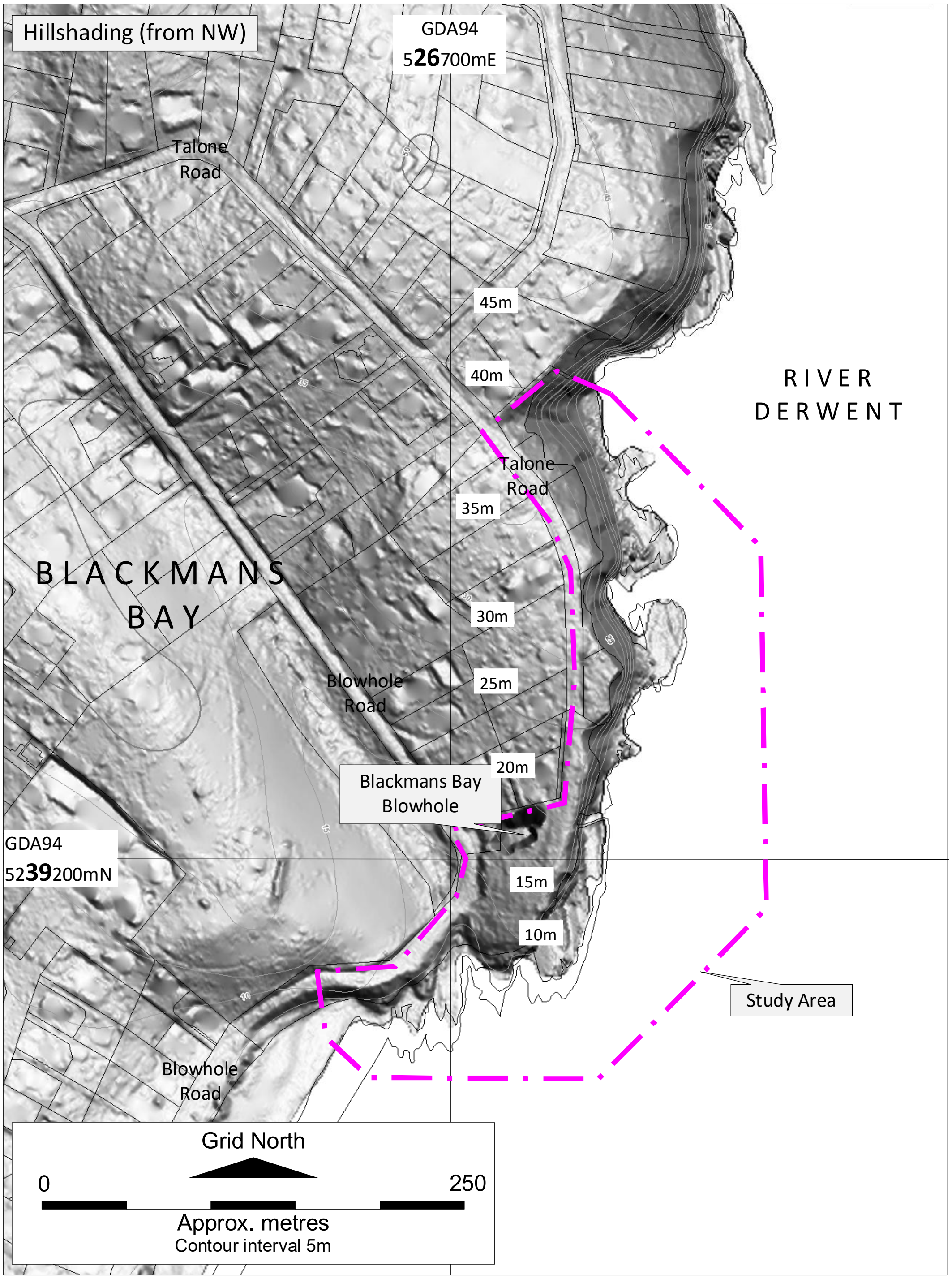
(8 pages)

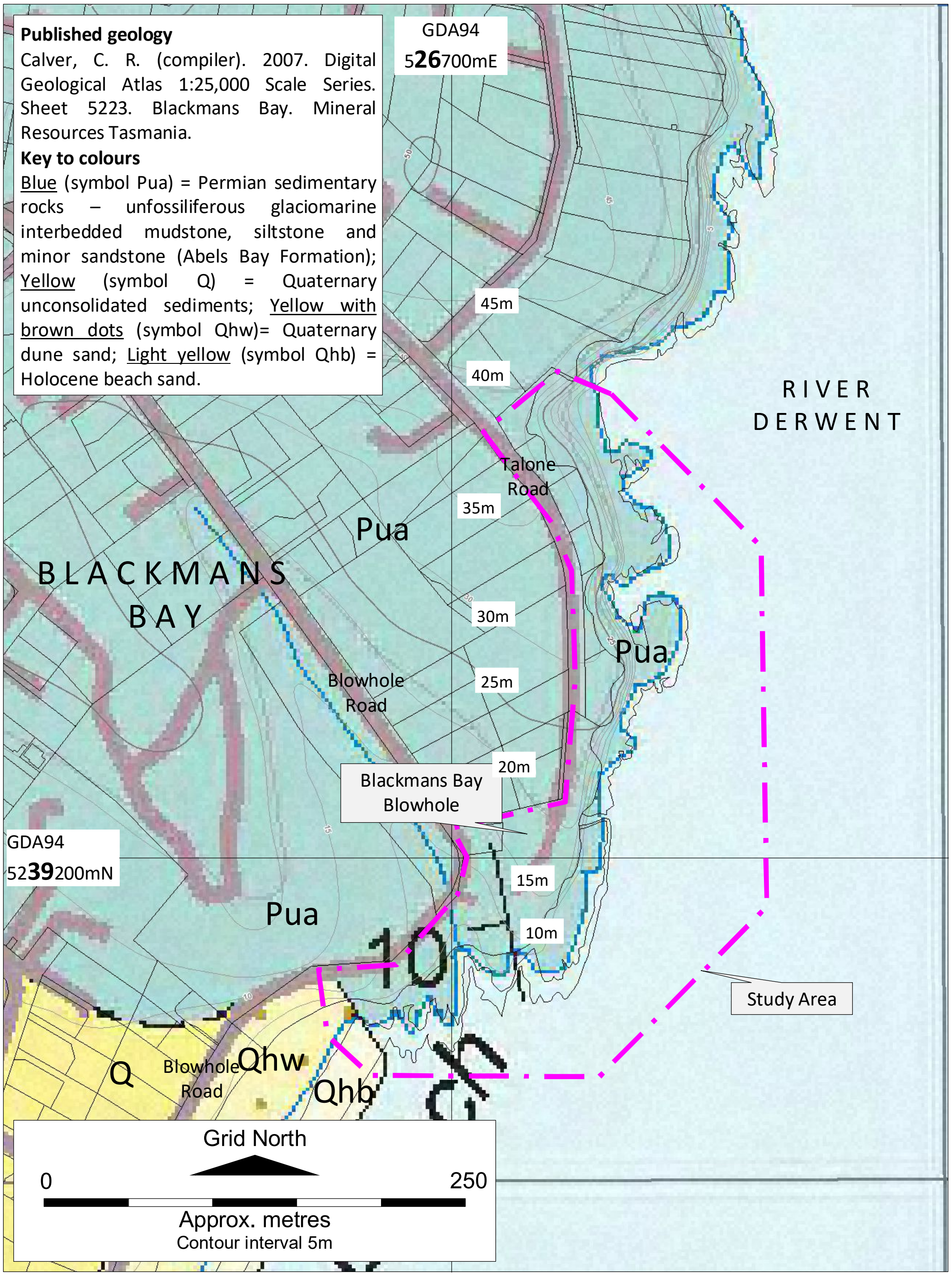
Location, cadastre, contours, aerial imagery, hill shading, published geology, and landslide, coastal erosion and coastal inundation hazard areas

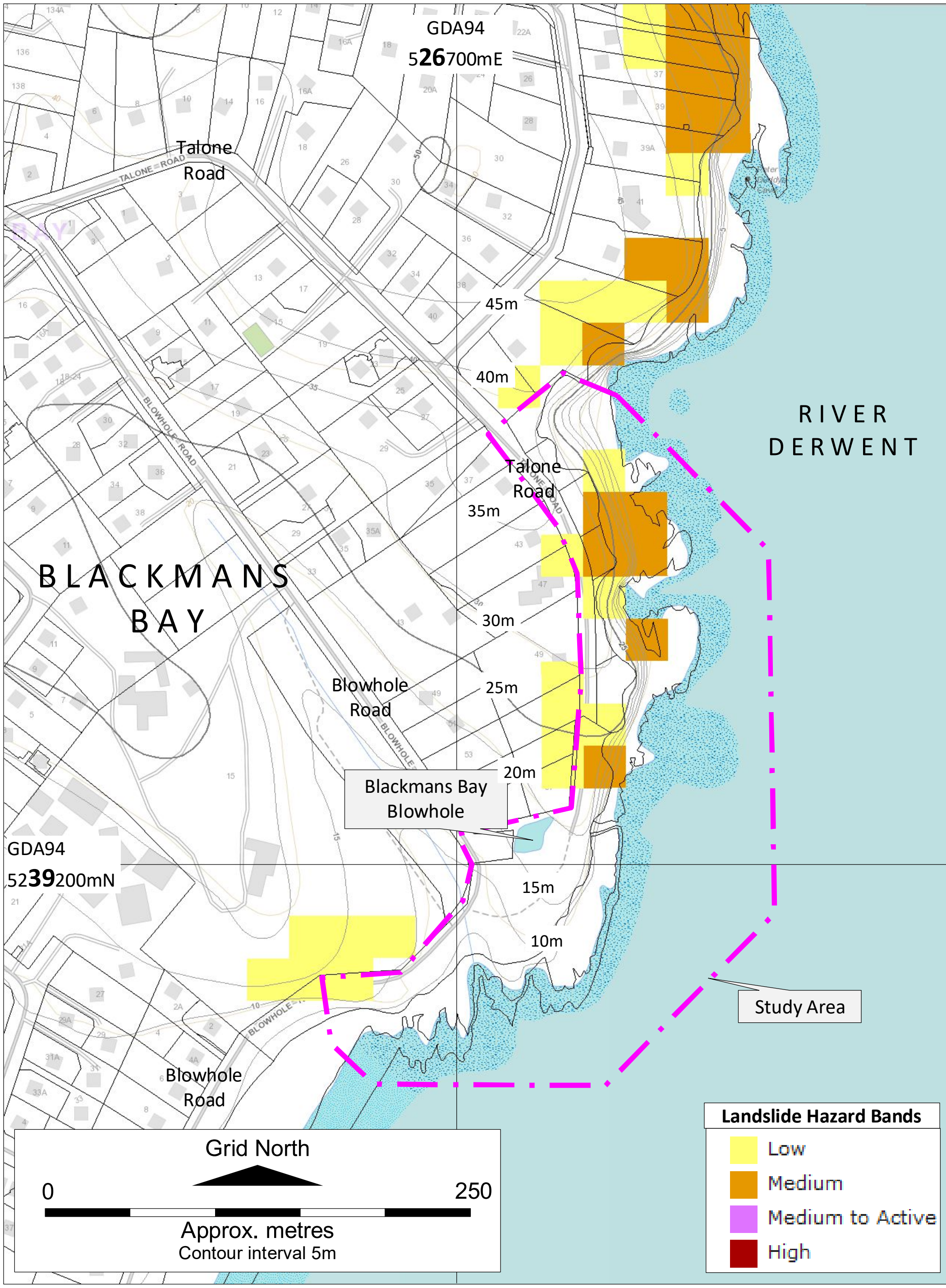
Source: www.thelist.tas.gov.au

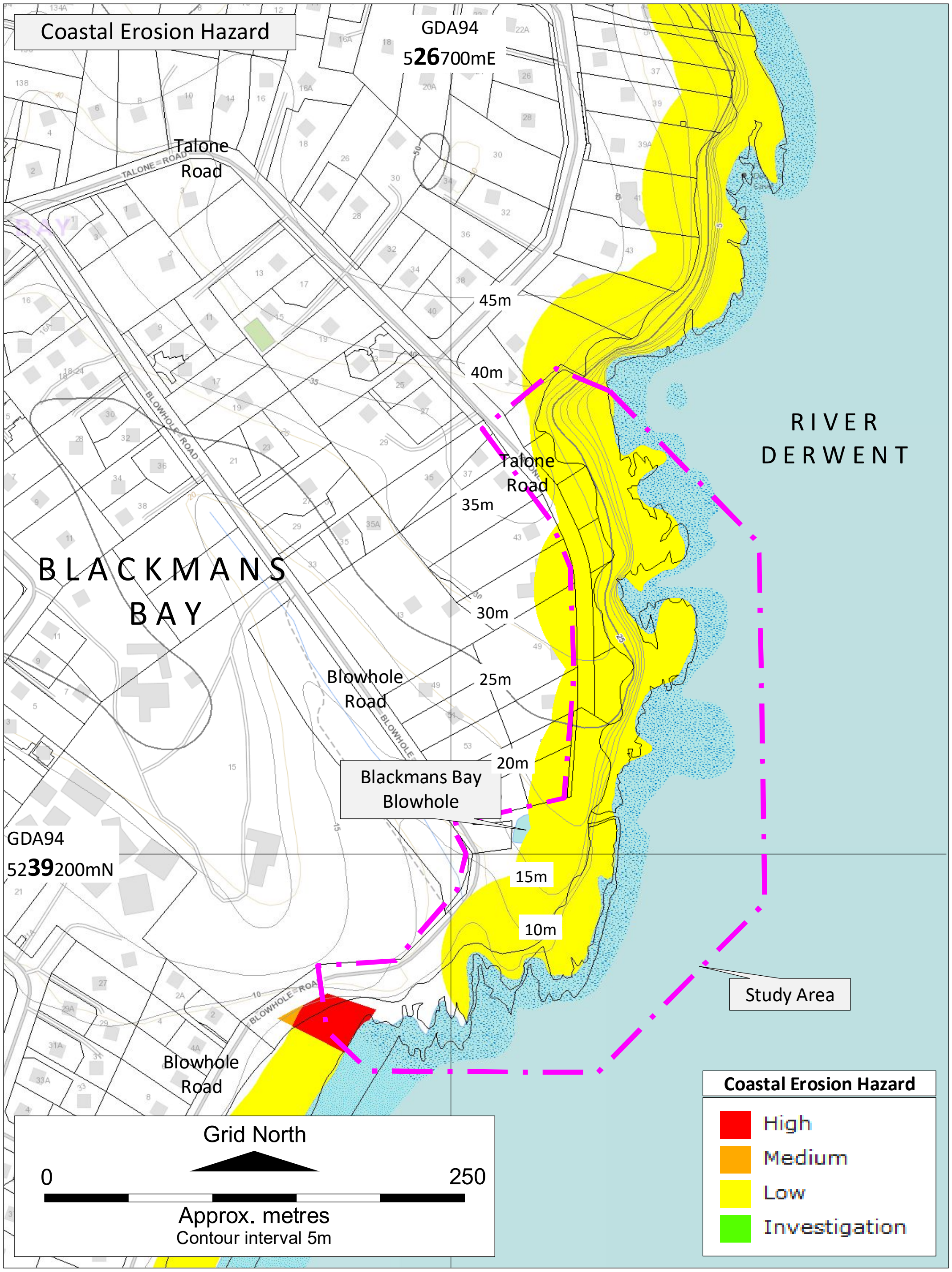


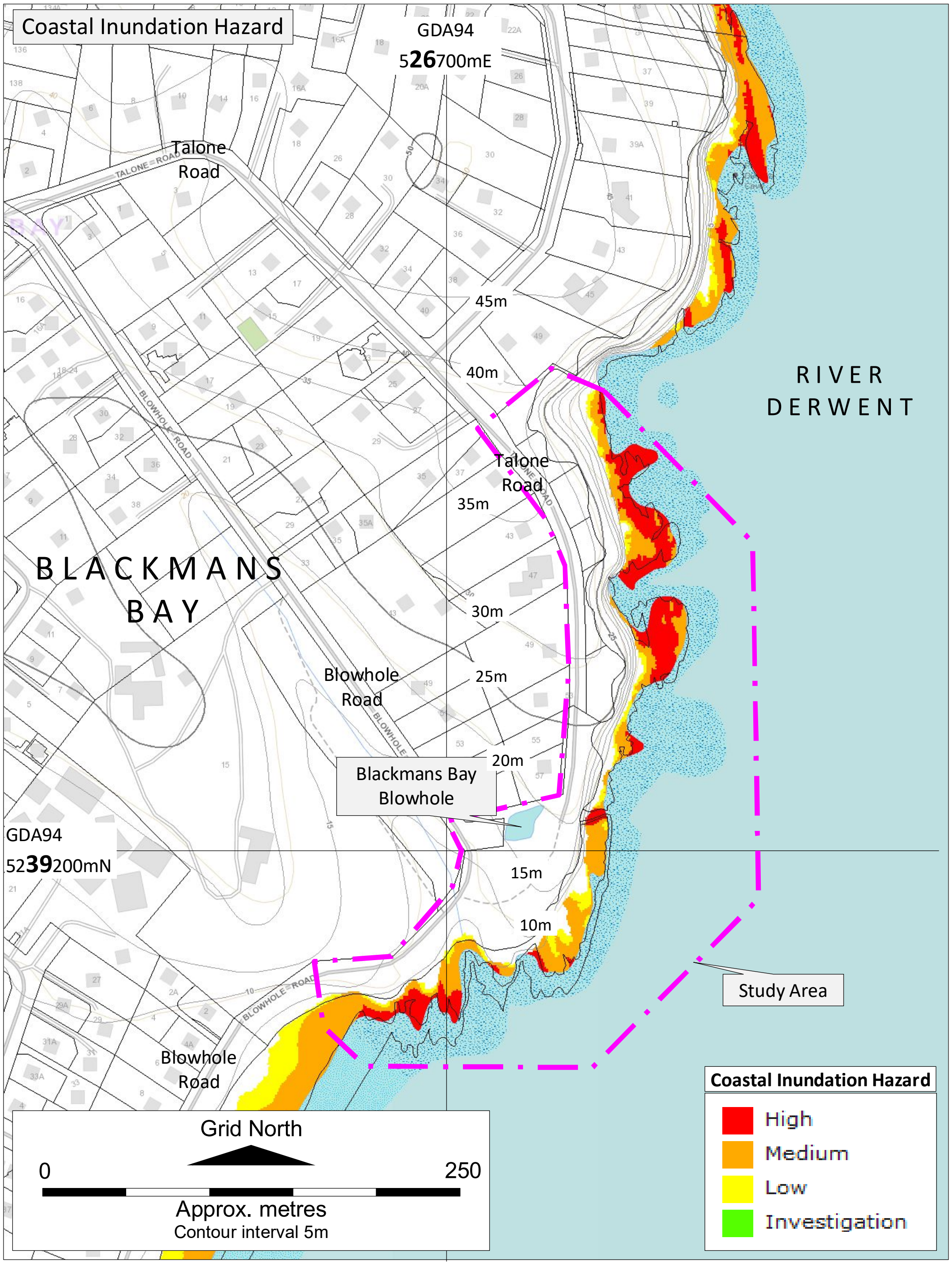

Aerial imagery
GDA94
526700mE
Talone Road
45m
40m
RIVER DERWENT
35m
BLACKMANS BAY
30m
25m
Blowhole Road
20m
Blackmans Bay Blowhole
GDA94
5239200mN
15m
10m
Study Area
Grid North
0
250
Approx. metres
Contour interval 5m

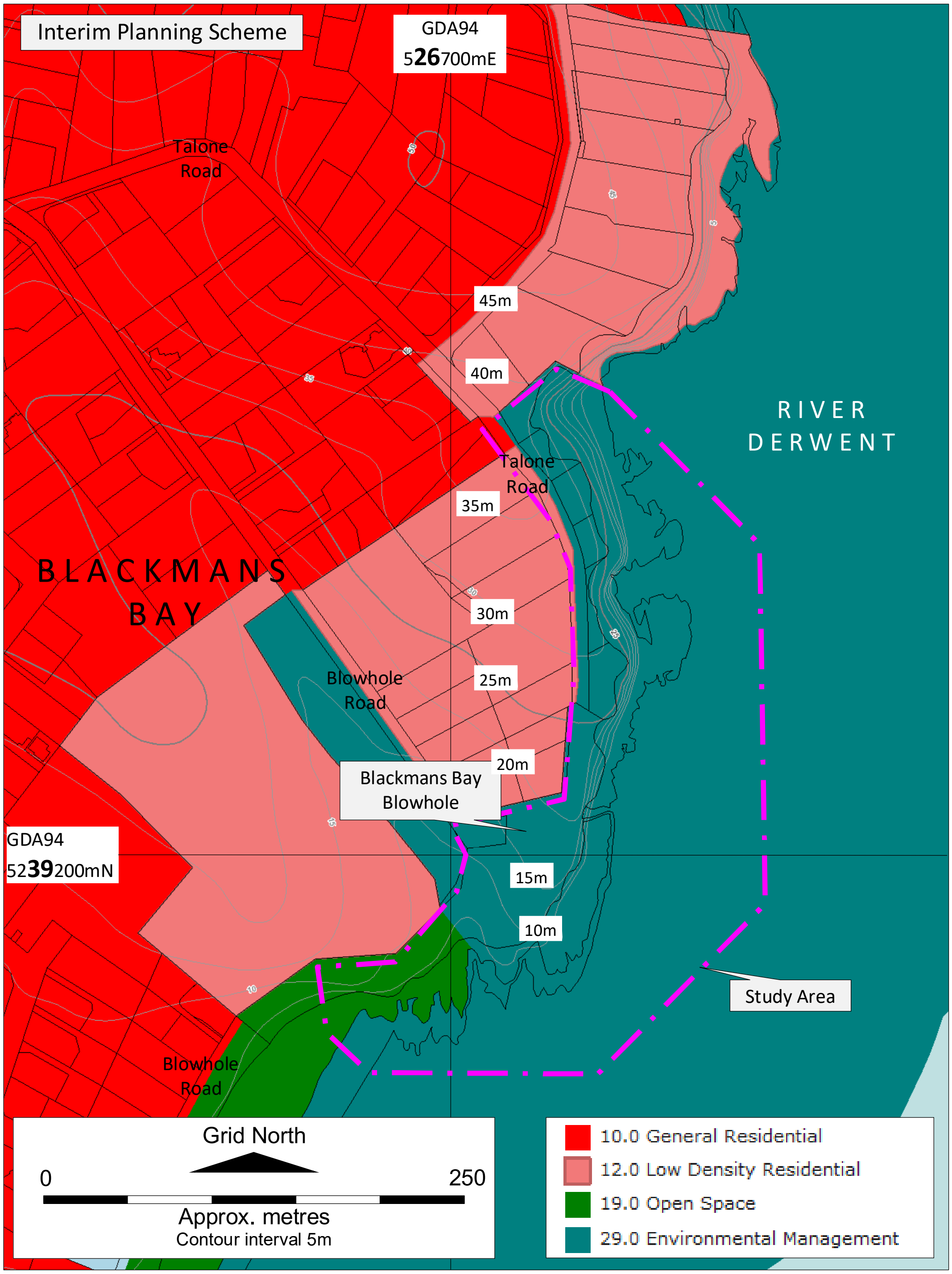

Hillshading (from NW)
GDA94
526700mE
Talone
Road
45m
40m
RIVER
DERWENT
Talone
Road
35m
BLACKMANS
BAY
30m
Blowhole
Road
25m
20m
Blackmans Bay
Blowhole
GDA94
5239200mN
15m
10m
Study Area
Blowhole
Road
Grid North
0
250
Approx. metres
Contour interval 5m


Published geology
Calver, C. R. (compiler). 2007. Digital Geological Atlas 1:25,000 Scale Series. Sheet 5223. Blackmans Bay. Mineral Resources Tasmania.
Key to colours
Blue (symbol Pua) = Permian sedimentary rocks – unfossiliferous glaciomarine interbedded mudstone, siltstone and minor sandstone (Abels Bay Formation); Yellow (symbol Q) = Quaternary unconsolidated sediments; Yellow with brown dots (symbol Qhw)= Quaternary dune sand; Light yellow (symbol Qhb) = Holocene beach sand.
GDA94
526700mE
45m
40m
RIVER
DERWENT
Talone
Road
35m
Pua
BLACKMANS
BAY
30m
Pua
Blowhole
Road
25m
20m
Blackmans Bay
Blowhole
GDA94
5239200mN
15m
Pua
10m
10
Study Area
Q
Blowhole
Road
Qhw
Qhb
Grid North
0
250
Approx. metres
Contour interval 5m


GDA94
526700mE
GDA94
5239200mN
Talone Road
Talone Road
Blowhole Road
Blowhole Road
BLACKMANS BAY
RIVER DERWENT
Blackmans Bay Blowhole
Study Area
45m
40m
35m
30m
25m
20m
15m
10m
Landslide Hazard Bands
Low
Medium
Medium to Active
High
Grid North
0
250
Approx. metres
Contour interval 5m


Coastal Erosion Hazard
GDA94
526700mE
GDA94
5239200mN
Talone Road
Talone Road
Blowhole Road
Blowhole Road
BLACKMANS BAY
RIVER DERWENT
Blackmans Bay Blowhole
Study Area
45m
40m
35m
30m
25m
20m
15m
10m
Grid North
0
250
Approx. metres
Contour interval 5m
Coastal Erosion Hazard
High
Medium
Low
Investigation


Coastal Inundation Hazard
GDA94
526700mE
Talone Road
45m
40m
RIVER
DERWENT
Talone Road
35m
BLACKMANS
BAY
30m
Blowhole Road
25m
20m
Blackmans Bay Blowhole
GDA94
5239200mN
15m
10m
Study Area
Blowhole Road
Grid North
0
250
Approx. metres
Contour interval 5m
Coastal Inundation Hazard
High
Medium
Low
Investigation


Interim Planning Scheme
GDA94
526700mE
Talone
Road
45m
40m
RIVER
DERWENT
Talone
Road
35m
BLACKMANS
BAY
30m
Blowhole
Road
25m
20m
Blackmans Bay
Blowhole
GDA94
5239200mN
15m
10m
Study Area
Blowhole
Road
Grid North
0
250
Approx. metres
Contour interval 5m
10.0 General Residential
12.0 Low Density Residential
19.0 Open Space
29.0 Environmental Management

Attachment 3

(3 pages)

Site photography

Hazard numbers correspond to those in Figures 4 and 5 in the report.

Drone imagery by Bill Cromer, 2 January 2020

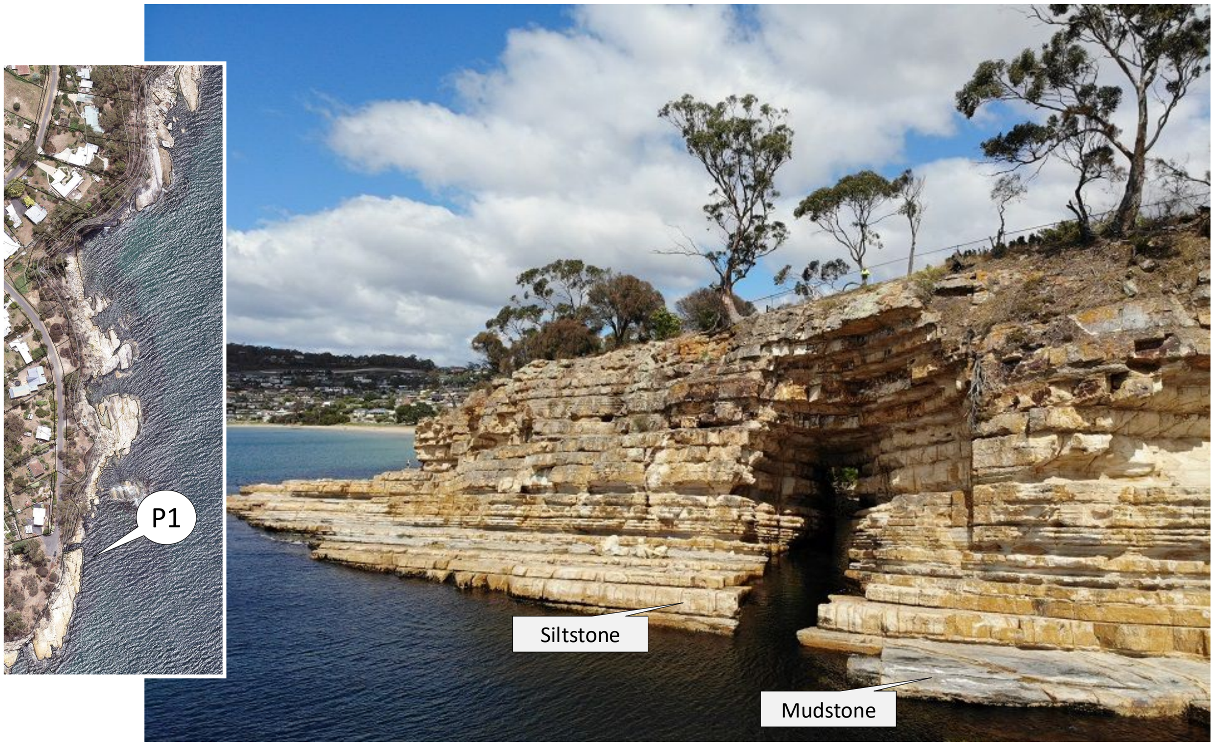
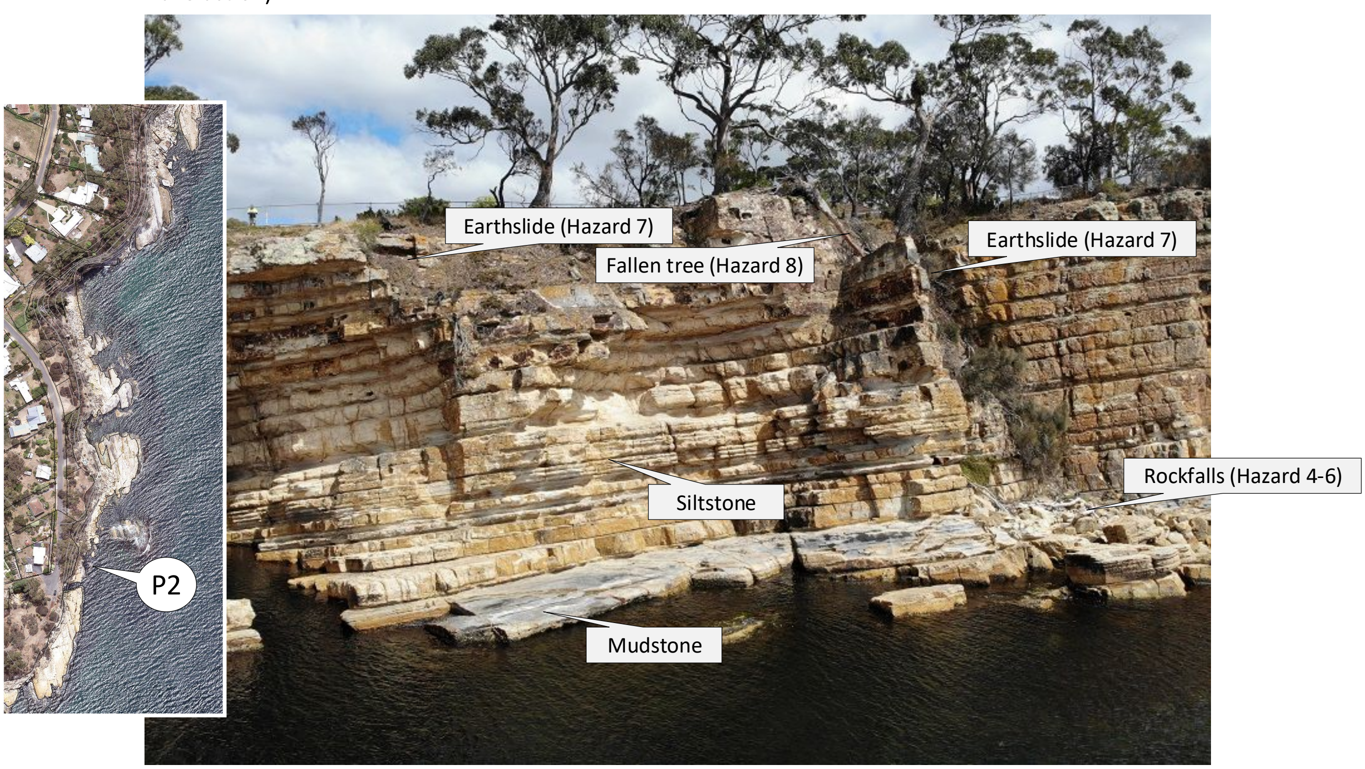


Plate 1 (above). View WSW towards the mouth of the Blackmans Bay Blowhole. The Permian sedimentary rocks dip at about 12^0 away from the camera. The shore platform is devoid of fallen rocks (removed by wave action).



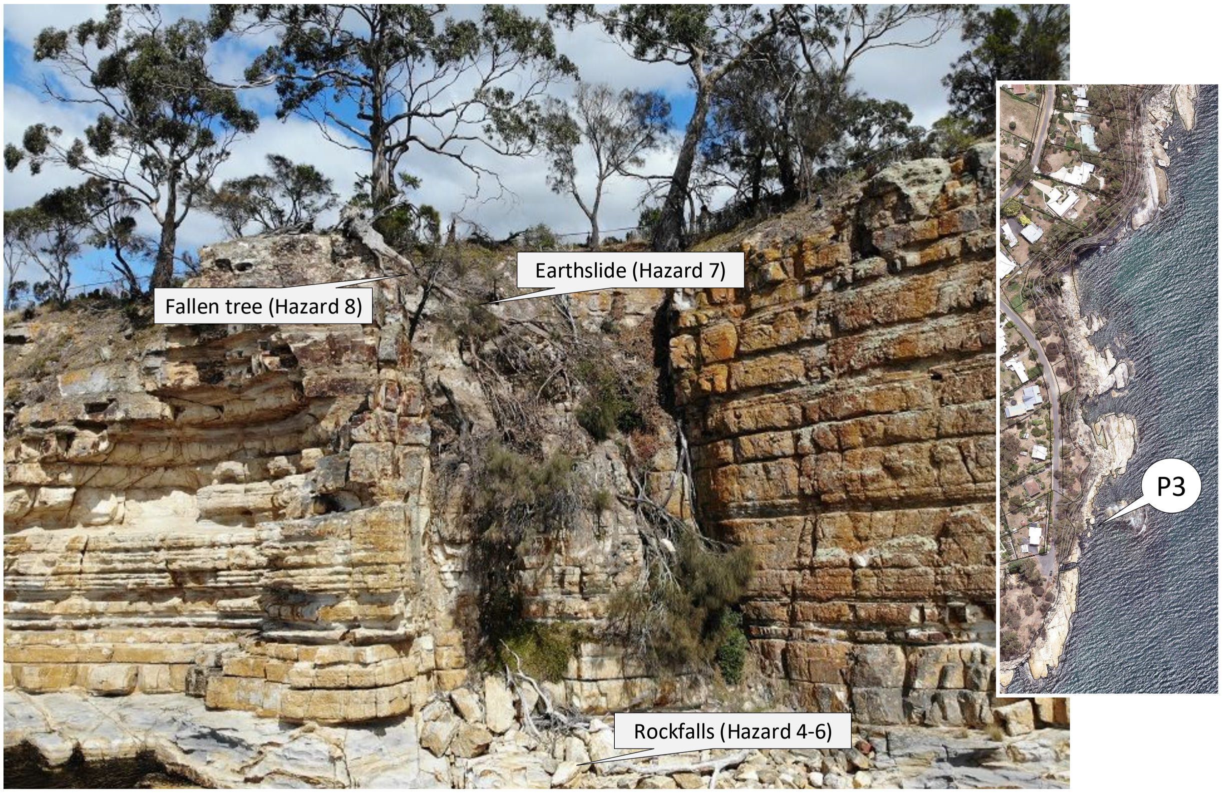
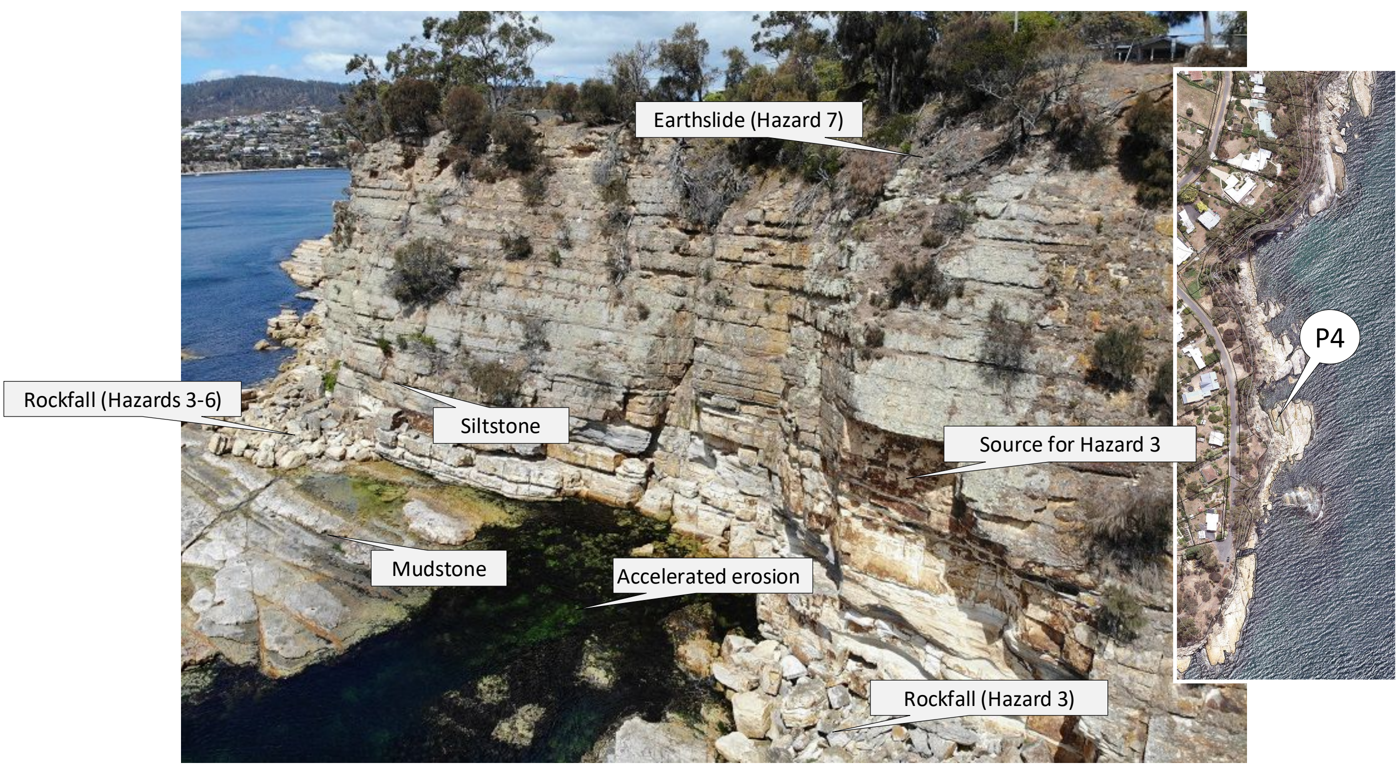


Plate 3 (above). View WSW towards a major set of subvertical joints trending in the same direction.

Plate 4 (below). View SSW. Note rockfalls, and accelerated marine erosion WSW along major joints



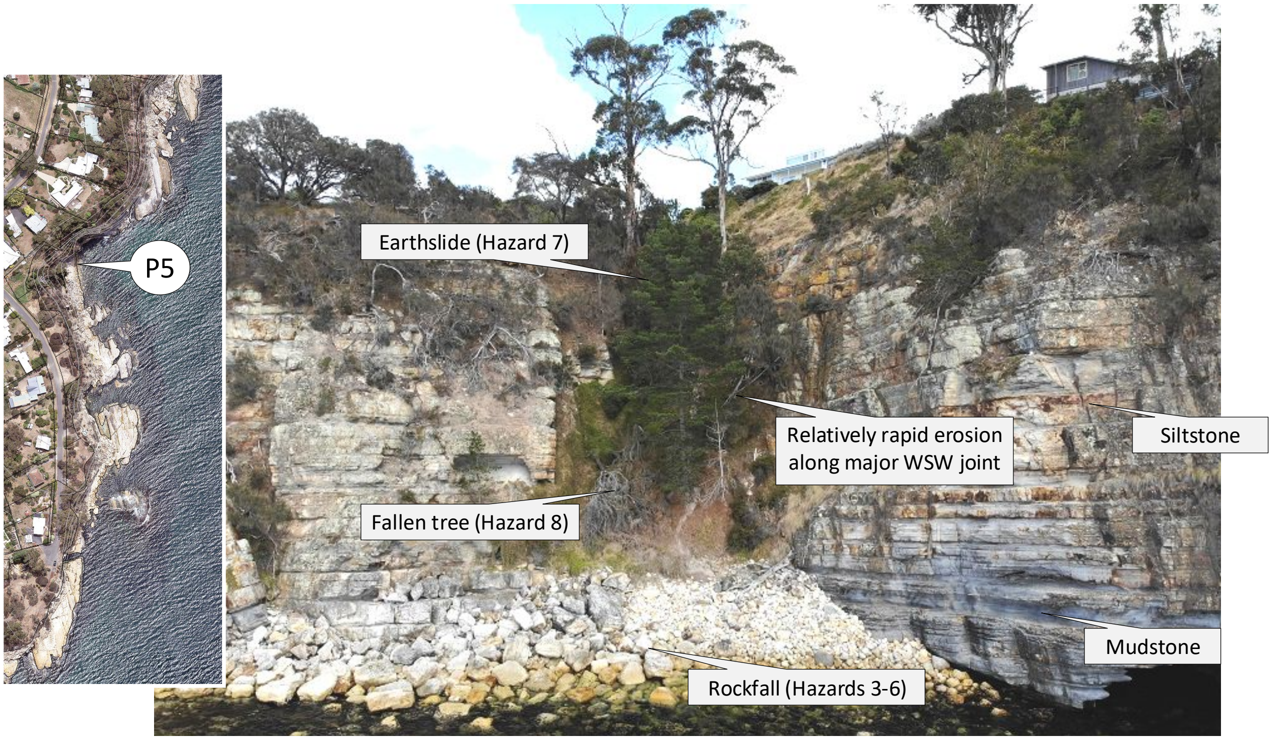
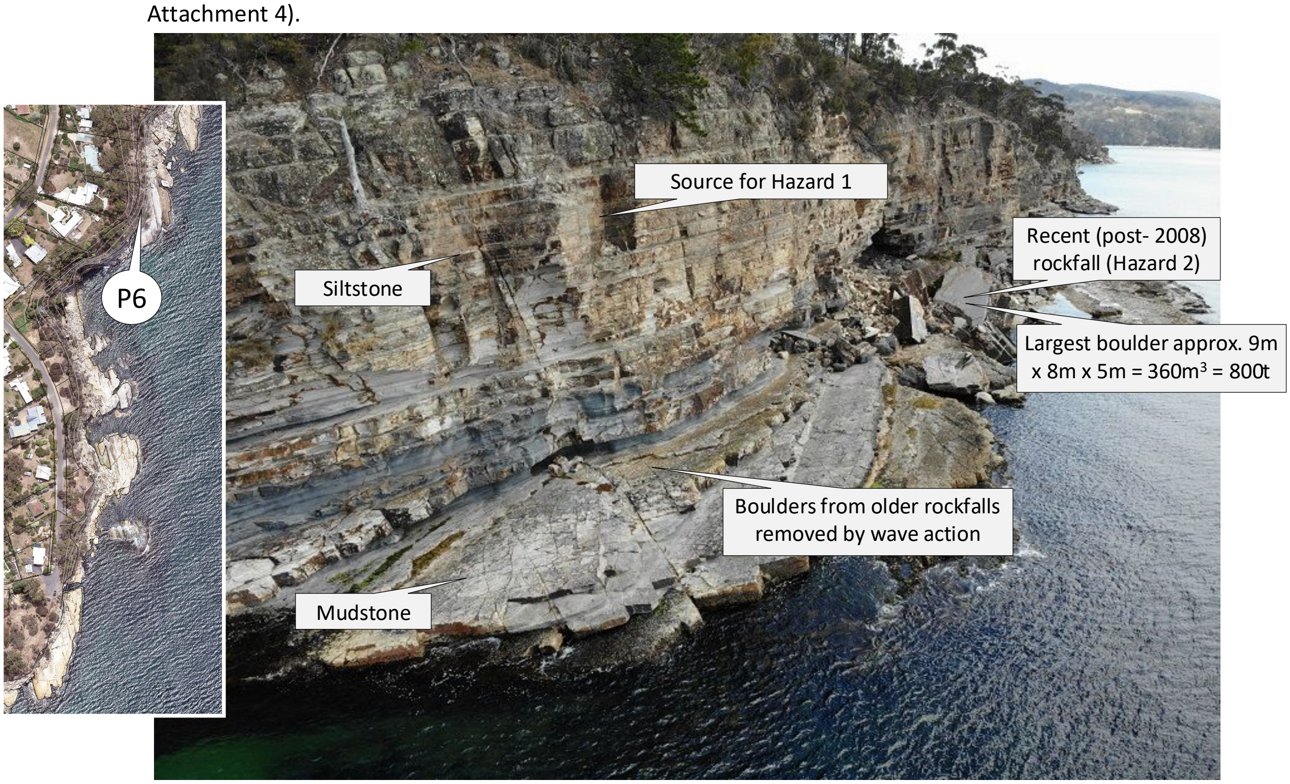


Plate 5 (above). View W towards a major set of subvertical joints trending WSW. Boulder (ie joint spacing) is smaller than elsewhere along the cliff line.

Plate 6 (below). View N. A major rock fall involving mostly mudstone occurred since March 2008 (see Attachment 4).



Attachment 4

(3 pages)

Comparative satellite imagery showing aspects of slope instability over 9.5 years

Hazard numbers correspond to those in Figures 4 and 5 in the report.

Source: Google Earth. Note varying angular distortion between images; tides and sun angles differ


2008, 31 March
2017, 13 November
Rockfall (Hazards 3-5)
Grid North
0
50
Approx. metres

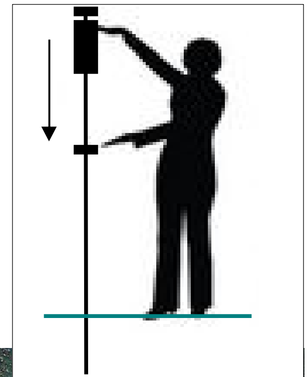

2008, 31 March
2017, 13 November
Rockfall (Hazard 2)
Largest boulder approx. 9m x 8m x 5m = 360m³ = 800t
Grid North
0
50
Approx. metres

Attachment 5

(7 pages)

Dynamic cone penetrometer (DCP) results

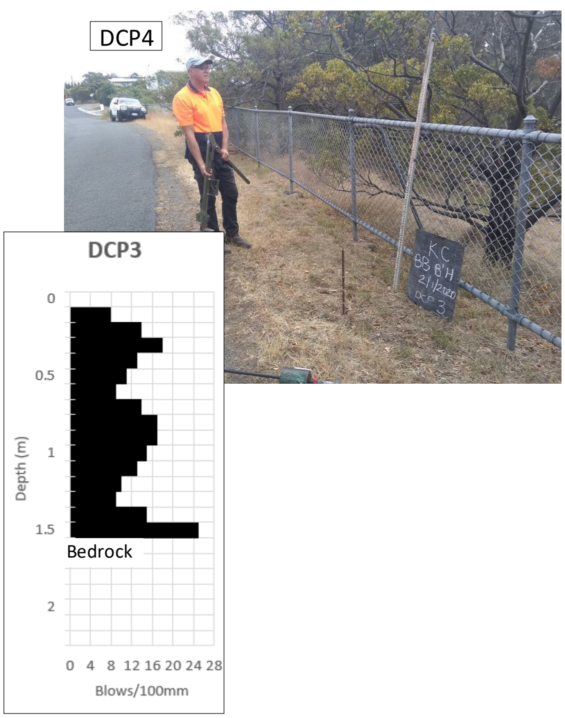
The Dynamic Cone Penetrometer (DCP) Test is a standard method of assessing the strengths of subsurface materials. A steel hammer weighing 9kg falls 510mm down a steel rod onto a stop, driving the rod (with a 20mm diameter steel cone tip) into the ground. The number of hammer blows to penetrate each 100mm of depth is recorded. The method is described in Australian Standard AS 1289.6.3.2 – 1997 Method 6.3.2: *Soil strength and consolidation tests – Determination of the penetration resistance of a soil – 9 kg dynamic cone penetrometer test.*

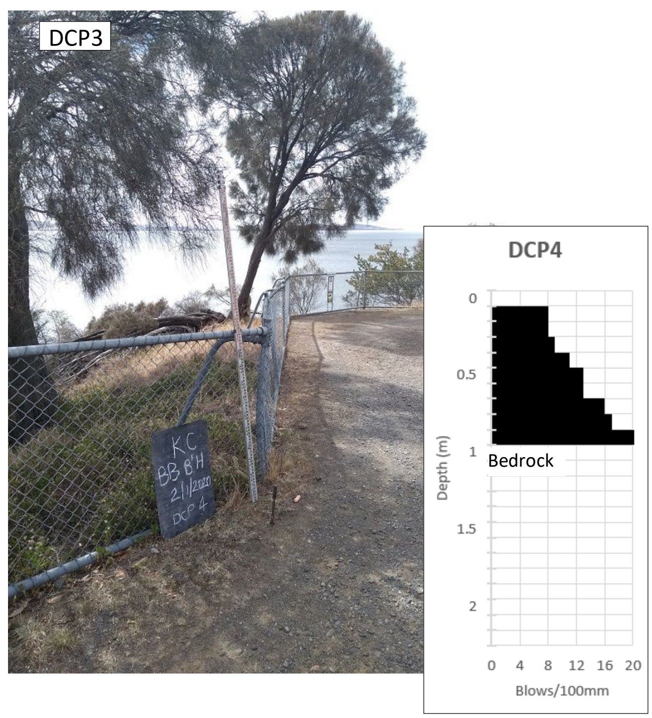


DCP locations are shown on the satellite image below. DCP profiles and site photographs are on the following five pages. Published correlations between DCP values and some soil properties are shown on Figure 4.1 (last page of this Attachment).

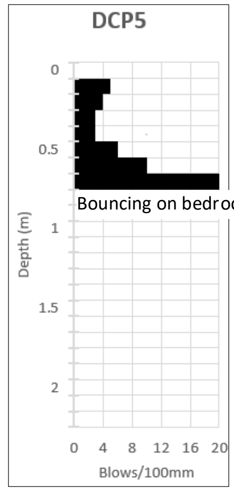

DCP1
DCP1
KC
BB B'H
21/1/2020
DCP 1
Depth (m)
0
0.5
1
1.5
2
Bouncing on bedrock
0 4 8 12 16 20
Blows/100mm


DCP2
DCP2
KC
BB B'H
Depth (m)
0
0.5
1
1.5
2
Bouncing on bedrock
0 4 8 12 16 20 24
Blows/100mm

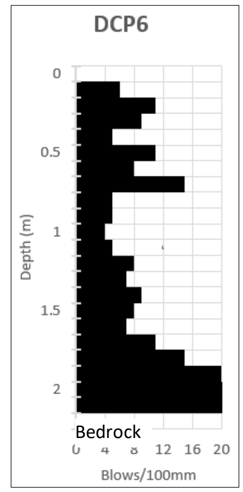

DCP4
DCP3
KC
Depth (m)
0
0.5
1
1.5
2
Bedrock
0 4 8 12 16 20 24 28
Blows/100mm


DCP3
DCP4
KC
BB B'H
Depth (m)
0
0.5
1
1.5
2
Bedrock
0 4 8 12 16 20
Blows/100mm

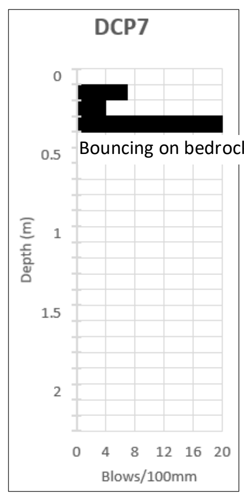

DCP5


DCP5
Bouncing on bedrock
Depth (m)
Blows/100mm

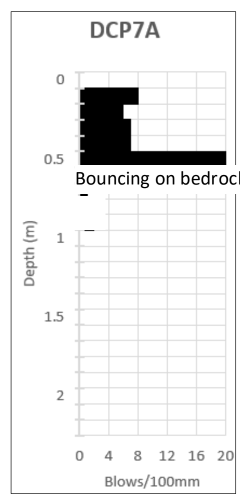

DCP6


DCP6
Bedrock
Depth (m)
Blows/100mm

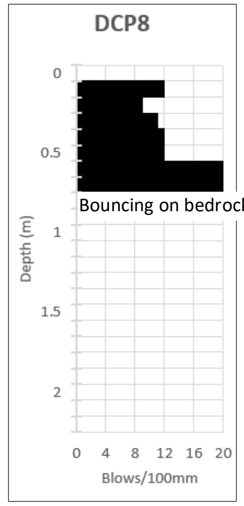

DCP7


DCP7
Bouncing on bedrock
Depth (m)
Blows/100mm

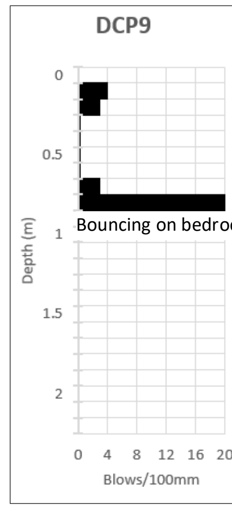

DCP7A


DCP7A
Bouncing on bedrock
Depth (m)
Blows/100mm

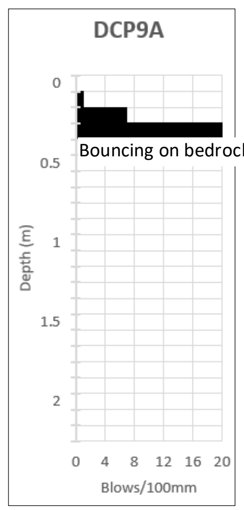

DCP8


DCP8
Depth (m)
0
0.5
1
1.5
2
Bouncing on bedrock
0 4 8 12 16 20
Blows/100mm

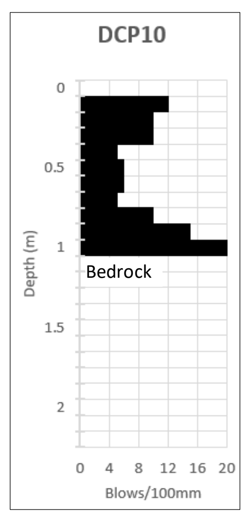

DCP9


DCP9
Depth (m)
0
0.5
1
1.5
2
Bouncing on bedrock
0 4 8 12 16 20
Blows/100mm

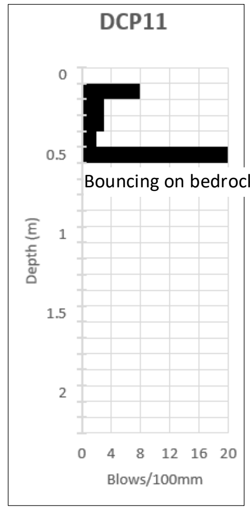

DCP9A


DCP9A
Depth (m)
0
0.5
1
1.5
2
Bouncing on bedrock
0 4 8 12 16 20
Blows/100mm

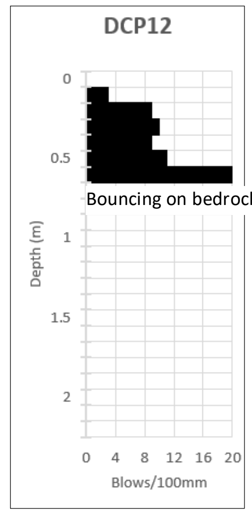

DCP10


DCP10
Depth (m)
0
0.5
1
1.5
2
Bedrock
0 4 8 12 16 20
Blows/100mm

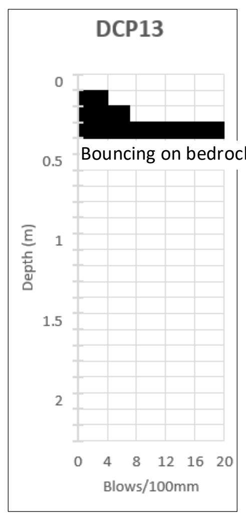

DCP11


DCP11
0
0.5
1
1.5
2
Depth (m)
Bouncing on bedrock
0 4 8 12 16 20
Blows/100mm

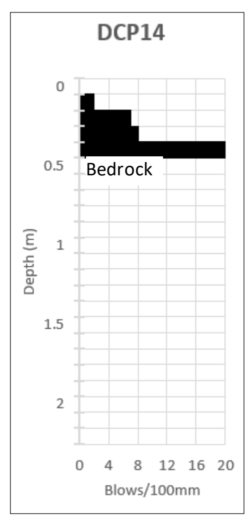

DCP12


DCP12
0
0.5
1
1.5
2
Depth (m)
Bouncing on bedrock
0 4 8 12 16 20
Blows/100mm

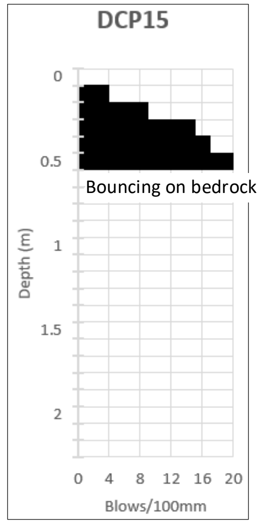

DCP13


DCP13
0
0.5
1
1.5
2
Depth (m)
Bouncing on bedrock
0 4 8 12 16 20
Blows/100mm

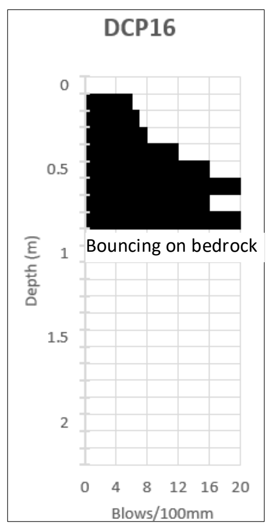

DCP14


DCP14
0
0.5
1
1.5
2
Depth (m)
Bedrock
0 4 8 12 16 20
Blows/100mm


DCP15
KC
BB B'H
21/1/2020


DCP15
0
0.5
1
1.5
2
Depth (m)
Bouncing on bedrock
0 4 8 12 16 20
Blows/100mm


DCP16
KC
BB B'H


DCP16
0
0.5
1
1.5
2
Depth (m)
Bouncing on bedrock
0 4 8 12 16 20
Blows/100mm

(a) Allowable bearing capacity from DCP results

Blows/100 mm	*Allowable bearing capacity (kPa)*	*Typical material*
≤1	≤50 kPa	Very soft to soft clays, very loose sands
1–2	50–100 kPa	Firm clays, loose sands
2–5	100–200 kPa	Stiff clays, medium dense sands
6–9	200–400 kPa	Very stiff clays, medium dense to dense sands
≥10	>400 kPa	Hard clays, dense to very dense sands

Reference: Look, B. (2014). Handbook of Geotechnical Investigation and Design Tables (2nd edition). CRC Press. The Netherlands. Table 5.15. The Table applies to shallow footings. Factor of Safety =3. For high and low plasticity clays the allowable bearing capacity may be lower and higher, respectively.

(b) Soil and rock parameters from DCP results

Material	*Description*	*DCP – n (blows/100 mm)*	*Strength*
Clays	V. soft	0–1	C_u = 0–12 kPa
	Soft	0–1	C_u = 12–25 kPa
	Firm	1–2	C_u = 25–50 kPa
	Stiff	2–5	C_u = 50–100 kPa
	V. stiff	6–9	C_u = 100–200 kPa
	Hard	>10	C_u > 200 kPa
Sands	V. loose	0–1	$\phi < 30°$
	Loose	1–3	$\phi = 30–35°$
	Med dense	3–8	$\phi = 35–40°$
	Dense	8–15	$\phi = 40–45°$
	V. dense	>15	$\phi > 45°$
Gravels, cobbles, boulders*		>10	$\phi = 35°$
		>20	$\phi > 40°$
Rock		>10	$c' = 25$ kPa, $\phi > 30°$
		>20	$c' > 50$ kPa, $\phi > 30°$

*Lowest value applies, erratic and high values are common in this material.

- The Dynamic Cone Penetrometer (DCP) is 1/3 the energy of the SPT, but the shape of the cone results in less friction than the Split Spoon of the SPT.
- $n \sim 1/3(N_o)_{60}$ used in the Table below. Due to easier penetration of cone, then nominally less than converted n-values shown for clay strength classification
- The top 0.5 m to 1.0 m of most clay profiles can have a lower DCP value and is indicative of the depth of the desiccation cracks.

Reference: Look, B. (2014). Handbook of Geotechnical Investigation and Design Tables (2nd edition). CRC Press. The Netherlands. Table 5.11.

(c) CBR values from DCP results

Blows/100 mm	*mm/blow*	*In situ CBR (%)*
<1	>100 mm	<2%
1–2	100–50 mm	2–4%
2–3	50–30 mm	4–6 %
3–5	30–20 mm	6–10%
5–7	20–15 mm	10–15%
7–10	15–10 mm	15–25%
10–15	10–7 mm	25–35%
15–20	7–5 mm	35–50%
20–25	5–4 mm	50–60%
>25	<4 mm	>60%

- The DCP is often used for the determination of the in situ CBR.
- Various correlations exist depending on the soil type. A site specific correlatic should be carried out where possible.
- The correlation is not as strong for values ≥ 10 blows/100 mm (10 mm/blow i.e. CBR > 20%.

Reference: Look, B. (2014). Handbook of Geotechnical Investigation and Design Tables (2nd edition). CRC Press. The Netherlands. Table 5.13.

Figure 5.1. Published correlations between DCP values and some soil properties

Attachment 6

(13 pages)

Landslide Risk Management

This Attachment addresses slope stability issues (rockfall/topple, landslide and tree falls) for Hazards 1 – 8 described in Section 3 of the report. Hazard locations are along and adjacent to the sea cliff in the study area depicted in Attachment 2. This Attachment is in accordance with Australian Geomechanics Society (AGS) *Landslide Risk Management* (2007)[9]. The process is depicted in Figure 6.1. The main types of landslide movement are shown in Figure 6.2 and Table 6.1.

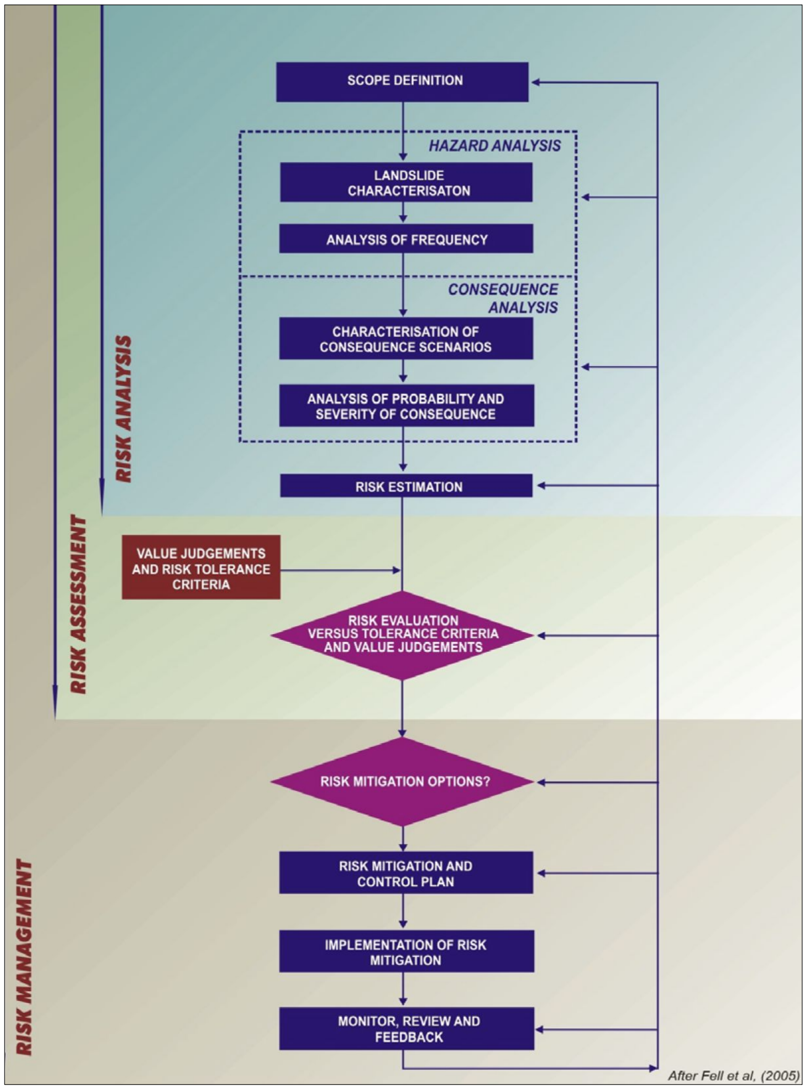


Figure 6.1. Framework for Landslide Risk Management

Source: Reproduced without amendment from AGS (2007a). Guideline for Landslide Susceptibility, Hazard and Risk Zoning. Australian Geomechanics, Vol 42 No 1 March 2007

[9] The five AGS documents are:
AGS (2007a). Guideline for Landslide Susceptibility, Hazard and Risk Zoning. Australian Geomechanics, Vol 42 No 1 March 2007
AGS (2007b). Commentary on Guideline for Landslide Susceptibility, Hazard and Risk Zoning. Australian Geomechanics, Vol 42 No 1 March 2007
AGS (2007c). Practice Notes Guidelines for Landslide Risk Management. Australian Geomechanics Vol 42 No 1 March 2007
AGS (2007d). Commentary on Practice Notes Guidelines for Landslide Risk Management. Australian Geomechanics Vol 42 No 1 March 2007
AGS (2007e). The Australian Geoguides for Slope Management and Maintenance. Australian Geomechanics Vol 42 No 1 March 2007

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

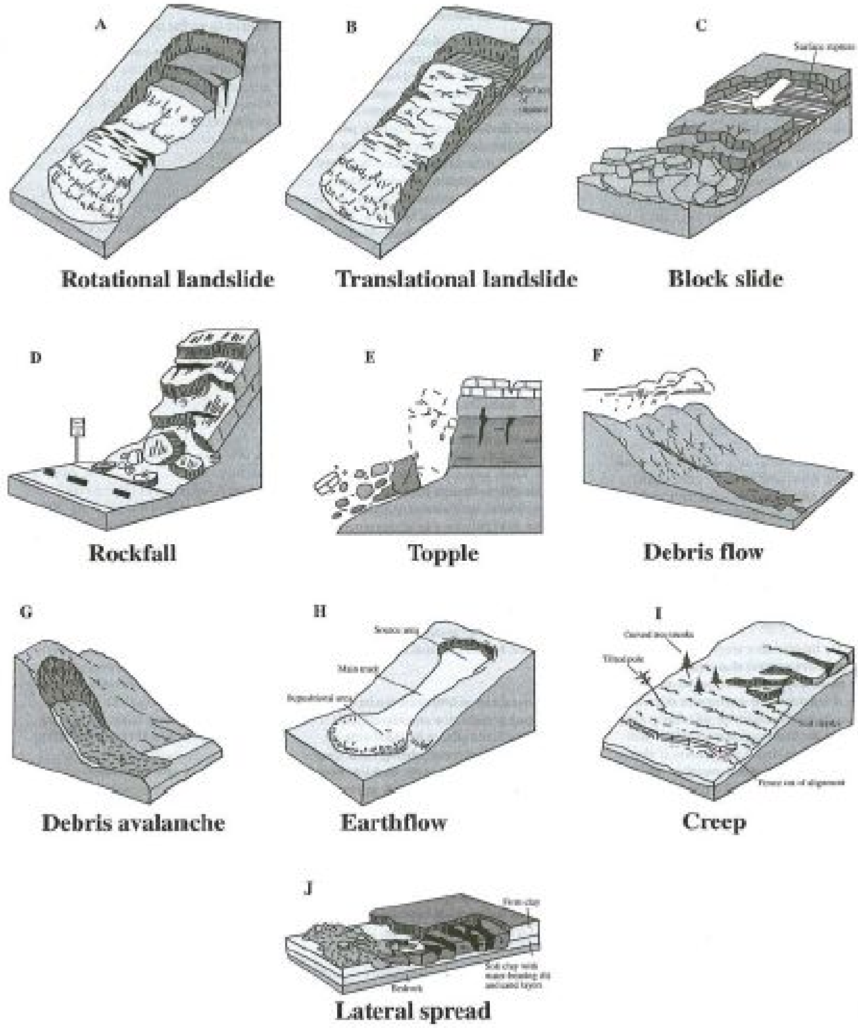


Figure B1: These schematics illustrate the major types of landslide movement.
(From US Geological Survey Fact Sheet 2004-3072, July 2004, with kind permission for reproduction.)

The nomenclature of a landslide can become more elaborate as more information about the movement becomes available. To build up the complete identification of the movement, descriptors are added in front of the two-term classification using a preferred sequence of terms. The suggested sequence provides a progressive narrowing of the focus of the descriptors, first by time and then by spatial location, beginning with a view of the whole landslide, continuing with parts of the movement and finally defining the materials involved. The recommended sequence, as shown in Table B2, describes activity (including state, distribution and style) followed by descriptions of all movements (including rate, water content, material and type). Definitions of the terms in Table B2 are given in Cruden & Varnes (1996).

Figure 6.2 Main types of landslide movement

Source: From Appendix B of AGS (2007c). Practice Notes Guidelines for Landslide Risk Management. Australian Geomechanics Vol 42 No 1 March 2007

Table 6.1 Main types of landslide movement

Source: From Appendix B of AGS (2007c). Practice Notes Guidelines for Landslide Risk Management. Australian Geomechanics Vol 42 No 1 March 2007

TYPE OF MOVEMENT		TYPE OF MATERIAL		
		BEDROCK	ENGINEERING SOILS	
			Predominantly Coarse	Predominantly Fine
FALLS		Rock fall	Debris fall	Earth fall
TOPPLES		Rock topple	Debris topple	Earth topple
SLIDES	ROTATIONAL	Rock slide	Debris slide	Earth slide
	TRANSLATIONAL			
LATERAL SPREADS		Rock spread	Debris spread	Earth spread
FLOWS		Rock flow (Deep creep)	Debris flow	Earth flow
			(Soil creep)	
COMPLEX	Combination of two or more principle types of movement			

LANDSLIDE RISK MANAGEMENT (LRM)

6.1 Preliminary

6.1.1 Desktop review of slope instability

A review of the Mineral Resources Tasmania landslide map and database revealed no known and catalogued instances of slope instability in or adjacent to the study area.

Attachment 2 shows the parts of the cliff line are in the Low and Medium Landslide Hazard Bands[10].

6.1.2 Field evidence and mechanisms/triggers of slope instability

<u>Rockfalls and topples</u>

Rockfalls and rock topples are the main forms of slope instability in the study area. Aerial and satellite imagery shows the foreshore is locally littered with rock debris. All sizes are involved, from failures involving single rock fragments weighing less than a kilogram, to individual cobbles weighing a few tens of kilograms, to individual boulders weighing several tonnes, to composite falls of thousands of well-graded rock material or boulders collectively involving hundreds of tonnes. Examples are shown in the photographs in Attachments 3 and 4.

<u>Earth slides</u>

Very small to small earth slides involving only the soil profile are evident at several locations along the cliff line. Most are focussed where major joints trend WSW, and some extend down the cliff face (Attachment 3).

Mechanisms for rockfalls/topples are primarily gravity-induced movements on bedding surfaces, joints and other defects, caused by slow weakening or erosion of fine particles by physical and chemical weathering by wind and water. Triggers for movement are related to the frequency and intensity of rain events, and less commonly to earthquake vibrations. The earthslides move over bedrock, and are triggered also mainly by rain.

6.1.3 Site plans and maps

Site plans and maps are included in Attachments to this report.

[10] Landslide Hazard Bands are computer-generated models from published geology at various scales and slope angles. Individual pixels on hazard band maps may be the size of a house or larger. The banding may need to be amended after site inspection.

6.2 Site sections and conceptual geological models

Conceptual geological cross sections are presented in Figures 5 and 6 in the report, at the locations shown in Figure 7.

6.3 Hazard Analysis

6.3.1 Hazard characterisation

As summarised in Section 3.1.2, three types of geotechnical hazards are identified in the study area, and are shown in Figures 5 and 6:

- Hazards 1 – 6 are rockfalls/topples involving different volumes of material – from failures of hundreds of tonnes (Hazards 1 and 2), to individual small boulders weighing a few kilograms (Hazard 6)[11]. Examples of these hazards are depicted in Plates 2 – 6 in Attachment 3, and in Attachment 4.
- Hazard 7 are very small landslides (earthslides[12]) from at or near the top of the sea cliffs, involving failure of the soil profile. Examples are shown in Plates 2, 3 and 5 in Attachment 3.
- Hazard 8 are tree and limb falls. Examples are depicted in Plates 2, 3 and 5 in Attachment 3.

The hazards are characterised as follows:

Scenario 1: Rockfall/rock topple
Small scale; in siltstone and sandstone, from any part of the cliff face; extremely rapid; involving a width of cliff face of at least 20m.

Scenario 2: Rockfall/rock topple
Small scale; in mudstone, from the lower parts of the cliff face; extremely rapid; involving a width of cliff face of at least 20m.

Scenario 3: Rockfall/rock topple
Very small scale; in siltstone, sandstone or mudstone, from any part of the cliff face; extremely rapid; involving one or more boulders over a width of cliff face of at least 5m.

Scenario 4: Rockfall/rock topple
Very small scale; in siltstone, sandstone or mudstone, from any part of the cliff face; extremely rapid; involving one or more boulders over a width of cliff face of at least 1m.

Scenario 5: Rockfall/rock topple
Very small scale; in siltstone, sandstone or mudstone, from any part of the cliff face; extremely rapid; involving one or more boulders over a width of cliff face of at least 0.5m.
.

Scenario 6: Rockfall/rock topple
Very small scale; in siltstone, sandstone or mudstone, from any part of the cliff face; extremely rapid; involving a single boulders (joint fragment) up to 0.1m in diameter.

Scenario 7: Earthslide
Very small scale landslide, from at or near cliff top, up to 5m wide and less than about 2m^3 in volume; extremely rapid.

Scenario 8: Tree or tree limb fall
Very small scale, from at or near cliff top, with a downslope affected zone up to about 5m wide; extremely rapid.

[11] The inset Tables on Figures 5 and 6 define landslide size and speed. Even rockfalls of hundreds of tonnes are "small".
[12] Earthslides are landslides involving mostly soil, with only minor proportions of rock.

Note that the nominal boulder sizes of Scenarios 1 – 6 are observable in the study area. The sizes chosen are intended as examples only, and any size could of course be represented.

6.3.2 Frequency analysis

Table 6.2 lists the subjective likelihood of occurrence of the scenarios shown in Figures 5 and 6 under current conditions. Terminology for measures of likelihood are explained in Attachment 7.

6.3.3 Elements at risk

Elements at risk for Scenarios 1 – 8 include sightseers, recreational walkers along the top and base of the cliff, abseiling individuals and groups, kayakers, swimmers and cliff jumpers.

It is envisaged that no rockfall/topple or any other form of landslide can credibly involve occupants of houses on the western side of Talone Road, or pedestrians and occupants of vehicles on the road.

Table 6.2 Evidence for and subjective likelihood of occurrence of Scenarios 1 – 8.

<table>
<tr><th></th><th>1</th><th>2</th><th>3</th></tr>
<tr><th></th><th>Scenario</th><th>Field Evidence</th><th>Current likelihood</th></tr>
<tr><td>1</td><td>Rockfall/rock topple
Small scale; in siltstone and sandstone, from any part of the cliff face; extremely rapid; involving a width of cliff face of at least 20m.</td><td>At least one source identified northeast of study area (see Plate 6 in Attachment 3)</td><td>Possible</td></tr>
<tr><td>2</td><td>Rockfall/rock topple
Small scale; in mudstone, from the lower parts of the cliff face; extremely rapid; involving a width of cliff face of at least 20m.</td><td>One recent (<20 year old) example identified northeast of study area (see Plate 6 in Attachment 3)</td><td>Likely</td></tr>
<tr><td>3</td><td>Rockfall/rock topple
Very small scale; in siltstone, sandstone or mudstone, from any part of the cliff face; extremely rapid; involving one or more boulders over a width of cliff face of at least 5m.</td><td rowspan="4">Within study area, at least one source identified (see Plate 4 in Attachment 3), and the results of many rockfalls/topples are the range of boulder sizes observed on shore platform (see Plates 3-6 in Attachment 3, and Attachment 4)</td><td>Almost Certain to Likely</td></tr>
<tr><td>4</td><td>Rockfall/rock topple
Very small scale; in siltstone, sandstone or mudstone, from any part of the cliff face; extremely rapid; involving one or more boulders over a width of cliff face of at least 1m.</td><td rowspan="5">Almost Certain</td></tr>
<tr><td>5</td><td>Rockfall/rock topple
Very small scale; in siltstone, sandstone or mudstone, from any part of the cliff face; extremely rapid; involving one or more boulders over a width of cliff face of at least 0.5m.</td></tr>
<tr><td>6</td><td>Rockfall/rock topple
Very small scale; in siltstone, sandstone or mudstone, from any part of the cliff face; extremely rapid; involving a single boulder (joint fragment) up to 0.1m in diameter.</td></tr>
<tr><td>7</td><td>Earthslide
Very small scale landslide, from at or near cliff top, up to 5m wide and less than about 2m3 in volume; extremely rapid, moist to wet, suspended to active</td><td>Several examples observed at and near cliff top along full length of study area (see Plates 2, 3 and 5 in Attachment 3)</td></tr>
<tr><td>8</td><td>Tree or tree limb fall
Very small scale fallen tree and/or limb, from at or near cliff top, with a downslope affected zone up to about 5m wide; extremely rapid.</td><td>Several examples observed at and near cliff top along full length of study area (see Plates 2, 3 and 5 in Attachment 3)</td></tr>
</table>

Notes
Column 1: refer to cross sections (Figures 4 and 5 in report) for explanations of size and speed.
Note definition of size is not from AGS2007c.
Column 3: refer to Attachment 7 for an explanation of Likelihood terms.

6.4 Consequence analysis and qualitative risk to property estimation

Table 6.3 is a consequence analysis and risk to property (assets) assessment for the eight scenarios in Figures 5 and 6. The assets are Talone Road and the fence along the top of the cliff line. There are no assets on or along the base of the cliff line.

Current subjective risk to assets is judged to be Low for Scenarios 1 and 8.

No risk treatment is recommended for any Scenario.

Table 6.3 Likelihood, consequence and qualitative risk analysis of Scenarios 1 – 8. Risks to infrastructure are Low for all hazards.

	1	2	3	4	5	6
	Scenario (Existing conditions)	**Likelihood of occurrence**	**Consequence to assets**	**Level of risk to assets above and behind**	**Level of risk to assets below**	**Recommended risk treatment**
1	**Rockfall/rock topple** Small scale; in siltstone and sandstone, from any part of the cliff face; extremely rapid; involving a width of cliff face of at least 20m.	Unlikely	Medium to road	Low	Not applicable (no assets below)	None
2	**Rockfall/rock topple** Small scale; in mudstone, from the lower parts of the cliff face; extremely rapid; involving a width of cliff face of at least 20m.	Likely	Insignificant			
3	**Rockfall/rock topple** Very small scale; in siltstone, sandstone or mudstone, from any part of the cliff face; extremely rapid; involving one or more boulders over a width of cliff face of at least 5m.	Almost Certain to Likely				
4	**Rockfall/rock topple** Very small scale; in siltstone, sandstone or mudstone, from any part of the cliff face; extremely rapid; involving one or more boulders over a width of cliff face of at least 1m.	Almost Certain				
5	**Rockfall/rock topple** Very small scale; in siltstone, sandstone or mudstone, from any part of the cliff face; extremely rapid; involving one or more boulders over a width of cliff face of at least 0.5m.					
6	**Rockfall/rock topple** Very small scale; in siltstone, sandstone or mudstone, from any part of the cliff face; extremely rapid; involving a single boulder (joint fragment) up to 0.1m in diameter.					
7	**Earthslide** Very small scale landslide, from at or near cliff top, up to 5m wide and less than about 2m3 in volume; extremely rapid, moist to wet, suspended to active					
8	**Tree or tree limb fall** Very small scale fallen tree and/or limb, from at or near cliff top, with a downslope affected zone up to about 5m wide; extremely rapid.					

Notes
Column 1: refer to cross sections (Figures 4 and 5 in report) for explanations of size and speed.
Note definition of size is not from AGS2007c.
Column 2: refer to Attachment 7 for an explanation of Likelihood terms.
Column 3: refer to Attachment 7 for an explanation of Consequence terms.
Assets(ie property, infrastructure) in this instance = Talone Road and fence
Column 4: refer to Attachment 7 for an explanation of Risk terms.

6.5 Quantitative risk to life estimation for various site activities

6.5.1 Example situations in the study area

Risk to life is more important than risk to property for the study area. The following four examples (Figure 6.3) are considered reasonable examples of existing activities in the study area. Other examples could of course also be generated.

Fig. 6.3(a). Example 1. A mobile recreational individual walking on the shore platform, subject to hazards 1 – 8.
See Figures 5 and 6 for cross sections.
See Table 6.2 for brief descriptions of hazards.
Individual makes a return traverse (red dotted line) once a fortnight along full foreshore length (350m) = 25 return traverses a year.

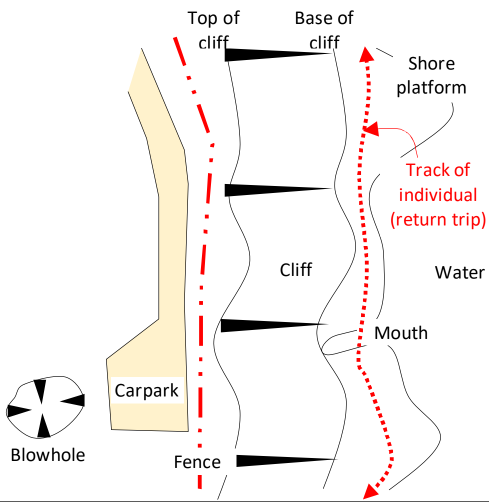


Fig. 6.3.(b). Example 2. Sightseers (3 people at a time) static at the fenceline at the Talone Street carpark, subject to hazard 1 only.
See Figure 5 for cross section.
See Table 6.2 for brief descriptions of hazards.
On average 3 people stand as a group (red oval) at the sightseeing spot in the carpark for 10 hours a day, 365 days a year.

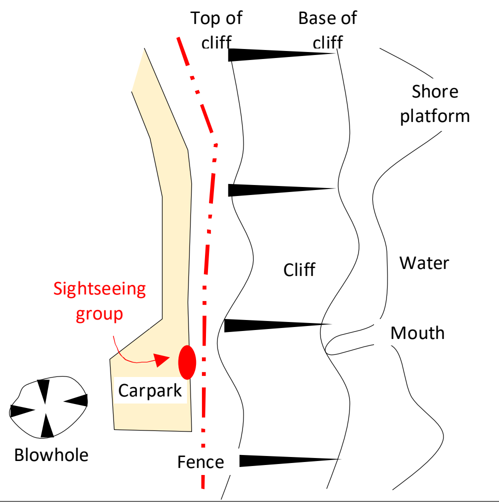


Fig. 6.3(c) Example 3. A small static abseiling group (5 people) at the base of the cliff near the blowhole mouth, subject to hazards 1, 3 and 4.
See Figures 5 and 6 for cross sections
See Table 6.2 for brief descriptions of hazards.
Up to 5 people stand as a group (red oval) on the shore platform near the blowhole mouth for 15 mins 25 times a year.

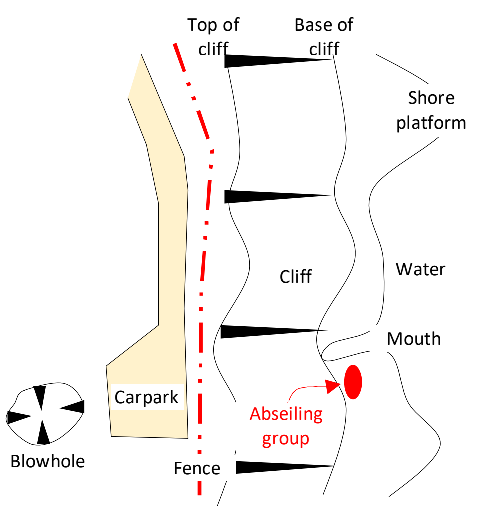


Fig. 6.3(d). Example 4. An individual mobile kayaker or swimmer entering the blowhole via its mouth (calm seas are presumed), subject to hazards 3 and 4.
See Figure 5 for cross section
See Table 6.2 for brief descriptions of hazards.
One kayaker or swimmer spends 0.25 hours on average each week at the site.

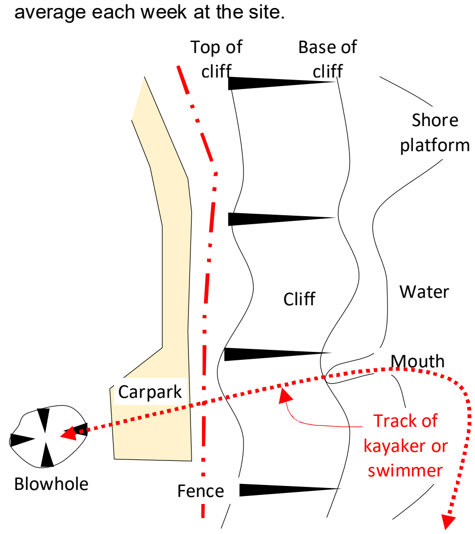


Figure 6.3 Schematic plans for examples 1 – 4.

6.5.2 Example 1 [Figure 6.3(a)]

In this example, a mobile recreational individual walks along the shore platform, and is exposed to hazards 1 – 8. He or she is assumed to be able to navigate across the mouth of the blowhole, and walks the full length of the study area – about 350m. Travelling at 1km/hour, a single traverse takes about 20 minutes, and the return trip a similar time. The individual does this once a fortnight on average, for a total of 16 hours per year, and a temporal probability [$P_{(T:S)}$] of 2 x 10^{-3}.

The foreshore in this example is considered an existing site/slope.

Frequency analysis inferred from site observations provides a range of likelihoods [$P_{(H)}$] for the hazards, summarised in Table 6.4. The summed risk to life [$R_{(LOL)}$][13] from all eight hazards for this individual is estimated at 6 x 10^{-6}.

Table 6.4 Risks to Life for Example 1

Scenario	$P_{[H]}$	n_i	w	f	d	$V_{[D:T]}$	s_i	$R_{[LOL]}$
1	0.001	50	1	1	20	1	1	8E-08
2	0.005	50	1	1	20	1	1	4E-07
3	0.05	50	1	1	5	1	1	1E-06
4	0.5	50	0.75	1	1	1	1	2E-06
5	1	50	0.5	1	0.5	1	1	1E-06
6	10	50	0.25	1	0.1	0.5	1	2E-07
7	0.1	50	0.5	1	5	0.3	1	1E-06
8	0.1	50	0.5	1	5	0.5	1	1E-06
							Total individual risk is sum of risks	6E-06

The F- N pairs for hazard 1, and all hazards combined, for this individual most at risk plot on the Acceptable region of the societal risk graph (Figure 6.4).

6.5.3 Example 2 [Figure 6.3(b)]

In this static example, on average, there are 3 people sightseeing at the fenceline at the Talone Street carpark for 10 hours a day, 365 days a year, for a total exposed population (e) of 43,800 people a year. Each person spends 15 minutes at the site, and is subject only to Hazard 1 where $P_{(H)}$ = 1 x 10^{-4}. The site is an existing element at risk.

An individual is present for 0.25 hours, which is 2.9 x 10^{-5} as a proportion of the year. The annual risk to loss of life to this individual most at risk is 1 x 10^{-4} x 1 x 2.9 x 10^{-5} x 1 = 3 x 10^{-9}.

13

Explanation of symbols used in risk to life assessment

$P_{[H]}$	the annual probability that the rockfall/topple tree fall occurs
n_i	the number of traverses the individual most at risk makes annually
w	the proportion of the shore platform width affected by the rockfall/topple (range 0 – 1)
f	a reduction factor to reflect probability of individual being present when rockfall occurs (range 0 – 1; 1 = no reduction)
d	boulder diameter or tree canopy size (metres)
$V_{[D:T]}$	Vulnerability of the individual most at risk impacted by the rockfall/topple (range 0 – 1; 1 = certain death)
s_i	speed (km/hr) of the individual most at risk along the shore platform (1km/hr for 350m long foreshore = about 40 minutes spent on foreshore daily by the individual)
$R_{[LOL]}$	the annual probability of loss of life of the individual most at risk. Derived from equation 3.1 in AGS2007c: R[LOL] = P[H] x P[S:H] x P[T:S] x V[D:T], where P[S:H] is probability of spatial impact. In example 1, it is = wd/l where l = length of shore platform, and where P[T:S] = temporal probability

To calculate the F-N pair for this situation, the temporal probability [$P_{(T:S)}$] is 0.42 (10 out of 24 hours every day). The probability of the hazard impacting the people is F = 1 x 10^{-4} x 1 x 0.42 = 4 x 10^{-5}. Assume all 3 people are killed if the hazard occurs (N = 3).

This F- N pair plots in the ALARP (As Low as Reasonably Practicable) region of the societal risk graph (Figure 6.4).

6.5.4 Example 3 [Figure 6.3(c)]

In this static example, 5 abseilers at a time gather at the base of the abseiling site below the Talone Street carpark, and spend 15 minutes each on the shore platform before climbing back up the cliff (all under supervision). The group repeats this exercise 25 times a year.

The site is an existing element at risk.

The group is at risk of life from exposure to Hazards 1, 3 and 4. It is assumed that death would not result from hazards 5, 6 and 7, and hazard 2 does not exist since the mudstone at the site is below the abseilers.

For individual risk to life:

- for Hazard 1, an individual is present for 0.25 x 25 = 6 hours per year, which is 7 x 10^{-4} as a proportion of the year. The annual risk to loss of life to this individual most at risk is 1 x 10^{-4} x 1 x 7 x 10^{-4} x 1 = 7 x 10^{-8}.
- for Hazard 3, the annual risk to loss of life to this individual most at risk is 2 x 10^{-2} x 1 x 7 x 10^{-4} x 1 = 1 x 10^{-5}, and
- for Hazard 4, the annual risk to loss of life to this individual most at risk is 5 x 10^{-1} x 1 x 7 x 10^{-4} x 1 = 3.5 x 10^{-4}.

For group risk to life, it is assumed that only Hazards 1 and 3 are capable of causing multiple deaths. To calculate the F-N pair for groups of five people at this site, the temporal probability [$P_{(T:S)}$] is 3.5 x 10^{-3} (ie 5 x 0.25 x 25 = 31 hours per year = 3.5 x 10^{-3} as a proportion of a year). The probability of hazard 1 impacting the people is F = 1 x 10^{-4} x 1 x 3.5 x 10^{-3} = 3.5 x 10^{-7}. The probability of hazard 3 impacting the people is F = 2 x 10^{-2} x 1 x 3.5 x 10^{-3} = 7 x 10^{-5}.

Assume all 5 people are killed if either hazard occurs (N = 5).

The F- N pair for hazard 1 plots in the Acceptable region of the societal risk graph (Figure 6.4).

The F- N pair for hazard 3 plots on the ALARP region of the societal risk graph (Figure 6.4).

6.5.5 Example 4 [Figure 6.3(d)]

In this mobile example, one individual kayaker or swimmer per week enters the blowhole via its mouth (calm seas are presumed necessary for entry, but are not common). The individual is subject to hazards 3 and 4. It is assumed that hazard 1 is not credible inside the blowhole, death would not result from hazards 5, 6 and 7, and hazard 2 does not exist since the mudstone at the site is below the abseilers. The blowhole and mouth is an existing element at risk.

Each individual spends 0.25 hours at the site. For individual risk to life:

- for Hazard 3, an individual is present for 0.25 x 50 = 12 hours per year, which is 1 x 10^{-3} as a proportion of the year. The annual risk to loss of life to this individual most at risk is 2 x 10^{-2} x 1 x 1 x 10^{-3} x 1 = 2 x 10^{-5}.

- for Hazard 4, the annual risk to loss of life to this individual most at risk is 0.5 x 1 x 1 x 10^{-3} x 1 = 5 x 10^{4}.

The F- N pair for hazard 4 for this individual most at risk plot on the ALARP region of the societal risk graph (Figure 6.4).

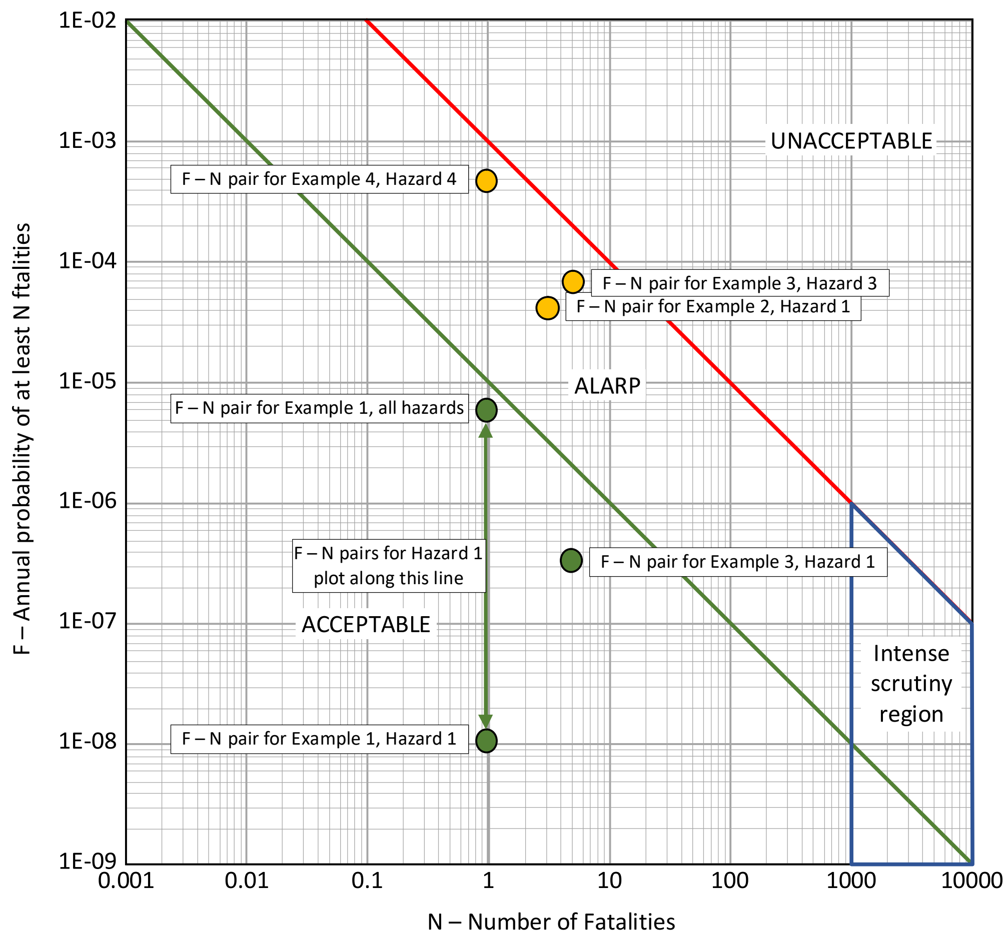


Figure 6.4 Societal risk graph for risks to life estimated for Examples 1 – 4 in the study area. The acceptability shown here of the risks is for guidance only and is based on AGS2007c Section 8 Table 1 reproduced here in Figure 6.5. Kingborough Council as regulator should assess the acceptability of the risks against its own organisational criteria.

6.6 Comment on acceptability criteria for landslide risk

6.6.1 Acceptability of risk to property

The regulatory authority shall determine whether or not a risk to property is acceptable, tolerable or otherwise.

Guidance is provided in the AGS (2007c) tables in Attachment 7.

6.6.2 Acceptability of risk to life

The regulatory authority shall determine whether or not a risk to life is acceptable, tolerable or otherwise. Guidance is provided in Figure 6.5, which is presented unamended from AGS (2007c) Section 8.

Table 1: AGS Suggested Tolerable loss of life individual risk.

Situation	Suggested Tolerable Loss of Life Risk for the person most at risk
Existing Slope (1) / Existing Development (2)	10^{-4} / annum
New Constructed Slope (3) / New Development (4) / Existing Landslide (5)	10^{-5} / annum

Notes:

1. "Existing Slopes" in this context are slopes that are not part of a recognizable landslide and have demonstrated non-failure performance over at least several seasons or events of extended adverse weather, usually being a period of at least 10 to 20 years.
2. "Existing Development" includes existing structures, and slopes that have been modified by cut and fill, that are not located on or part of a recognizable landslide and have demonstrated non-failure performance over at least several seasons or events of extended adverse weather, usually being a period of at least 10 to 20 years.
3. "New Constructed Slope" includes any change to existing slopes by cut or fill or changes to existing slopes by new stabilisation works (including replacement of existing retaining walls or replacement of existing stabilisation measures, such as rock bolts or catch fences).
4. "New Development" includes any new structure or change to an existing slope or structure. Where changes to an existing structure or slope result in any cut or fill of less than 1.0m vertical height from the toe to the crest and this change does not increase the risk, then the Existing Slope / Existing Structure criterion may be adopted. Where changes to an existing structure do not increase the building footprint or do not result in an overall change in footing loads, then the Existing Development criterion may be adopted.
5. "Existing Landslides" have been considered likely to require remedial works and hence would become a New Constructed Slope and require the lower risk. Even where remedial works are not required per se, it would be reasonable expectation of the public for a known landslide to be assessed to the lower risk category as a matter of "public safety".

Acceptable risks are usually considered to be one order of magnitude lower than the Tolerable Risks.

It is important to distinguish between "acceptable risks" and "tolerable risks".

Tolerable Risks are risks within a range that society can live with so as to secure certain benefits. It is a range of risk regarded as non-negligible and needing to be kept under review and reduced further if practicable.

Acceptable Risks are risks which everyone affected is prepared to accept. Action to further reduce such risk is usually not required unless reasonably practicable measures are available at low cost in terms of money, time and effort.

AGS suggests that for most development in existing urban area criteria based on Tolerable Risks levels are applicable because of the trade-off between the risks, the benefits of development and the cost of risk mitigation.

Figure 6.5 Guidance on risk to life criteria (AGS (2007c), Section 8 (Table 1 and its accompanying notes on pages 77 and 78). In relation to Notes 1 – 5, it is suggested that the sea cliffs in the study area at Blackmans Bay would reasonably fall into "Existing Slopes" since a very large proportion of them show no recognisable landsliding "over at least several seasons…" even though their very existence is due to slope instability (albeit mostly over much longer time frames). Categorising the cliffs as "Existing Landslides" would seem unreasonable, since in this report none of the observed landslides or rockfalls is regarded as requiring remediation.

6.7 Adherence of this LRM to AGS (2007)

Table 6.5 compares the items required by AGS (2007c) to be addressed in LRM, with this report.

Table 6.5. Extent of adherence of this report to AGS (2007c) reporting requirements

AGS (2007c) Section 10

REPORTING STANDARDS

"Section 10.1 The report on the risk assessment is to document the data gathered, the logic applied and conclusion reached in a defensible manner.

The practitioner will gather relevant data, will assess the relevance of the data and will reach conclusions as to the appropriate geotechnical model and basic assessment of the slope forming processes and rates. Full documentation of these results provides evidence of completion, provides transparency in the light of uncertainty, enables the assessment to be re-examined or extended at a later date and enables the assessment to be defended against critical review. The process often identifies uncertainties or limitations of the assessment which also need to be documented and understood."

"Section 10.2 The data to be presented includes:	**Review of the current report**	
	Data included in report?	**Stated explanation for omission of missing data**
a. List of data sources.	Yes	
b. Discussion of investigation methods used, and any limitations thereof.	Yes	
c. Site plan (to scale) with geomorphic mapping results.	Yes	
d. All factual data from investigations, such as borehole and test pit logs, laboratory test results, groundwater level observations, record photographs.	Yes	
e. Location of all subsurface investigations and/or outcrops/cuttings.	Yes	
f. Location of cross section(s).	Yes	
g. Cross section(s) (to scale) with interpreted subsurface model showing investigation locations.	Yes	
h. Evidence of past performance.	Yes	
i. Local history of instability with assessed trigger events.	Yes	
j. Identification of landslides, on plan or section or both, and discussed in terms of the geomorphic model, relevant slope forming process and process rates. Landslides need to be considered above the site, below the site and adjacent to the site.	Yes	
k. Assessed likelihood of each landslide with basis thereof.	Yes	
l. Assessed consequence to property and life for each landslide with basis thereof.	Yes	
m. Resulting risk for each landslide.	Yes	
n. Risk assessment in relation to tolerable risk criteria (e.g. regulator's published criteria where appropriate).	Yes	
o. Risk mitigation measures and options, including reassessed risk once these measures are implemented."	Yes	

"Where any of the above is not or cannot be completed, the report should document the missing elements, including an explanation as to why. The report needs to clearly state whether the risk assessment is based on existing conditions or with risk treatment measures implemented. In some cases, the assessment for both existing and after treatment should be documented to demonstrate the effect of risk control measures on reducing risk. A report which does not properly document the assessment is of limited value and would appear to have no reasonable basis."

6.8 Certificate of currency for Professional Indemnity Insurance

A copy of the certificate of currency for Professional Indemnity Insurance for William C Cromer Pty Ltd is included here as Figure 6.6.

tasman underwriting

LLOYD'S

Tasman Underwriting Pty Ltd is a Corporate Authorised Representative of Austagencies Pty Ltd ABN 76 006 090 464 AFSL 244584

Level 13, 141 Walker Street, North Sydney NSW 2060
PO Box 1813 North Sydney NSW 2059

Facsimile: (02) 9930 9501
Telephone: (02) 9930 9542

CERTIFICATE OF CURRENCY

Type:	Professional Indemnity Insurance
Insured:	William C. Cromer Pty Ltd
Profession:	Consulting Geotechnical, Environmental and Geological Engineers
Limit of Indemnity:	$1,000,000 any one Claim/$2,000,000 in the aggregate
Period of Insurance:	From: 4.00pm 31 August 2019 To: 4.00pm 31 August 2020
Retroactive Date:	Unlimited (excluding any known Claims/Circumstances)
Insurers:	100% Certain Underwriters at Lloyd's, London per Tasman Underwriting Pty Limited, Sydney.

Please refer to the policy document and any endorsements for the full terms and conditions of this insurance.

Signed:

Roy Daly
For and on behalf of Tasman Underwriting Pty Limited

Dated: In Sydney this Tuesday, 20 August 2019

This Certificate has been issued in our capacity as agents for Certain Underwriters at Lloyd's, London. It does not reflect in detail the policy terms or conditions and merely provides a very brief summary of the insurance that is, to the best of our knowledge, in existence at the date we have issued this Certificate. If you wish to obtain details of the policy terms, conditions, restrictions, exclusions or warranties, you must refer to the policy document.

In issuing this Certificate, we do not guarantee that the insurance outlined will continue to remain in force for the Period of Insurance as the policy may be cancelled or altered by either party to the contract at any time in accordance with the terms and conditions of the policy or in accordance with the terms of The Insurance Contracts Act 1984. We accept no responsibility or liability to advise any party who may be relying on this Certificate of any such alteration to, or cancellation, of the policy.

Figure 6.6 Confirmation of insurance for William C Cromer Pty. Ltd.

Attachment 7

(2 pages)

Qualitative terminology used in assessing risk to property

Source: Appendix C of AGS2007c.

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

APPENDIX C: LANDSLIDE RISK ASSESSMENT

QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY

QUALITATIVE MEASURES OF LIKELIHOOD

Approximate Annual Probability		Implied Indicative Landslide Recurrence Interval		Description	Descriptor	Level
Indicative Value	**Notional Boundary**					
10^{-1}	$5x10^{-2}$	10 years	20 years	The event is expected to occur over the design life.	ALMOST CERTAIN	A
10^{-2}		100 years		The event will probably occur under adverse conditions over the design life.	LIKELY	B
10^{-3}	$5x10^{-3}$	1000 years	200 years	The event could occur under adverse conditions over the design life.	POSSIBLE	C
10^{-4}	$5x10^{-4}$	10,000 years	2000 years	The event might occur under very adverse circumstances over the design life.	UNLIKELY	D
10^{-5}	$5x10^{-5}$	100,000 years	20,000 years	The event is conceivable but only under exceptional circumstances over the design life.	RARE	E
10^{-6}	$5x10^{-6}$	1,000,000 years	200,000 years	The event is inconceivable or fanciful over the design life.	BARELY CREDIBLE	F

Note: (1) The table should be used from left to right; use Approximate Annual Probability or Description to assign Descriptor, not *vice versa*.

QUALITATIVE MEASURES OF CONSEQUENCES TO PROPERTY

Approximate Cost of Damage		Description	Descriptor	Level
Indicative Value	**Notional Boundary**			
200%		Structure(s) completely destroyed and/or large scale damage requiring major engineering works for stabilisation. Could cause at least one adjacent property major consequence damage.	CATASTROPHIC	1
60%	100%	Extensive damage to most of structure, and/or extending beyond site boundaries requiring significant stabilisation works. Could cause at least one adjacent property medium consequence damage.	MAJOR	2
20%	40%	Moderate damage to some of structure, and/or significant part of site requiring large stabilisation works. Could cause at least one adjacent property minor consequence damage.	MEDIUM	3
5%	10%	Limited damage to part of structure, and/or part of site requiring some reinstatement stabilisation works.	MINOR	4
0.5%	1%	Little damage. (Note for high probability event (Almost Certain), this category may be subdivided at a notional boundary of 0.1%. See Risk Matrix.)	INSIGNIFICANT	5

Notes: (2) The Approximate Cost of Damage is expressed as a percentage of market value, being the cost of the improved value of the unaffected property which includes the land plus the unaffected structures.

(3) The Approximate Cost is to be an estimate of the direct cost of the damage, such as the cost of reinstatement of the damaged portion of the property (land plus structures), stabilisation works required to render the site to tolerable risk level for the landslide which has occurred and professional design fees, and consequential costs such as legal fees, temporary accommodation. It does not include additional stabilisation works to address other landslides which may affect the property.

(4) The table should be used from left to right; use Approximate Cost of Damage or Description to assign Descriptor, not vice versa

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

APPENDIX C: – QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY (CONTINUED)

QUALITATIVE RISK ANALYSIS MATRIX – LEVEL OF RISK TO PROPERTY

LIKELIHOOD		CONSEQUENCES TO PROPERTY (With Indicative Approximate Cost of Damage)				
	Indicative Value of Approximate Annual Probability	1: CATASTROPHIC 200%	2: MAJOR 60%	3: MEDIUM 20%	4: MINOR 5%	5: INSIGNIFICANT 0.5%
A – ALMOST CERTAIN	10^{-1}	VH	VH	VH	H	M or L (5)
B - LIKELY	10^{-2}	VH	VH	H	M	L
C - POSSIBLE	10^{-3}	VH	H	M	M	VL
D - UNLIKELY	10^{-4}	H	M	L	L	VL
E - RARE	10^{-5}	M	L	L	VL	VL
F - BARELY CREDIBLE	10^{-6}	L	VL	VL	VL	VL

Notes: (5) For Cell A5, may be subdivided such that a consequence of less than 0.1% is Low Risk.
(6) When considering a risk assessment it must be clearly stated whether it is for existing conditions or with risk control measures which may not be implemented at the current time.

RISK LEVEL IMPLICATIONS

Risk Level		Example Implications (7)
VH	VERY HIGH RISK	Unacceptable without treatment. Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to Low; may be too expensive and not practical. Work likely to cost more than value of the property.
H	HIGH RISK	Unacceptable without treatment. Detailed investigation, planning and implementation of treatment options required to reduce risk to Low. Work would cost a substantial sum in relation to the value of the property.
M	MODERATE RISK	May be tolerated in certain circumstances (subject to regulator's approval) but requires investigation, planning and implementation of treatment options to reduce the risk to Low. Treatment options to reduce to Low risk should be implemented as soon as practicable.
L	LOW RISK	Usually acceptable to regulators. Where treatment has been required to reduce the risk to this level, ongoing maintenance is required.
VL	VERY LOW RISK	Acceptable. Manage by normal slope maintenance procedures.

Note: (7) The implications for a particular situation are to be determined by all parties to the risk assessment and may depend on the nature of the property at risk; these are only given as a general guide.

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