Robe Obelisk

Landslide Stability Assessment

District Council of Robe

December 18

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Tonkin CONSULTING

Document History and Status

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1 Background

1.1 Introduction

Tonkin Consulting was engaged by the District Council of Robe (Council) to provide an engineering and geotechnical assessment on the current condition of the coast line at the Obelisk on Cape Dombey and to provide recommendations regarding the stability of the current carpark located at the Obelisk from a visual inspection. As part of our services we also filmed the coastline near Cape Dombey and the associated Coastal Walking Trail to allow assessment of the potential stability risks along this section of the coastline.

The coastline near Cape Dombey is known to be receding rapidly. Council has, over time, proactively had specialists undertake assessments of the rate and risk of long-term erosion and degradation that occurs to the cliffs.

This report is to document the observed conditions around the coastal walking trail as of November 2018 from the Robe Obelisk to near the junction of Adam Lindsay Gordon Drive and Buckler Street and to provide comment on the risk to public safety, with recommendations to Council regarding the risk to public safety.

The observations and recommendations within this report were prepared by Tonkin Consulting based on the information provided by Council and from the visual/aerial inspection undertaken on the 29 November 2018.

1.2 Desktop Survey

1.2.1 Site Geology

South Australian Resource Information Geoserver

The South Australian Resource Information Geoserver https://map.sarig.sa.gov.au/ indicates that the cliffs around Cape Dombey are composed of Bridgewater Formation which is described as '*Poorly consolidated yellow pinkish-brown fine to coarse fossiliferous calcareous sand, calcarenite. Locally capped by calcrete. As coastal beach and associated aeolian dune. Forms stranded series of elongated beach ridges, subparallel to present coast'.*

Coast Landscapes of South Australia – Robert P. Bourman,

Bourman in 'Coast Landscapes of South Australia' (2016) https://www.adelaide.edu.au/press/titles/coast-sa indicates that the cliff exposures near the Obelisk at Cape Dombey are part of the Robe Range and states .

'The Robe Range cliff exposures reveal large-scale planar 'cross-bedding' which represents the faces of coastal dunes as they have receded over time. These coastal dunes have a calcrete palesol which is developed on the crest of the cliff faces creating a capped thick calcrete.'

'The essential character of coastal landscapes is a reflection of major geological structures such as folds, faults and the dips and strikes of the rocks which is commonly control the broad orientation of rocky shorelines. The detailed character of the coast is commonly reflected in the relative resistance of the rocks to erosion as influenced by their mineralogical compositions and susceptibilities to weathering.'

The differential strength of the rock that makes up the cliff exposures allows for weakened layers to be readily removed and eroded which facilitates the undercutting and weathering of the cliffs.

Summary

The cliff in the vicinity of Cape Dombey can be described as comprising variable limestone with a relatively strong cap of calcrete overlying weaker and more erodible rock.

Due to the mineralogical composition of the Cape Dombey Cliffs and the 'cross-bedding' that is visibly observable along that section of the coast, it is expected that erosive forces will exploit any pre-existing weathered zones or relatively susceptible geological layers within the cliff face creating localised weakened points.

1.3 Historic Reporting

1.3.1 Obelisk Stability - 2015

Coffey undertook a geotechnical assessment of the stability of the Obelisk in 2015 and provided recommendations to Council regarding the feasibility of establishing a work platform at the Obelisk. The report acknowledges the continuous care required to access the obelisk platform and the risk of physically entering the landform highlighting the narrow walkway, cliff overhangs, poor working conditions and instability of the Obelisk.

1.3.2 Cliff Top Erosion Adjacent Cape Dombey Robe, South Australia – Coastal Management Branch Technical Report - 2009

The Coastal Management Branch undertook a Cliff Top Erosion assessment of the Robe Cliffs and compared the rate of erosion from historic survey undertaken in 1987. The following findings were made.

1.3.2.1 Summary

- Erosion varies in relation to ocean swell, height of cliff face, mineralogical makeup and exposure class.
- Consideration of rising ocean levels and the rate of erosion is most likely a positive relationship. As platforms (shelving) at water level become submerged, subaqueous erosion (from wave action) is likely to increase.
- 48 Sites were surveyed to measure the rate of erosion which varied from site to site with a maximum erosion measured of 26 metres in 27 years with an average erosion of 5.9 metres.
- A comparison of the landform type (Embayment, Promontory, Straight) and Wave Exposure (Exposed, Sheltered) was undertaken to identify the effect that erosion has on each site type with a recommendation that a 30-metre buffer should be planned for along the exposed coast.
- Recommendations;
    - Cliff top edge is to be resurveyed at Cape Dombey to detect change since 1987
    - The cliff top between Robe and long beach is surveyed for future erosion monitoring
    - A strategy is developed to manage erosion where assets are at risk
    - That cliff stability and cliff top erosion rates are reassessed at a future date based on the results of a resurvey and sea level rise data.

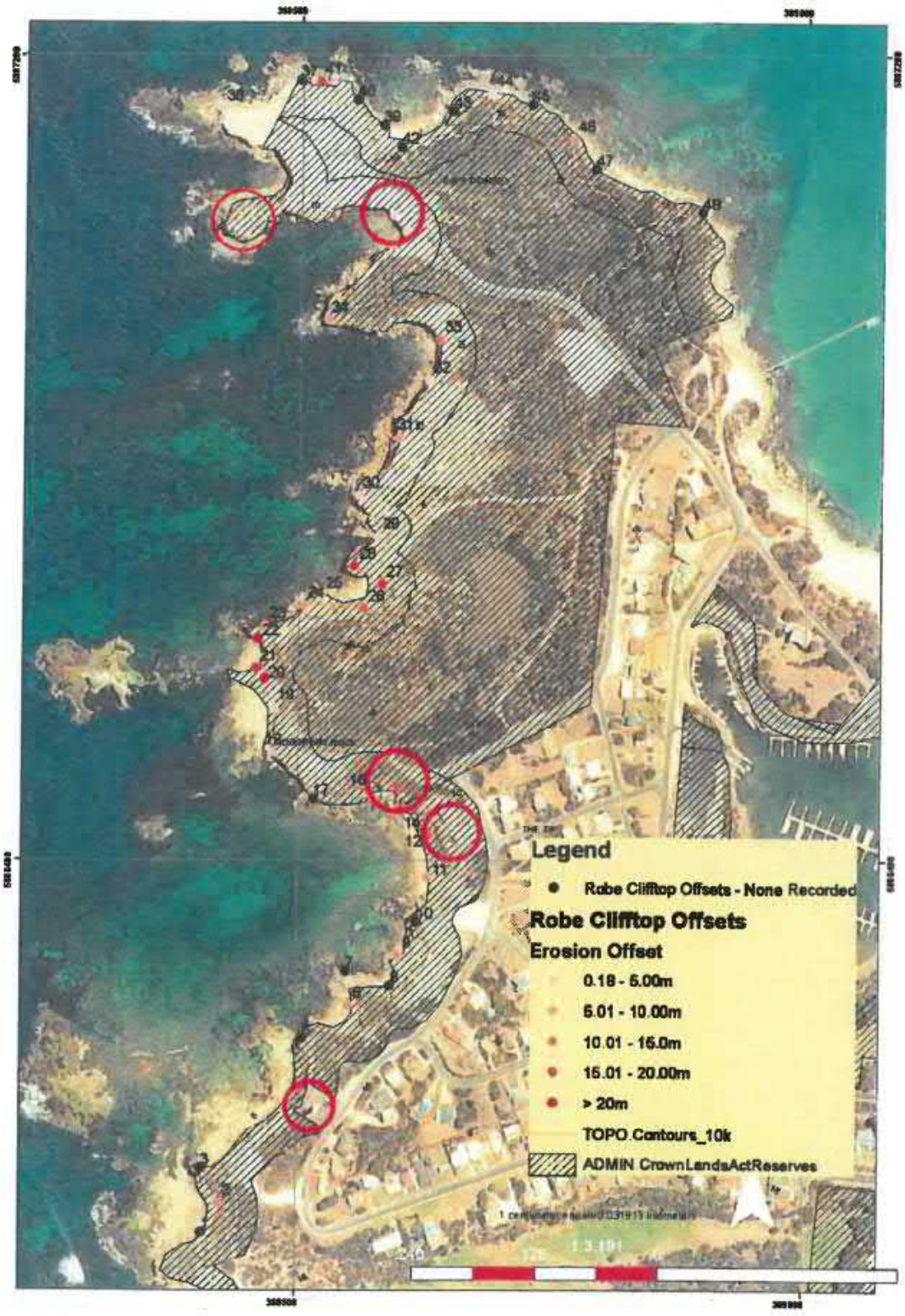

Figure 1 ***2008 image showing the 48 sites where the cliff top position was compared. Sites are coloured according the extent of erosion (in metres) that was measured. Black indicates no erosion. The red circles show assets located within the 30 metres risk zone - Fotheringham. D, 2009***

2 Fieldwork Observations

Lyndon Sanders, Principal Geotechnical Engineer, and Jason Barnett, Civil Engineer and Aerial Photographer, visited the Robe Obelisk and the coastal walking trail on 29 November 2018, following discussions with Roger Sweetman from Council at the Obelisk car park.

The visit was primarily intended to allow Tonkin to comment on the stability of the cliffs near the Obelisk but was extended to fly the drone (necessary for the Obelisk studies) over the Coastal Walking Trail to document any potential stability risks in this area. Approximately 2.3km of the costal cliff face were recorded and areas of potential stability risk were documented.

Field notes and photographs taken during the site visit are retained on our project files. Map 1 documents the extent of the drone survey undertaken on the 29th of November and provides an overview of the video footage taken is presented in Appendix A and B. This map documents a relative chainage along the surveyed coastal cliff face which is referenced throughout this report.

2.1 Site Overview

2.3km of the cliff top was video surveyed and inspected on site. From a post-fieldwork review of the footage, 15 sites along the coastal walking trail have been identified as 'watch sites' and have been ranked based on their assessed risk . Note that this is a subjective assessment made based on the vision provided and without further engineering assessment can only be regarded as such.

Appendix C provides the documented aerial photography of sites of considered risk for council to monitor. These observed points of interest are documented in Map 2. The ranking of the sites is to provide the reader with an indicative understanding of the current erosion zones identified and identify the regularity at which council should monitor these areas.

Note that the High-ranking sites require some level of council action to ensure public safety can be ensured. These sites are discussed in detail within this section and a recommendation provided in Section 3.

The ranking doesn't consider the structural integrity of the current cliff face and is a visual assessment based on the footage captured.

Table 2.1 Table of Identified Sites of Long-term Stability Concern

ID	Chainage (m)	Description	Ranking
RZ1	50	Cliff Overhang - Differential Erosion	Medium
RZ2	370	Obelisk Main Carpark - Cliff Undercutting	High
RZ3	630	Obelisk Main Carpark - Cliff Undercutting	High
RZ4	670	Obelisk Main Carpark Entrance - Cliff Undercutting	High
RZ5	825	Large Cliff Undercutting at exposure point	Medium
RZ6	1000	Cliff Undercutting -10m from nature walk	Medium
RZ7	1100	Cilff Overhang - Differential Erosion	Medium
RZ8	1200	Blow Hole - Sink Hole	High
RZ9	1220	Large Undercutting at exposure point	Low
RZ10	1330	Doorway Rock - Instability Potential	Low
RZ11	1580	Nature Walk Car Park 2 - Undercutting	Medium
RZ12	1750	Undercutting of Cliff Face with large soil mass above	Medium
RZ13	1900	Differential Erosion - Fenced Off Walkway	Low
RZ14	2150	Large Cavity under point	Medium
RZ15	2250	Nature Walk Car Park South - Large Undercutting	High

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25 0 25 50 75 100 m

N

Job Number:	20181771
Filename:	20181771GQ001
Revision:	REV A
Date:	2018-12-11T10:13:13
Drawn:	Jason Barnett

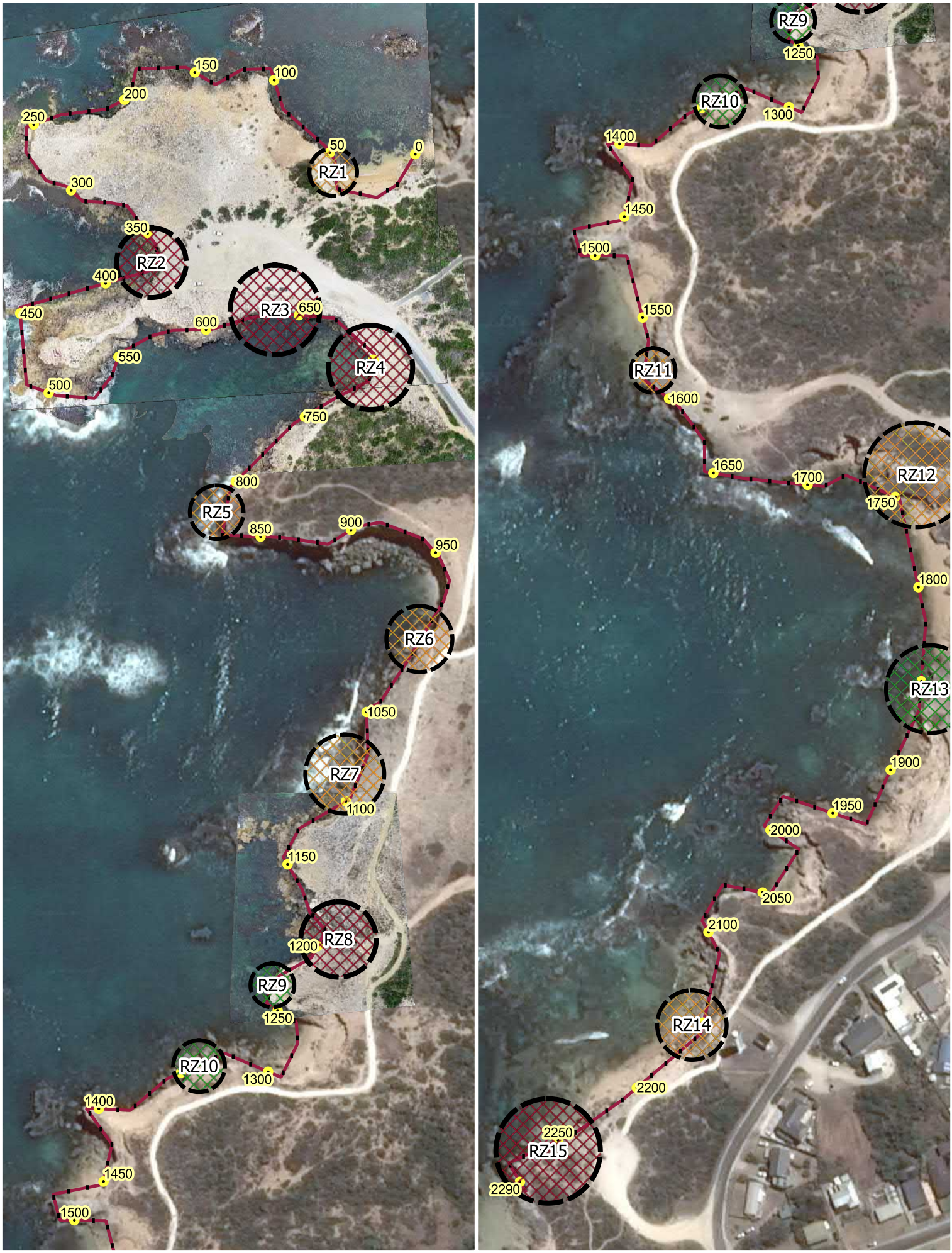
Data Acknowledgement:
Aerial Photography taken by Tonkin Consulting, 29/11/2018
Aerial from Google, 2018

Cliff Face
50m Chainages
10m Chainages

DISTRICT COUNCIL OF ROBE

CLIFF STABILITY ASSESSMENT
COASTAL CHAINAGE OVERVIEW

MAP 1



25 0 25 50 75 100 m

N

Cliff Face
50m Chainages
10m Chainages

POI Zones
High
Medium
Low

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Job Number:	20181771	Data Acknowledgement:
Filename:	20181771M002	Aerial photography taken by Tonkin Consulting, 29/11/2018
Revision:	REV A	
Date:	2018-12-11T13:32:49	Aerial from Google, 2018
Drawn:	Jason Barnett	

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CLIFF STABILITY ASSESSMENT SITES OF CONCERN

MAP 2

2.1.1 Obelisk Main Carpark

As seen in Figure 2, Figure 3 and Figure 4 the cliffs around the Obelisk car park are undercut. The undercutting is caused by wave and water erosion and will be ongoing. Because the drone requires satellite coverage for navigation, and because its sensors limit how close it can come to solid ground, we were unable to fly below undercut areas to assess how far they extend under the carparks. However, our judgement based on our observations through camera zoom lenses and from the drone flying as close to the undercuts as we judged prudent suggest that they do extend to underlie portions of the carpark. This imagery is documented in Appendix B and C.

Any area of ground lying over an undercut will be less stable than if it were underlain by solid ground. The stability will decrease over time as a result of ongoing erosion of the undercut and eventually the undercut will collapse. It is impossible to estimate the rate of erosion on the basis of current data, although the attached photographs of the ground near the Obelisk suggests that it may be rapid in this vicinity (See Appendix B).

Bridgewater Formation is known to be variable in composition and strength. The rate of erosion will also be variable; the unevenness of the coast - the bays and points near the Obelisk - is testament enough to that.

Fotheringham. D, 2009 documents that the main carpark cliff is receding at 1-3cm/year based on the historic coastal survey undertaken and has ranked the site with as a high-risk erosion site with the potential of up to 30m of localised costal recession. This places the road alignment within the expected recession.

We do not know how far the current undercuts extend although we think they may go under the car park. Based on literature the cliff appears to be receeding at 1-3cm/year but consideration of photography from 1950 to 2006 indicates that this may be an underestimation.

It is not obvious how fast the undercuts are getting bigger (although we're sure they are) and we don't know how strong the ground is. In combination this means that it is impossible to estimate the risk of cliff collapse to the car park and its users. However, that risk is clearly higher than for a carpark set on solid ground and is clearly increasing over time.

Figure 2 CH 370 – Obelisk Main Car Park North Side – Undercut of Cliff Face

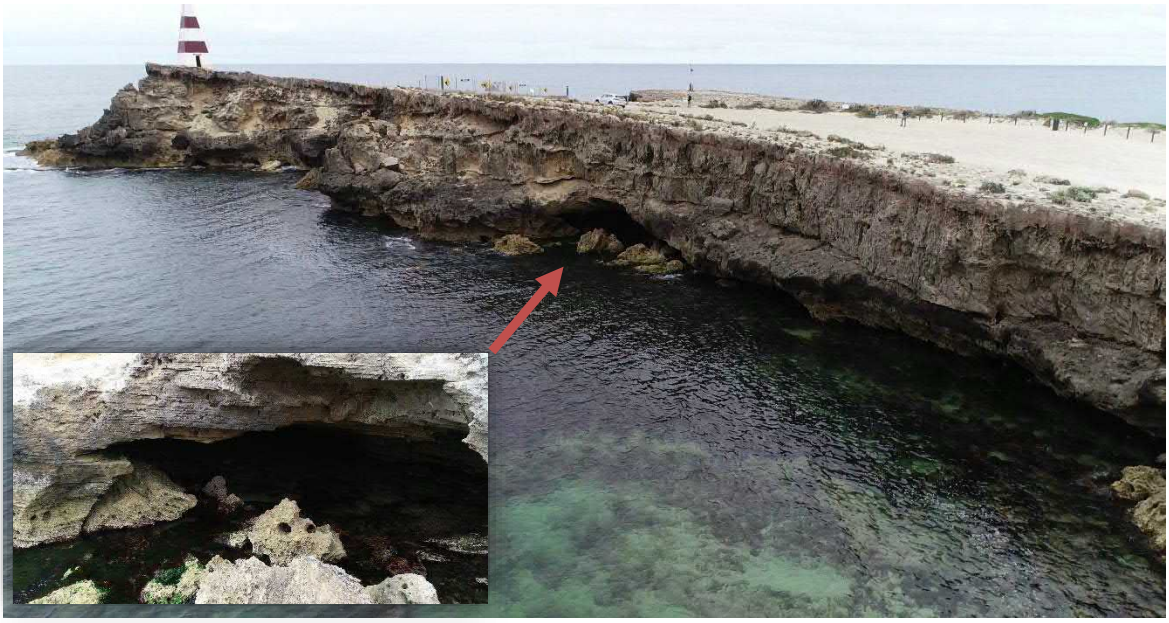


Figure 3 CH 620 to CH 660 - Obelisk Main Car Park South Side – Undercut of Cliff Face

Figure 4 CH 690 to CH 720 - Obelisk Main Car Park Entrance – Undercut of Cliff Face

2.1.2 Obelisk Nature Walk – Blow Hole

There is a blowhole around 350 m directly south from the entrance to the Obelisk carpark and located at approximately chainage 1200 (See Map 1 and Figure 5). This is covered with a metal grate. A few metres east from the Blowhole there is an area of depressed ground around 1.5 m diameter with a small pothole in its middle. This area is distinctly softer underfoot than the surrounding ground, consistent with the presence of a cavity under the ground surface. A few metres north east from the depressed ground, there is a nest of boulders partly covering a depressed area in the ground which we judge is probably a partly infilled cavity. Figure 6 documents the two weakened locations and shows an elevation profile which indicates the localised depressions.

The blowhole and the two inferred cavities lie near the end of an erosion feature in the cliffs shown in Figure 5. This is almost certainly connected with the known blowhole and is very likely, in our opinion, to be connected with the other cavities (See Figure 7).

Sinkholes develop when soil infilling to cavities in the ground (these cavities generally develop as the limestone is dissolved by infiltrating stormwater) is eroded away, leaving only the cavity. The erosion proceeds from the base of the cavity and speeds up as material is eroded away.

Eventually, the infilling soil does not have sufficient strength to stand, the cavity empties and a sinkhole suddenly appears (over seconds to minutes, typically). It is not possible to predict when a sinkhole will appear.

Figure 5 CH 1200 – Obelisk Nature Walk Blow Hole – Undercutting Beneath Blowhole

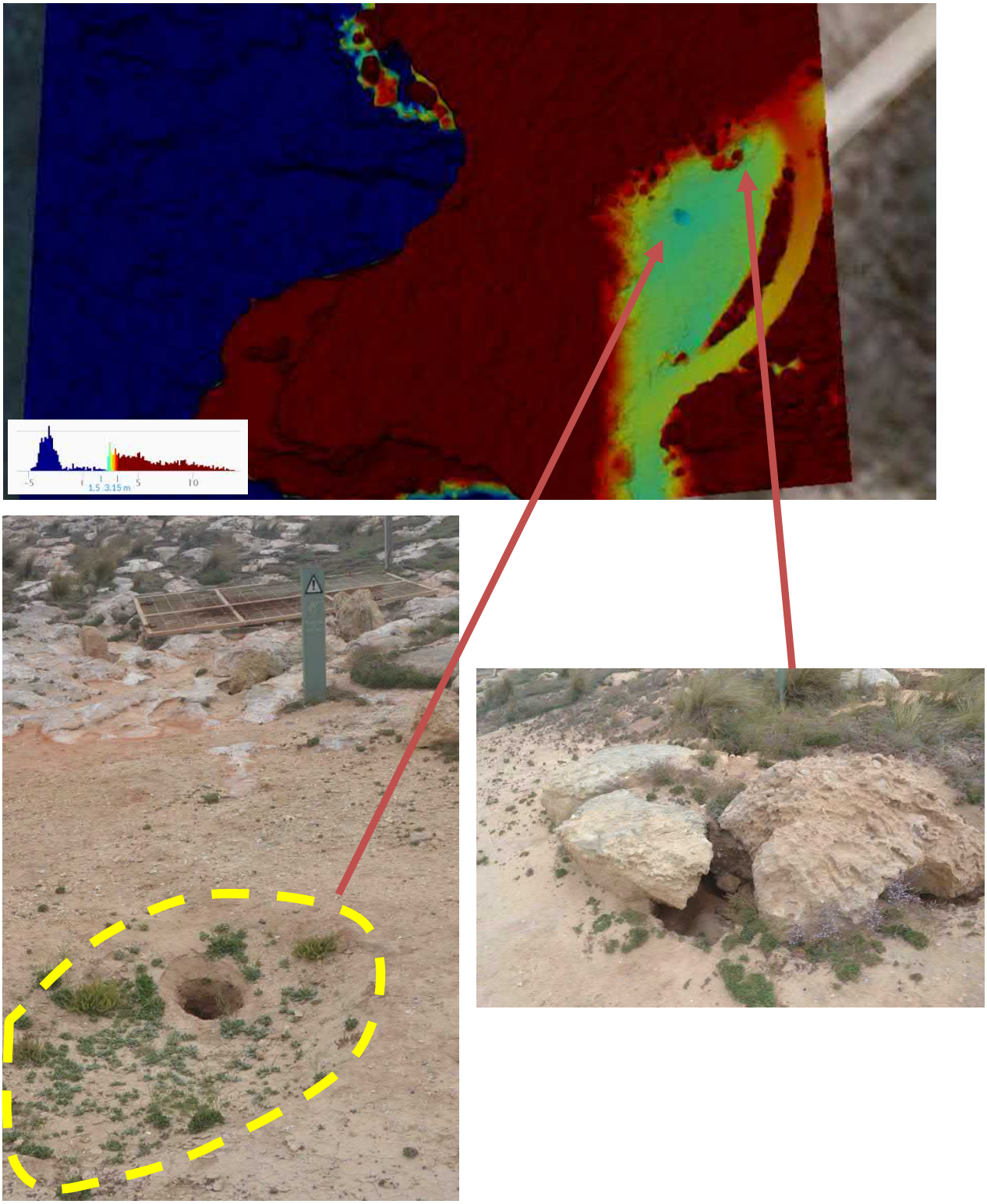


Figure 6 *CH 1200 – Obelisk Nature Walk Blow Hole – Sinkhole Heat Elevation Map (Top) and Sinkhole Locations (Bottom)*

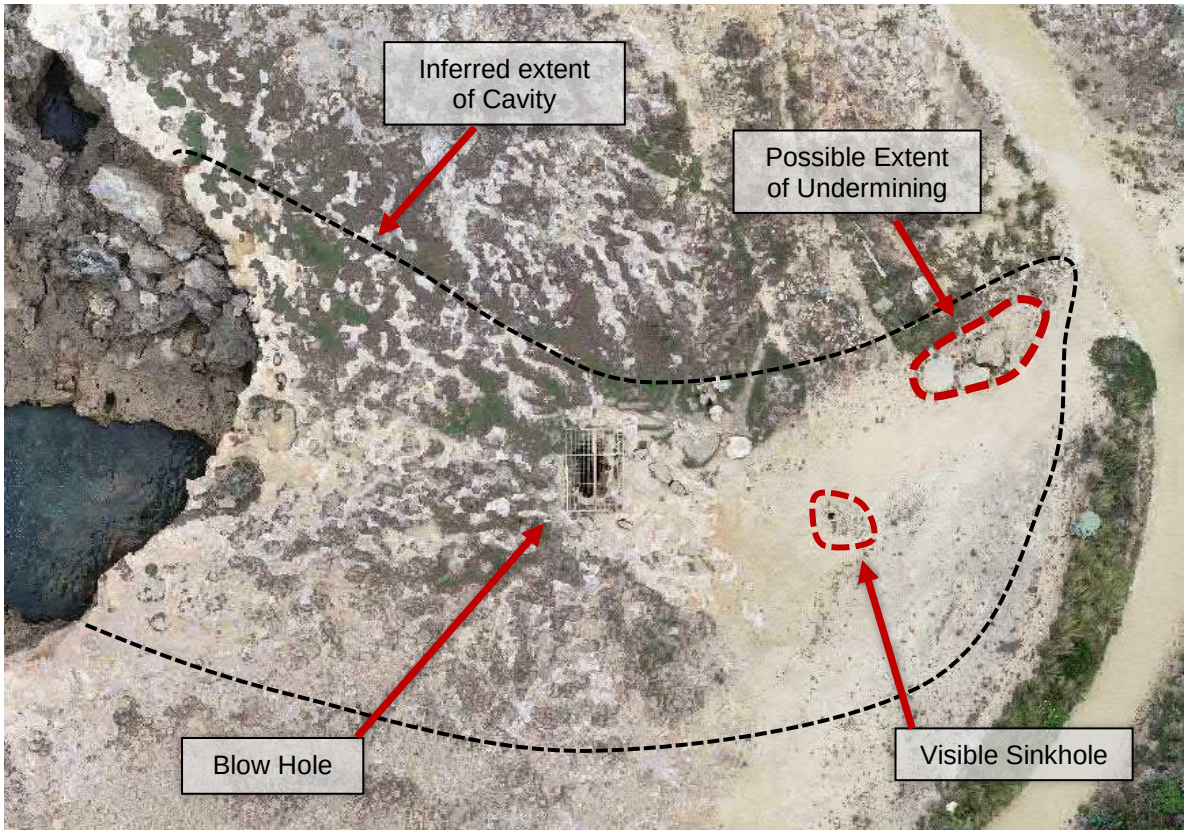


Figure 7 CH 1200 – Obelisk Nature Walk Blow Hole – Sink Hole

2.1.3 Southern Carpark – Cliff Stability

Figure 8 shows an aerial view of the carpark near the southern end of the Coastal Walking Trail. The nearby cliffs are undercut. There are indications (debris heaps) to the north of the existing undercut suggesting the relatively recent collapse of a previously undercut area. As far as we can tell, the existing undercut does not extend below the Southern carpark. However, we estimate the thickness of the rock arch over the existing undercut to be no more than about 1.5 m in places. Sightseers can be observed standing on top of that arch. (Figure 9)

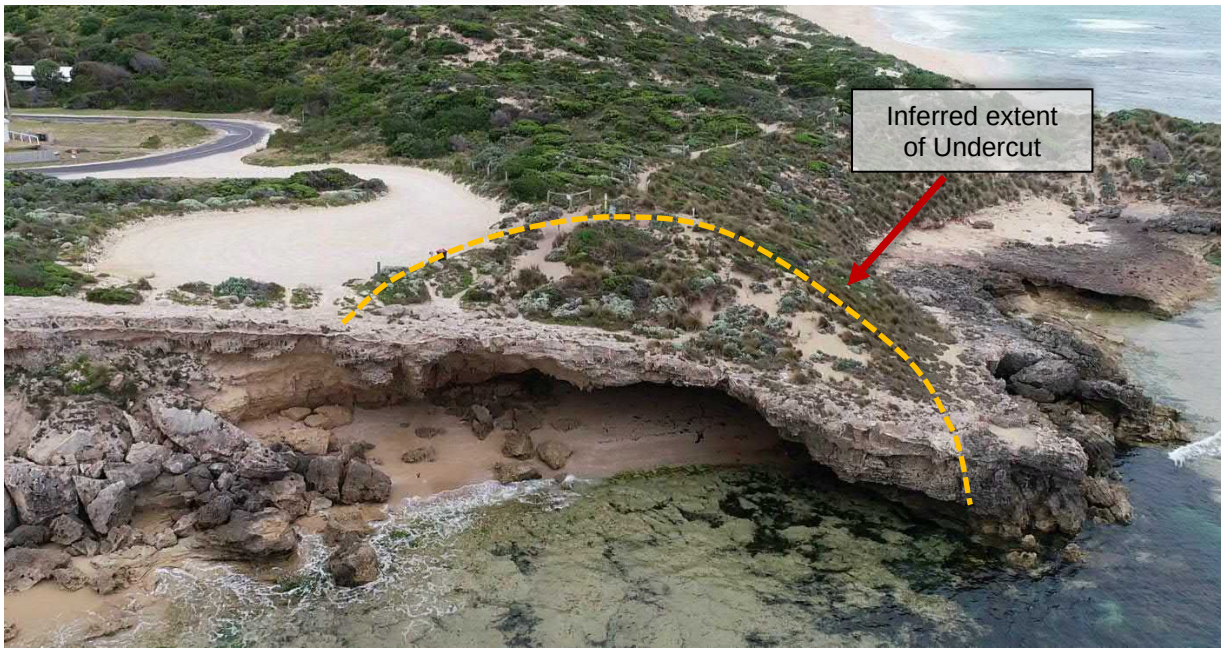


Figure 8 CH 2250 – Southern Carpark – Undercutting of Cliff

Figure 9 CH 2250 – Southern Carpark – People Standing on top of undercut Cliff

2.1.4 Obelisk Nature Walk – Chainage 825 to 1050

On the Obelisk Nature walk there is a large cliff top overhang with a significant amount of undercutting which has created a large void. At the time of the inspection this was not fully understood and hence the footage captured is limited in this area. There is an informal walking path that has been abandoned as part of the recent trail upgrade.

As far as we can tell the undercutting could be underneath the informal walking path documented in Figure 11. It is believed that the risk of collapse will increase as erosion persists at the foundation of the cliff face.

Figure 10 CH 825 – Large cavity under informal walking path.

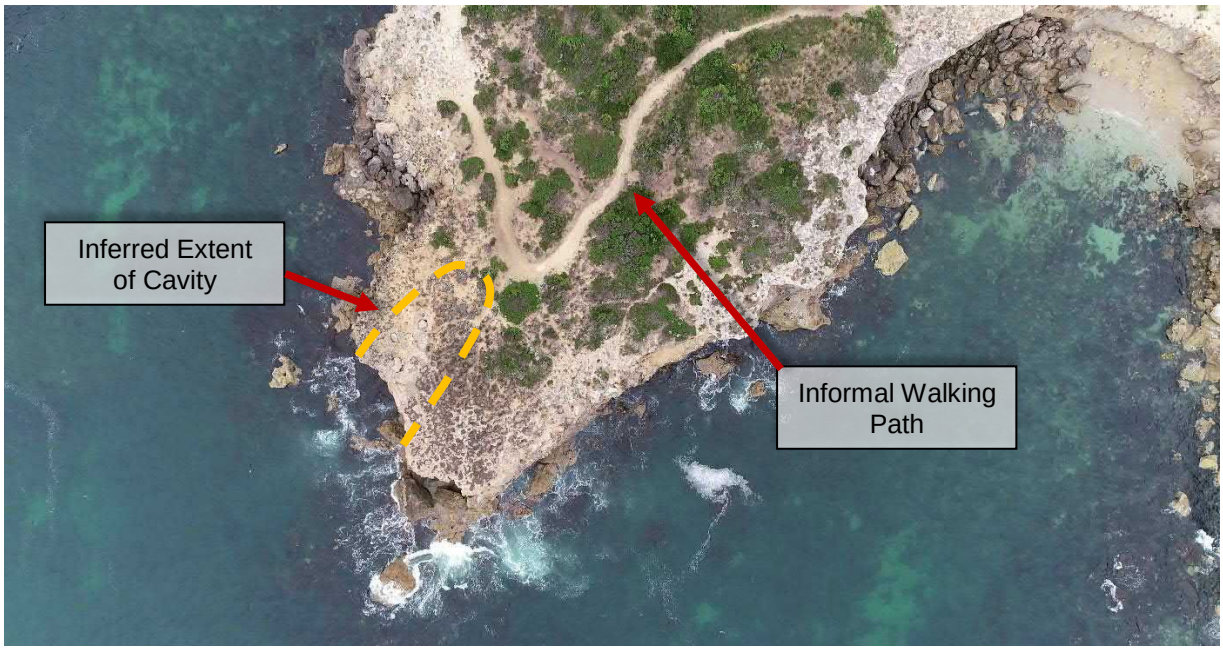


Figure 11 CH 825 – Informal walking path and assumed extent of cavity

3 Recommendations

3.1 Main Obelisk Car Park – Public Access

Recommendation

Based on the overview provided in Section 2.1.1 and again in regard to discussions with Council on their risk appetite, we recommend that Council controls public access to the present Obelisk carpark.

We suggest a 10m exclusion buffer from the cliff edge and seen in Map 3. This exclusion won't affect parking noticeably but may narrow the entrance to the carpark. This is based on the available information we have around the undercutting around the carpark.

It might be assumed that the undercut extends 10 m in from the cliff edge at the observed (and video'd/photo'd) location on the northern side of the carpark, and 10 m from the whole of the cliff edge on the southern side. Our observations suggest undercutting for that whole length, but the undercut is so close to the water level along much of it that we cannot know how far back it goes. Where we could look into the 'caves' our observations suggest that the undercut extends more than 5 m behind the cliff face, possibly up to 8 m in places and potentially more.

We have no measurements to back up the assumption, and there a no reliable strength measurements of the cliff materials that might allow a very approximate calculation of the stability of the cliff with such an undercut. However, where long overhangs are present in the cliffs near the Obelisk, these are no more than 10 m deep (into the cliff) , suggesting that they fail before they get to that size. The overhang near the Blowhole extends further into the cliff, but it not very wide, so that it is supported on both sides.

If it is assumed that the undercut extends 10 m from the cliff face then an exclusion zone could be set out at that distance on the assumption that the failure would probably generate a vertical face in the cliff, consistent with our observations of the cliffs near the Obelisk generally.

This is based on no more science than is set out above and implementing it would be at Council's risk, but it may provide a path forward that mitigates Council's risk without totally closing the tourist attraction this season.

Obviously, this is a temporary measure for the tourist season. Further assessment/monitoring should be undertaken to confirm suitable long-term actions.

If it were possible to determine the extent of undercutting, it might be possible reduce the exclusion zone buffer however, investigating the undercuts would mean managing some unusual Workplace Health and Safety risks, which may make it impractical to undertake those investigations which would be necessary to reassess the risk.

The recommended actions are summarised below;

- A minimum exclusion zone of 10m from the edge of cliff (See Map 3)
- Restricting large/heavy vehicle access where possible
- Introducing a 10m exclusion zone for vehicle and pedestrian access as suggested in Map 3.
- Frequent (at least annual) monitoring of the Obelisk cliff around the carpark to ensure risk to public safety is minimised.
- Design of the future carpark acknowledging that in the future the carpark will not be trafficable by vehicle.

3.2 Obelisk Nature Walk – Blow Hole

Recommendation

Based on discussions with Council on the 29th November, we understand that the risk of sudden sinkhole development in this public area would not be acceptable to Council. We recommend that Council implements to practicable measures, to as far as practicable prevent public access to the area of the incipient sinkholes. It may also be prudent to install signage describing the inherent risks of access the area. As the path currently skirts the area of highest risk, it would be sensible to provide signage at both entrances to alert the public.

The following Actions are summarised;

- Prevent public access to the area of the sinkholes where practicable (See Figure 7)
- Monitor the ground stability around the areas of concern and monitor any further movement or loss of ground strength in the area.
- Introduce signage around the blow hole which indicates the risk of entering the area.

3.3 Southern Carpark – Cliff Stability

Recommendation

We recommend that Council take practicable measures to restrict, and if possible prevent, public access to the area of the arch near the Southern carpark. It may also be prudent to install signage describing the inherent risks of accessing the area. At present there would appear to be not justification for closing the carpark, although it would be useful to obtain survey to demonstrate how far the undercutting extends as the footage from this site visit is hard to determine how far this extends.

Depending on site access and WHS considerations, this might be possible by terrestrial photogrammetry.

The following Actions are summarised;

- Prevent public access to the walking areas over the arch near the carpark to the extent practicable
- Introduce signage near the carpark to indicate the risk of entering the area

3.4 Obelisk Nature Walk – Chainage 825 Informal Walking Path Cavity

Recommendation

We suggest that council introduces additional signage at the entrance to the informal walking path as it is a risk that the public will take this walking trail. It is thought that the risk of current collapse is not high but will occur as erosion persists and undercuts the foundation. It should be monitored as the stability over time is compromised.

The following Actions are summarised;

- Undertake additional inspections as time permits to ensure long-term stability.
- Prevent public access where practical.
- Introduce signage near the entrance to the informal walking path to indicate the risk of entering the area.

3.5 Cape Dombey – Cliff Stability

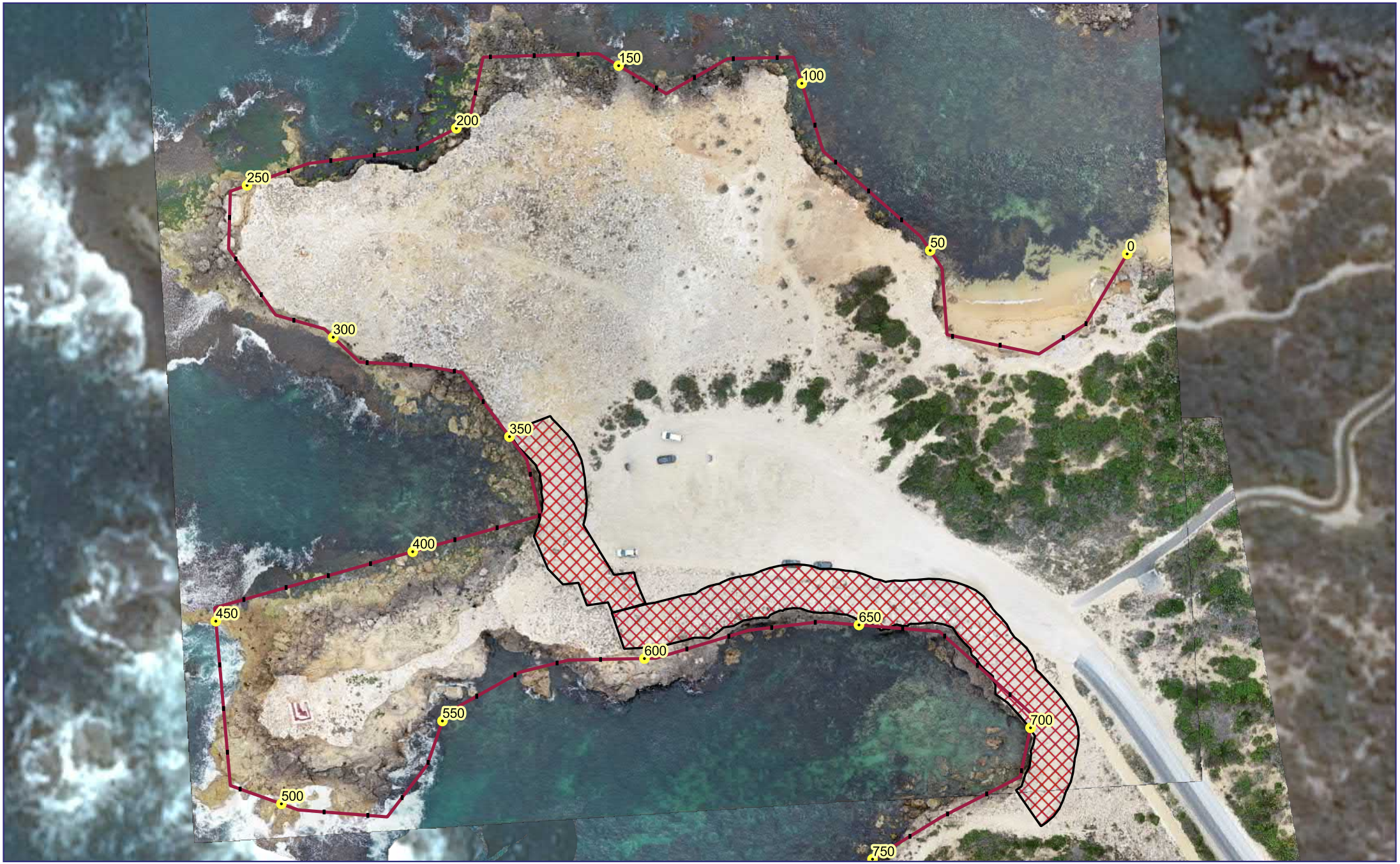
Recommendation

We suggest that further periodic drone surveys may provide Council with information that would assist in assessing the rate of erosion in the cliffs and the rate at which they are receding/collapsing. Weather conditions strongly affect the practicalities of drone flying, particularly near cliffs and other features that may affect satellite coverage. Our current belief and recommendation is that drone surveys around November/December and towards the end of March probably represent reasonably achievable timing

By undertaking visual/drone inspections prior to peak tourism seasons and undertaking practical actions to reduce risk, Council should be able to effectively manage the ongoing risk due to coastal erosion around the Obelisk Nature Walk.

The following Actions are summarised;

- Undertake frequent drone survey of the coast around Robe.
- Compare historic footage to determine rate of coastal recession.
- Undertake an informed risk assessment on the current watch zones along the Robe Coast.



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Job Number: 20181771
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Date: 2 Dec 2018
Drawn: Jason Barnett

Data Acknowledgement:
Aerial Photography taken by Tonkin Consulting, 29th November, 2018
Aerial from Google, 2018

0 10 20 30 40 50 m

Cliff Face
50m Chainages
10m Chainages
10m Exclusion Zone

N

District Council of Robe

CLIFF STABILITY ASSESSMENT
OBELISK CARPARK

MAP 3

References

Coffey Geotechnics. 2015. The Obelisk, Robe, Geotechnical Assessment. Coffey Geotechnics

Fotheringham. D, 2009. Cliff Top Erosion Adjacent Cape Domby, South Australia, Coastal Management Branch Technical Report 2009/08

SA Government, 2018. [online]: https://map.sarig.sa.gov.au/ [Accessed 29 Nov. 2018].

Appendix A

Field Photographs – Top Down Aerial (Approximately 120m from Surface)

Appendix A - Top Down Aerial (Approx 120m from Surface)

Chainage 0 to 100

Chainage 100 to 300

Chainage 300 to 400

Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview. (MAP 1)
Obelisk Carpark viewed in Chainage 300 to 400. Noted as high risk
Aerial Imagery Captured on the 29th of November 2018

Appendix A - Top Down Aerial (Approx 120m from Surface)

Chainage 400 to 600

Chainage 600 to 800

Chainage 800 to 900

Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview.
Obelisk Carpark viewed in Chainage 600 to 800. Noted as high risk
Aerial Imagery Captured on the 29th of November 2018

Appendix A - Top Down Aerial (Approx 120m from Surface)

Chainage 900 to 1100

Chainage 1100 to 1150

Chainage 1150 to 1230

Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview.
Obelisk Nature Walk Blow Hole viewed in Chainage1150 to 1230. Noted as high risk and to be monitored.
Aerial Imagery Captured on the 29th of November 2018

Appendix A - Top Down Aerial (Approx 120m from Surface)

Chainage 1230 to 1350

Chainage 1350 to 1400

Chainage 1400 to 1500

Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview.
Aerial Imagery Captured on the 29th of November 2018

Appendix A - Top Down Aerial (Approx 120m from Surface)

Chainage 1500 to 1600

Chainage 1600 to 1700

Chainage 1700 to 1800

Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview.
Aerial Imagery Captured on the 29th of November 2018

Appendix A - Top Down Aerial (Approx 120m from Surface)

Chainage 1800 to 1870

Chainage 1870 to 2000

Chainage 2000 to 2100

Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview.
Aerial Imagery Captured on the 29th of November 2018

Appendix A - Top Down Aerial (Approx 120m from Surface)

Chainage 2100 to 2150

Chainage 2150 to 2200

Chainage 2200 - 2290

Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview.
Aerial Imagery Captured on the 29th of November 2018

Appendix B

Field Photographs – Perspective Aerial (Approximately 120m from Surface)

Appendix B - Perspective Aerial (Approx 120m from Surface)

Chainage 0 to 200

Chainage 200 to 450

Chainage 450 to 825

Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview.
Aerial Imagery Captured on the 29th of November 2018

Appendix B - Perspective Aerial (Approx 120m from Surface)

Chainage 825 to 1050

Chainage 1000 to 1250

Chainage 1050 to 1220

Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview.
Aerial Imagery Captured on the 29th of November 2018

Appendix B - Perspective Aerial (Approx 120m from Surface)

Chainage 1150 to 1600

Chainage 1400 to 1600

Chainage 1500 to 1800

Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview.
Aerial Imagery Captured on the 29th of November 2018

Appendix B - Perspective Aerial (Approx 120m from Surface)

Chainage 1600 to 2000

Chainage 1800 to 2100

Chainage 2100 to 2300

Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview.
Aerial Imagery Captured on the 29th of November 2018

Appendix C

Field Photographs - Points of Interest

Appendix C - Points of Interest

RZ1_0 - Cliff Overhang (Right Side) - Chainage 50

RZ2_0 - Obelisk Main Car Park North Side - Chainage 370

RZ2_1 - Obelisk Main Car Park North Side - Chainage 370

Note: Aerial Photos and chainages to be read in conjunction with 20181771M03 - Areas of Considered Risk
Aerial Imagery Captured on the 29th of November 2018

Appendix C - Points of Interest

RZ2_2 - Obelisk Main Car Park North Side - Chainage 370

RZ2_3 - Obelisk Main Car Park North Side - Chainage 370

RZ2_4 - Obelisk Main Car Park North Side - Chainage 370

Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview.
Aerial Imagery Captured on the 29th of November 2018

Appendix C - Points of Interest

RZ3_0 - Obelisk Main Car Park South Side - Chainage 630

RZ3_1 - Obelisk Main Car Park South Side - Chainage 630

RZ3_2 - Obelisk Main Car Park South Side (Adjusted Brightness) - Chainage 630

Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview.
Aerial Imagery Captured on the 29th of November 2018

Appendix C - Points of Interest

RZ4_0 - Obelisk Main Car Park Entrance - Chainage 670

RZ4_1 - Obelisk Main Car Park Entrance - Chainage 670

RZ4_2 - Obelisk Main Car Park Entrance - Chainage 670

Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview.
Aerial Imagery Captured on the 29th of November 2018

Appendix C - Points of Interest

RZ5_0 - Cliff Undercutting - Chainage 825

RZ6_0 - Cliff Undercutting (Right Side) - Chainage 1000

RZ6_1 - Cliff Undercutting - Chainage 1000

Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview.
Aerial Imagery Captured on the 29th of November 2018

RZ6_2 - Cliff Undercutting - Chainage 1000

RZ6_3 - Cliff Undercutting - Chainage 1000

RZ7_0 - Cliff Overhang - Chainage 1100

Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview.
Aerial Imagery Captured on the 29th of November 2018

Appendix C - Points of Interest

RZ7_1 - Cliff Overhang - Chainage 1100

RZ8_0 - Blow Hole Undercutting of Cliff Face- Chainage 1200

RZ8_1 - Blow Hole Undercutting of Cliff Face- Chainage 1200

Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview.
Aerial Imagery Captured on the 29th of November 2018

Appendix C - Points of Interest

RZ8_2 - Blow Hole Undercutting of Cliff Face- Chainage 1200

RZ8_3 - Blow Hole Undercutting of Cliff Face- Chainage 1200

RZ9 - Undercutting of Cliff - Chainage 1220

Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview.
Aerial Imagery Captured on the 29th of November 2018

Appendix C - Points of Interest

RZ10_0 - Doorway Rock - Chainage 1330

RZ10_1 - Doorway Rock - Chainage 1330

RZ11 - Undercutting of Cliff (North Side of Carpark) - Car Park 2 - Chainage 1580

Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview.
Aerial Imagery Captured on the 29th of November 2018

Appendix C - Points of Interest

RZ12_0 - Undercut of Cliff Face with large soil mass above - Chainage 1750

RZ13_0 - Overhanging of Cliff Face - Chainage 1900

RZ14_0 - Undercutting of Cliff - Chainage 2150

Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview.
Aerial Imagery Captured on the 29th of November 2018

Appendix C - Points of Interest

RZ15_0 - Obelisk Nature Walk - Southern Carpark - Undercutitng of Cliff - Chainage 2250

RZ15_1 - Obelisk Nature Walk - Southern Carpark - Undercutitng of Cliff - Chainage 2250

RZ15_2 - Obelisk Nature Walk - Southern Carpark - Undercutitng of Cliff - Chainage 2250

Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview.
Aerial Imagery Captured on the 29th of November 2018

Appendix A - Top Down Aerial (Approx 120m from Surface)

Chainage 0 to 100

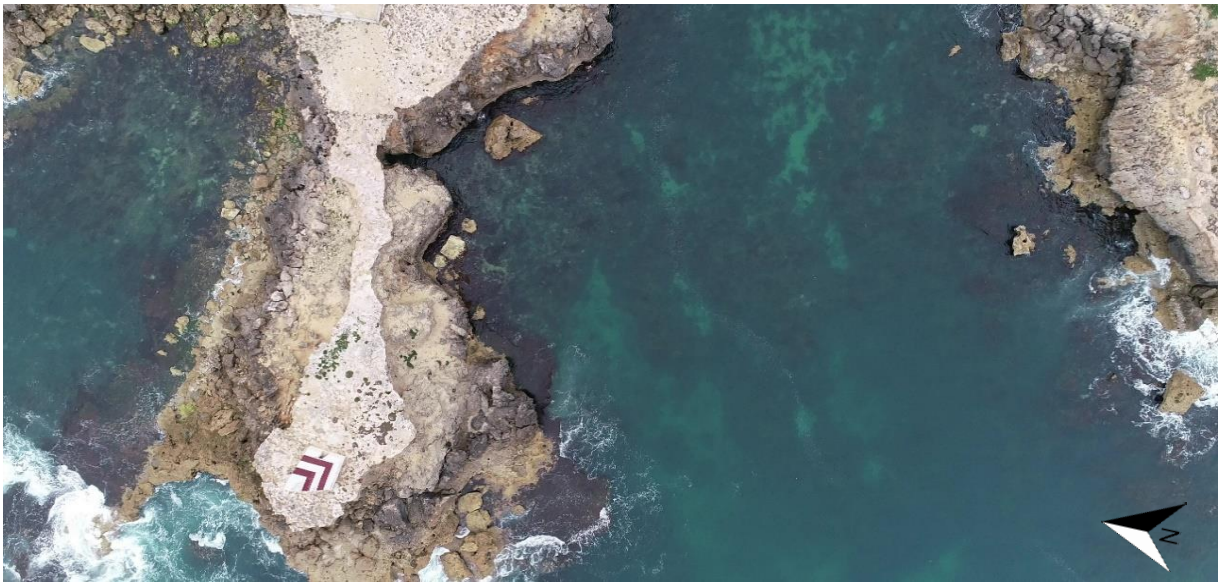
Chainage 100 to 300

Chainage 300 to 400

Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview. (MAP 1)
Obelisk Carpark viewed in Chainage 300 to 400. Noted as high risk
Aerial Imagery Captured on the 29th of November 2018

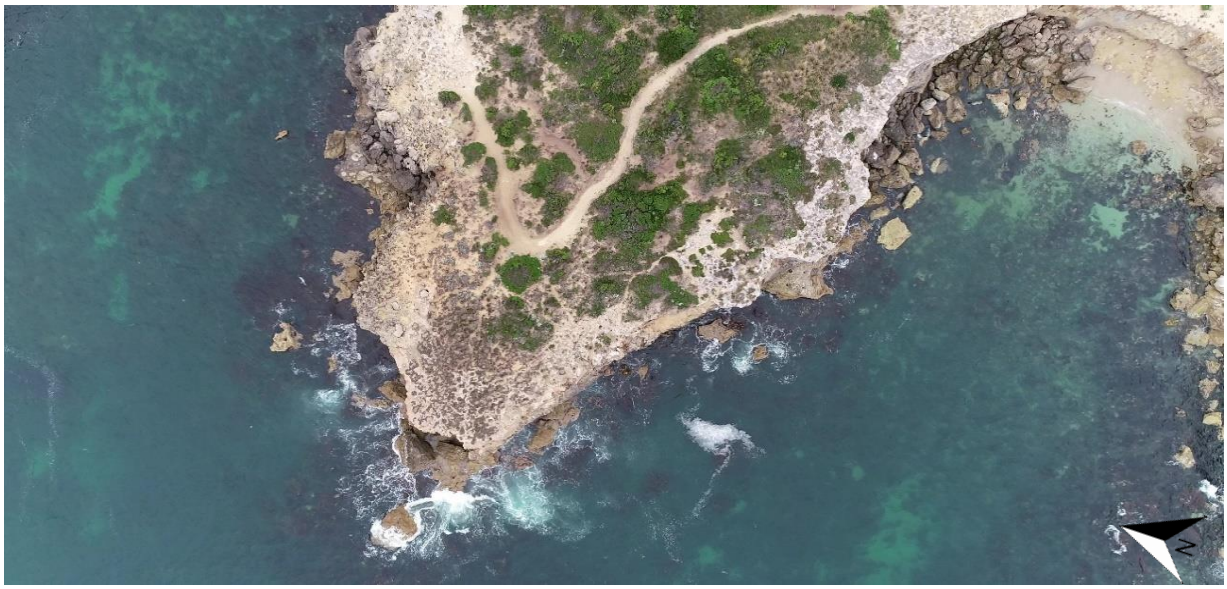
Appendix A - Top Down Aerial (Approx 120m from Surface)

Chainage 400 to 600



Chainage 600 to 800

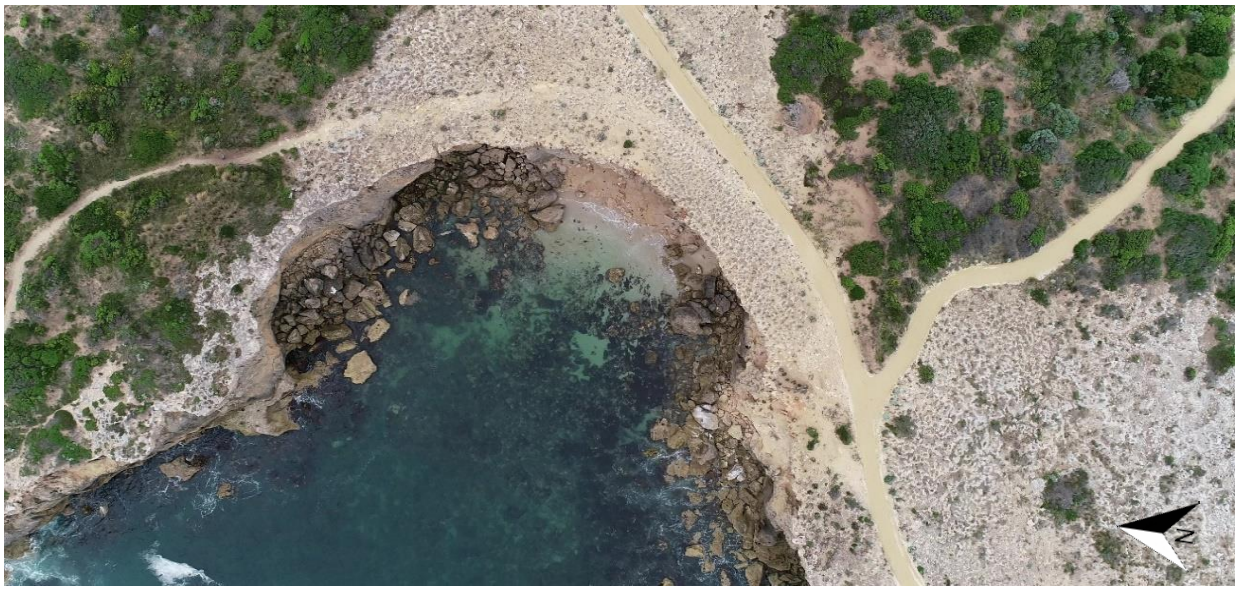
Chainage 800 to 900



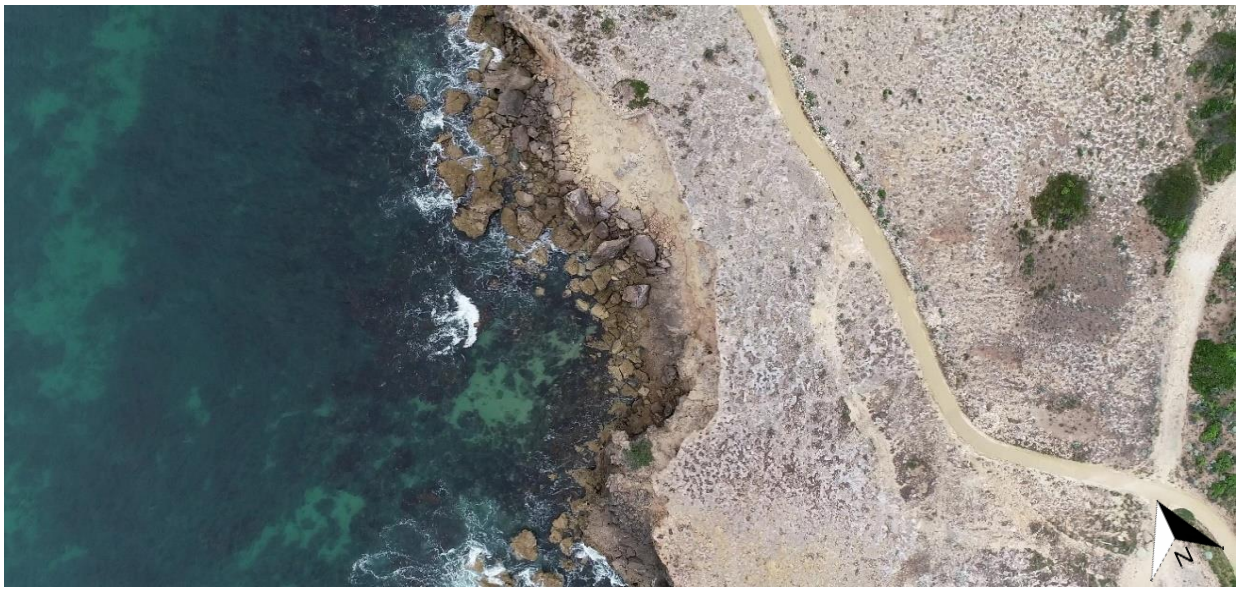
Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview.
Obelisk Carpark viewed in Chainage 600 to 800. Noted as high risk
Aerial Imagery Captured on the 29th of November 2018

Appendix A - Top Down Aerial (Approx 120m from Surface)

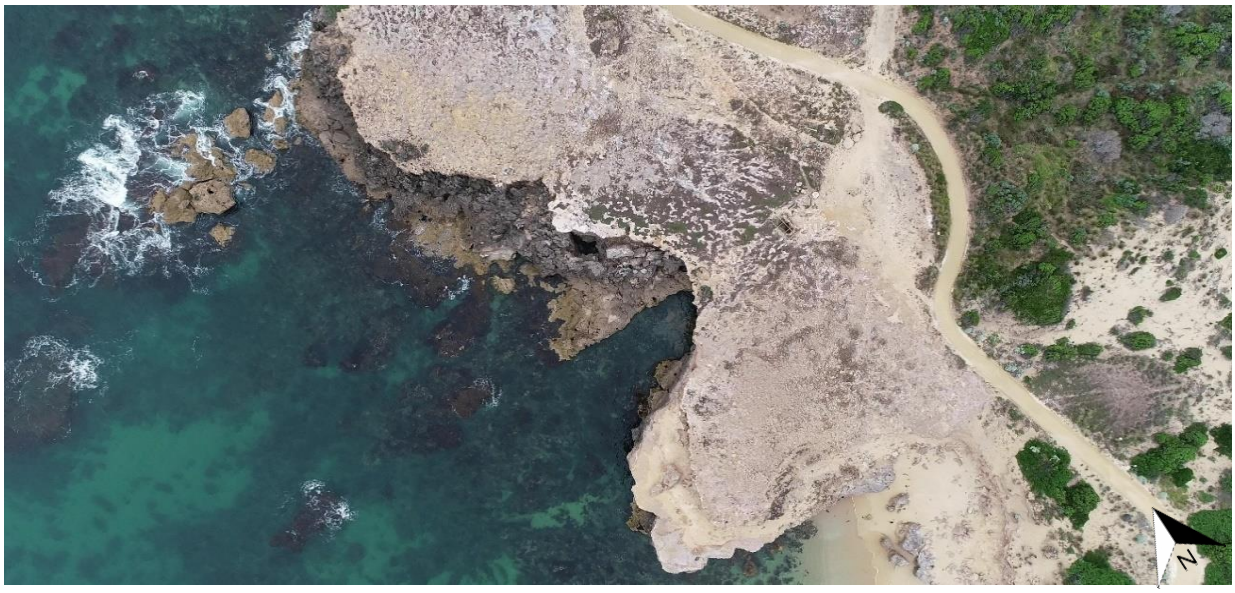
Chainage 900 to 1100



Chainage 1100 to 1150



Chainage 1150 to 1230

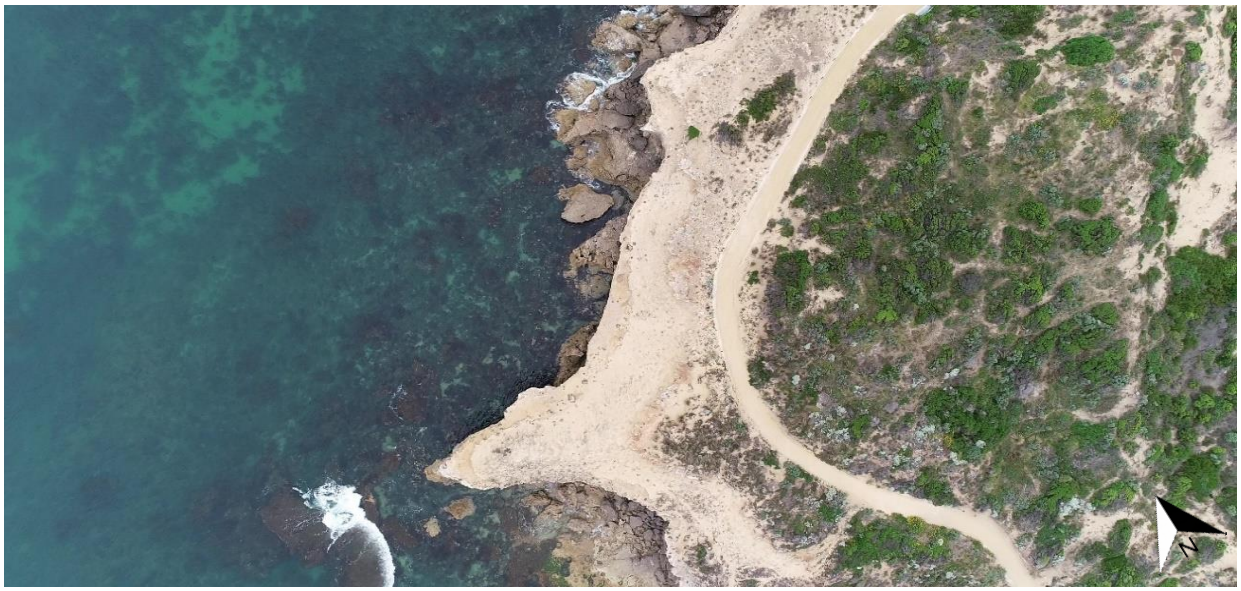


Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview.
Obelisk Nature Walk Blow Hole viewed in Chainage1150 to 1230. Noted as high risk and to be monitored.
Aerial Imagery Captured on the 29th of November 2018

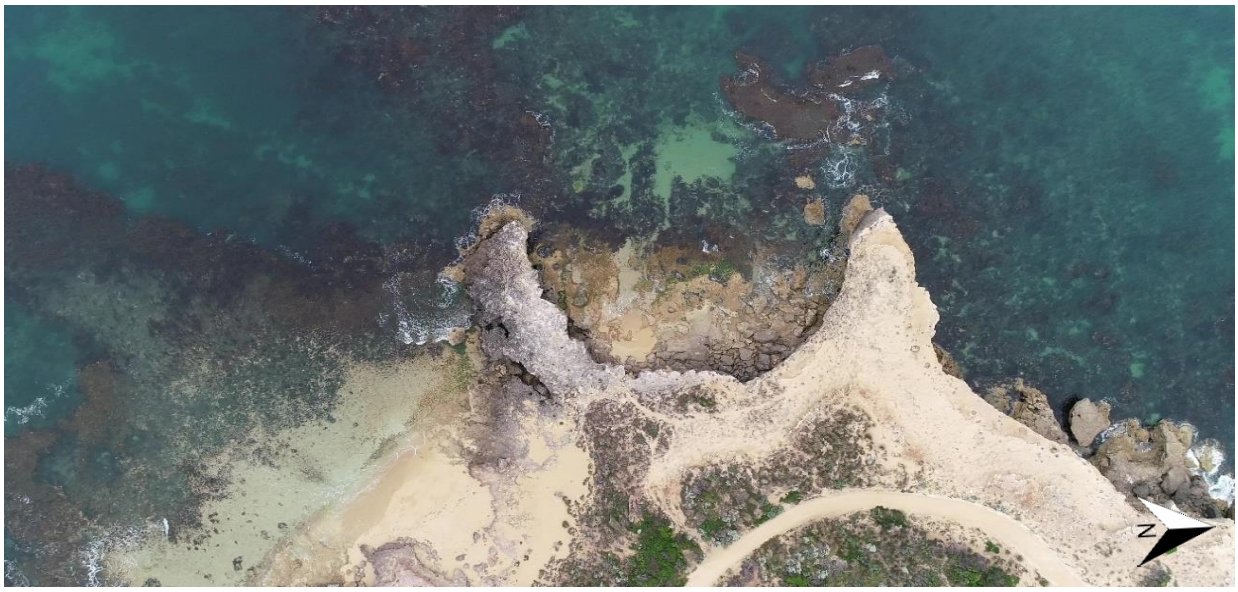
Appendix A - Top Down Aerial (Approx 120m from Surface)

Chainage 1230 to 1350

Chainage 1350 to 1400



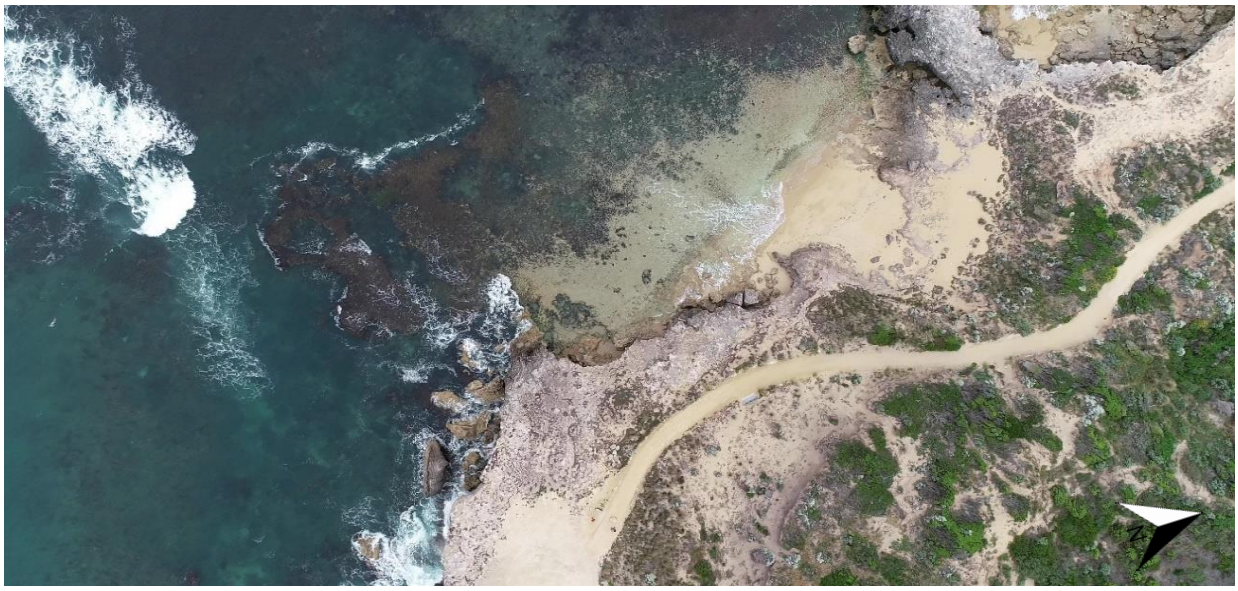
Chainage 1400 to 1500



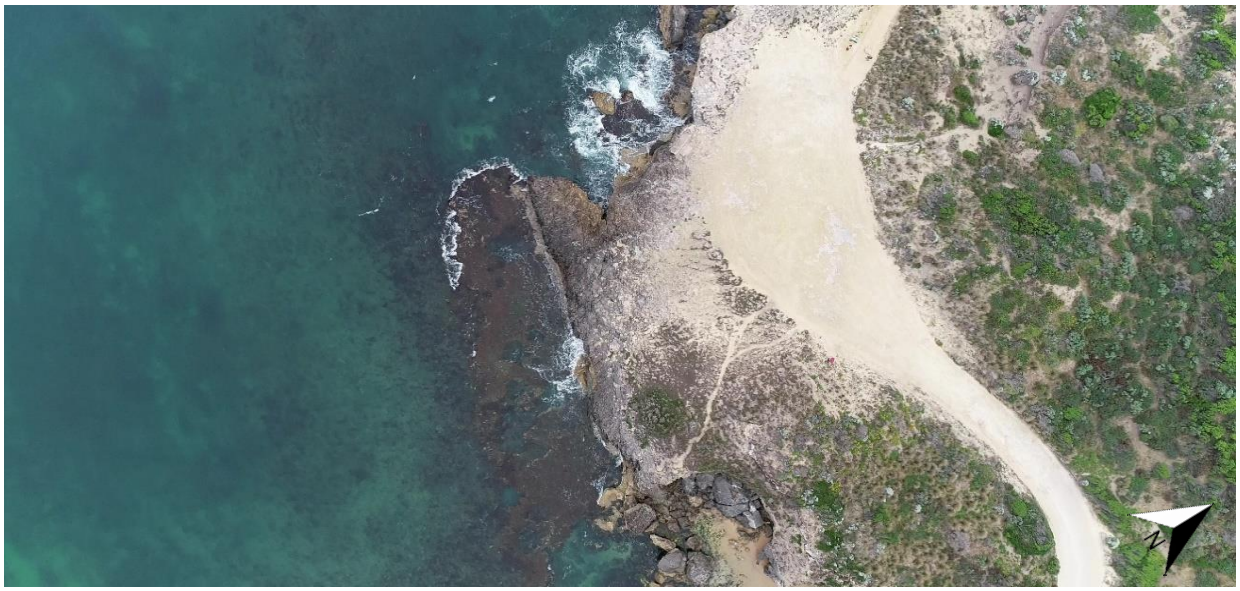
Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview.
Aerial Imagery Captured on the 29th of November 2018

Appendix A - Top Down Aerial (Approx 120m from Surface)

Chainage 1500 to 1600



Chainage 1600 to 1700



Chainage 1700 to 1800

Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview.
Aerial Imagery Captured on the 29th of November 2018

Appendix A - Top Down Aerial (Approx 120m from Surface)

Chainage 1800 to 1870

Chainage 1870 to 2000

Chainage 2000 to 2100

Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview.
Aerial Imagery Captured on the 29th of November 2018

Appendix A - Top Down Aerial (Approx 120m from Surface)

Chainage 2100 to 2150

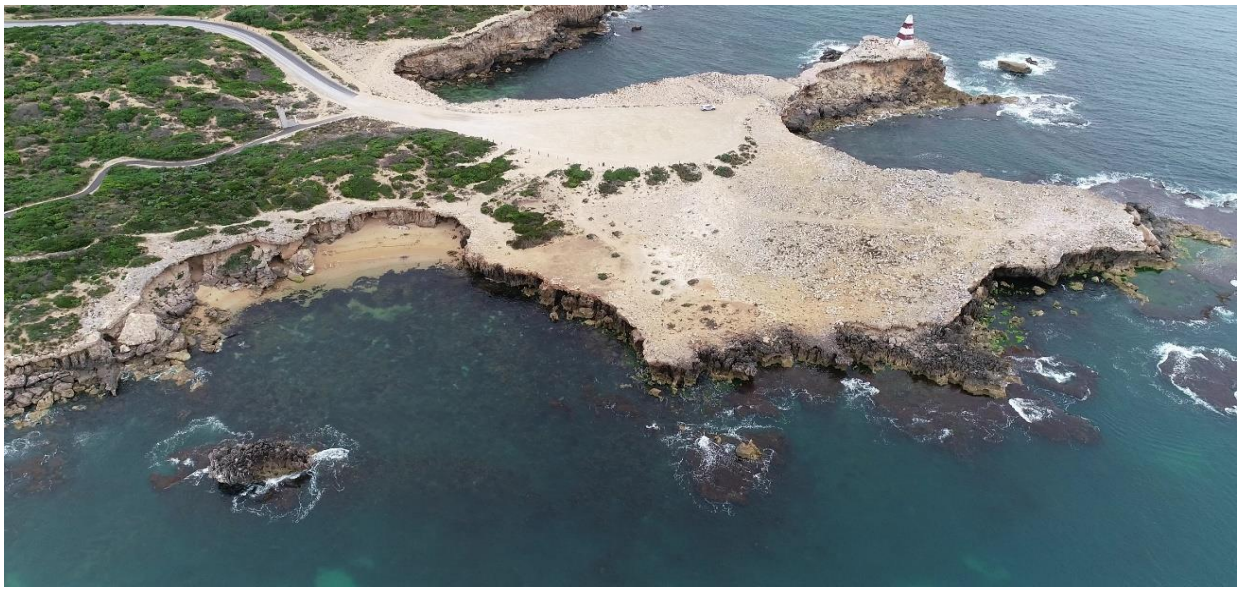
Chainage 2150 to 2200

Chainage 2200 - 2290

Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview.
Aerial Imagery Captured on the 29th of November 2018

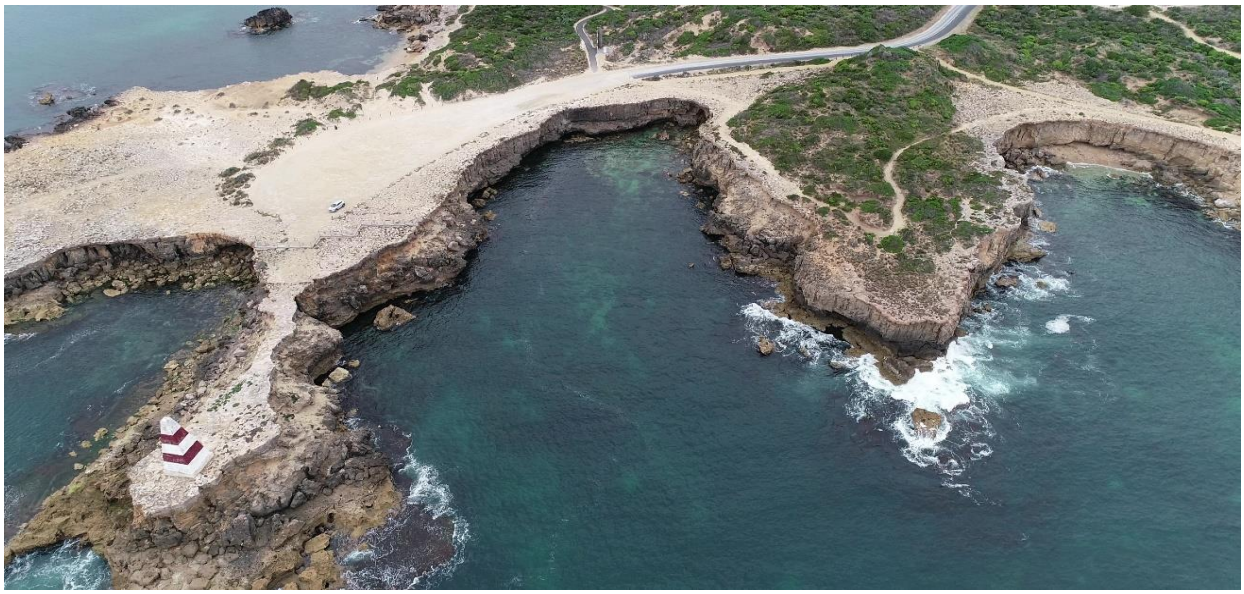
Appendix B - Perspective Aerial (Approx 120m from Surface)

Chainage 0 to 200



Chainage 200 to 450

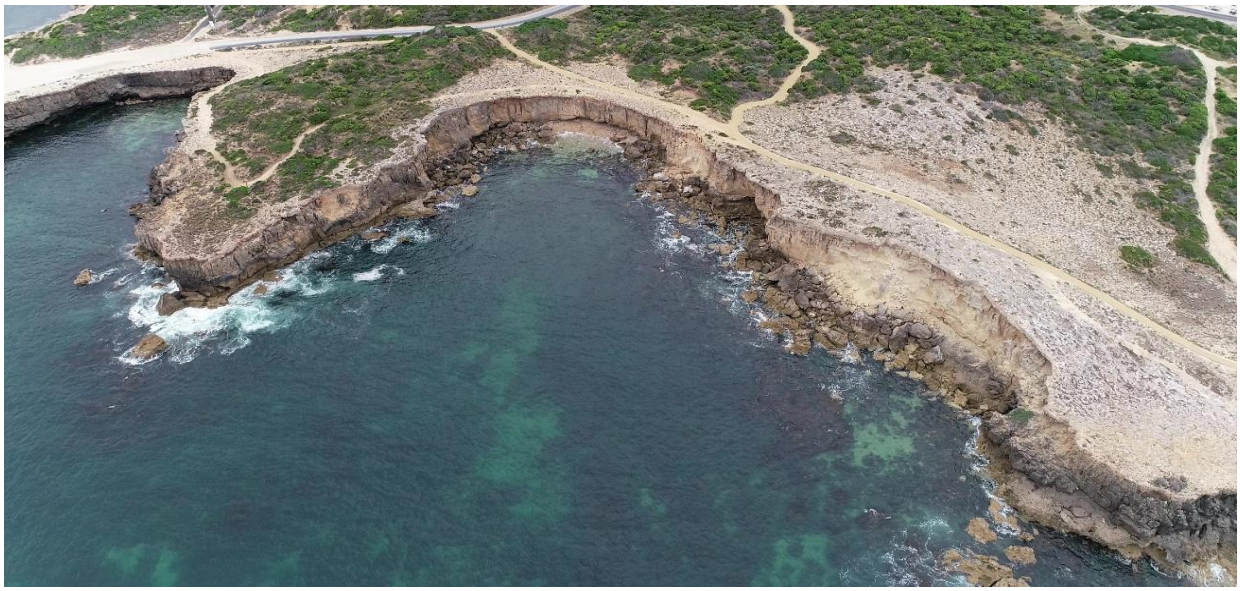
Chainage 450 to 825



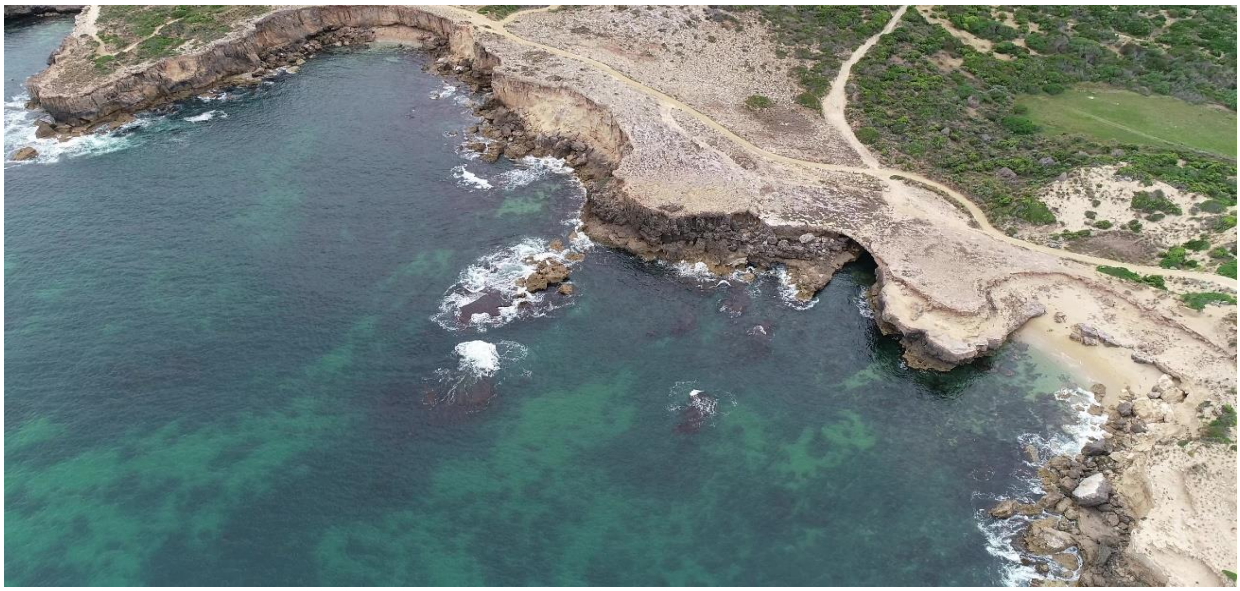
Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview.
Aerial Imagery Captured on the 29th of November 2018

Appendix B - Perspective Aerial (Approx 120m from Surface)

Chainage 825 to 1050



Chainage 1000 to 1250



Chainage 1050 to 1220

Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview.
Aerial Imagery Captured on the 29th of November 2018

Appendix B - Perspective Aerial (Approx 120m from Surface)

Chainage 1150 to 1600

Chainage 1400 to 1600

Chainage 1500 to 1800

Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview.
Aerial Imagery Captured on the 29th of November 2018

Appendix B - Perspective Aerial (Approx 120m from Surface)

Chainage 1600 to 2000

Chainage 1800 to 2100

Chainage 2100 to 2300

Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview.
Aerial Imagery Captured on the 29th of November 2018

Appendix C - Points of Interest

RZ1_0 - Cliff Overhang (Right Side) - Chainage 50

RZ2_0 - Obelisk Main Car Park North Side - Chainage 370

RZ2_1 - Obelisk Main Car Park North Side - Chainage 370

Note: Aerial Photos and chainages to be read in conjunction with 20181771M03 - Areas of Considered Risk
Aerial Imagery Captured on the 29th of November 2018

RZ2_2 - Obelisk Main Car Park North Side - Chainage 370

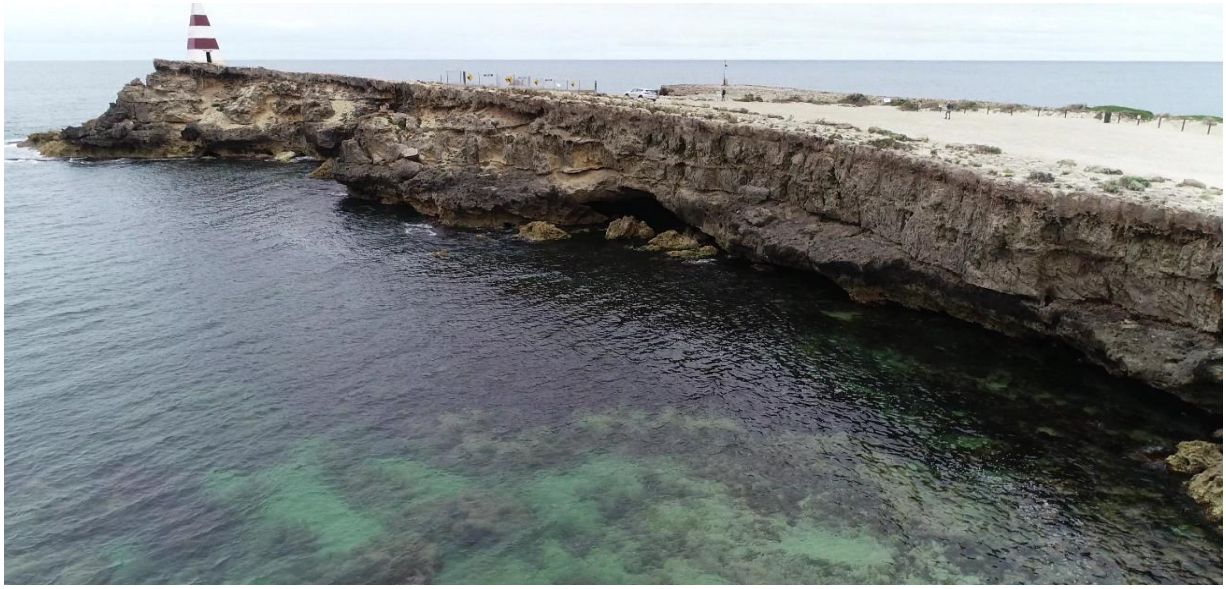
RZ2_3 - Obelisk Main Car Park North Side - Chainage 370

RZ2_4 - Obelisk Main Car Park North Side - Chainage 370

Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview.
Aerial Imagery Captured on the 29th of November 2018

Appendix C - Points of Interest

RZ3_0 - Obelisk Main Car Park South Side - Chainage 630



RZ3_1 - Obelisk Main Car Park South Side - Chainage 630

RZ3_2 - Obelisk Main Car Park South Side (Adjusted Brightness) - Chainage 630

Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview.
Aerial Imagery Captured on the 29th of November 2018

Appendix C - Points of Interest

RZ4_0 - Obelisk Main Car Park Entrance - Chainage 670

RZ4_1 - Obelisk Main Car Park Entrance - Chainage 670

RZ4_2 - Obelisk Main Car Park Entrance - Chainage 670

Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview.
Aerial Imagery Captured on the 29th of November 2018

Appendix C - Points of Interest

RZ5_0 - Cliff Undercutting - Chainage 825

RZ6_0 - Cliff Undercutting (Right Side) - Chainage 1000

RZ6_1 - Cliff Undercutting - Chainage 1000

Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview.
Aerial Imagery Captured on the 29th of November 2018

Appendix C - Points of Interest

RZ6_2 - Cliff Undercutting - Chainage 1000

RZ6_3 - Cliff Undercutting - Chainage 1000

RZ7_0 - Cliff Overhang - Chainage 1100

Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview.
Aerial Imagery Captured on the 29th of November 2018

Appendix C - Points of Interest

RZ7_1 - Cliff Overhang - Chainage 1100

RZ8_0 - Blow Hole Undercutting of Cliff Face- Chainage 1200

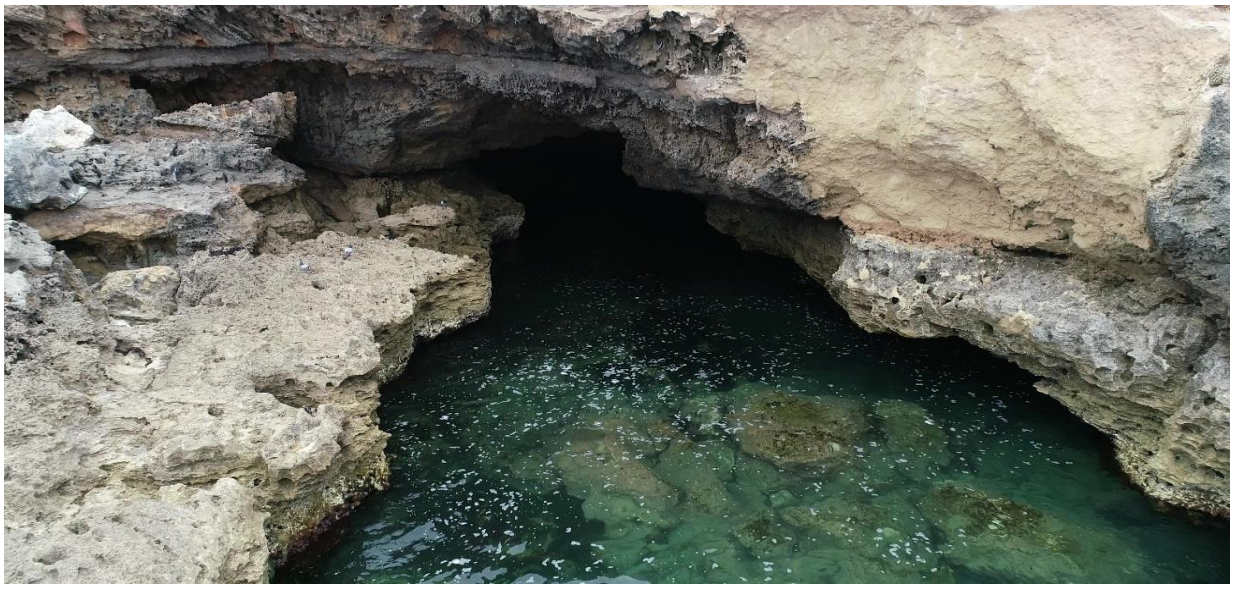
RZ8_1 - Blow Hole Undercutting of Cliff Face- Chainage 1200

Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview.
Aerial Imagery Captured on the 29th of November 2018

Appendix C - Points of Interest

RZ8_2 - Blow Hole Undercutting of Cliff Face- Chainage 1200

RZ8_3 - Blow Hole Undercutting of Cliff Face- Chainage 1200

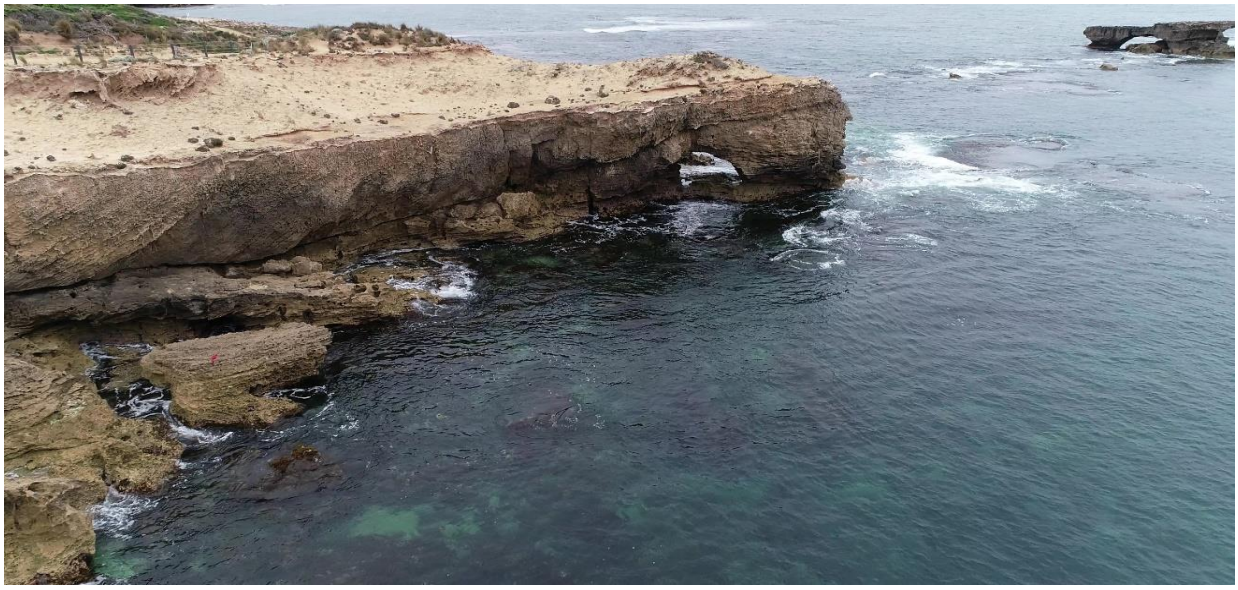


RZ9 - Undercutting of Cliff - Chainage 1220

Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview.
Aerial Imagery Captured on the 29th of November 2018

Appendix C - Points of Interest

RZ10_0 - Doorway Rock - Chainage 1330



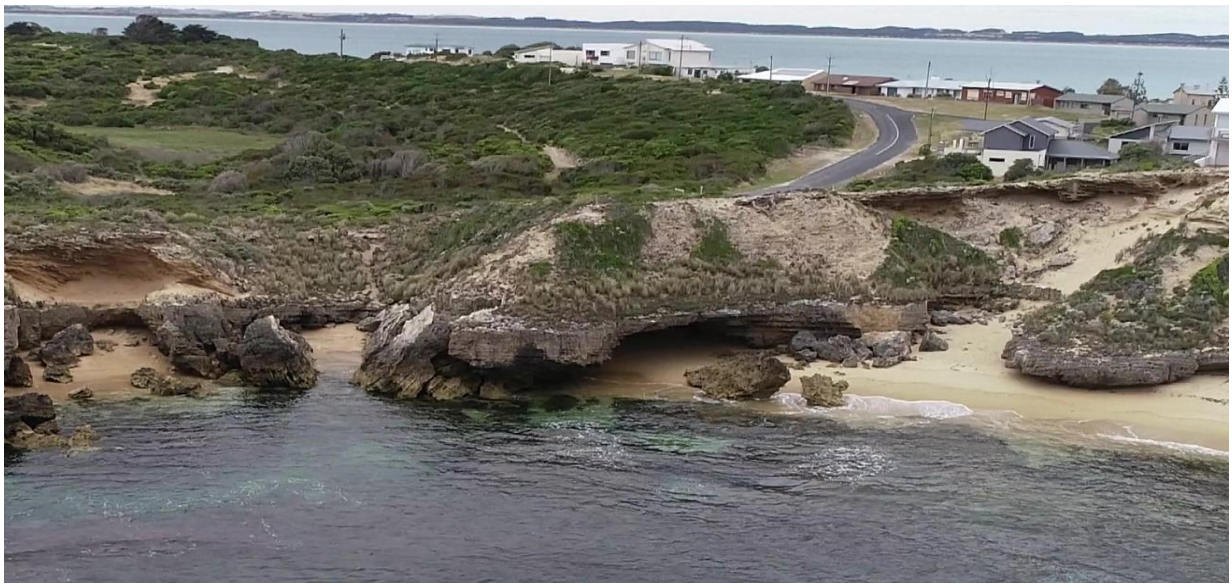
RZ10_1 - Doorway Rock - Chainage 1330

RZ11 - Undercutting of Cliff (North Side of Carpark) - Car Park 2 - Chainage 1580

Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview.
Aerial Imagery Captured on the 29th of November 2018

Appendix C - Points of Interest

RZ12_0 - Undercut of Cliff Face with large soil mass above - Chainage 1750



RZ13_0 - Overhanging of Cliff Face - Chainage 1900

RZ14_0 - Undercutting of Cliff - Chainage 2150

Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview.
Aerial Imagery Captured on the 29th of November 2018

Appendix C - Points of Interest

RZ15_0 - Obelisk Nature Walk - Southern Carpark - Undercutitng of Cliff - Chainage 2250

RZ15_1 - Obelisk Nature Walk - Southern Carpark - Undercutitng of Cliff - Chainage 2250

RZ15_2 - Obelisk Nature Walk - Southern Carpark - Undercutitng of Cliff - Chainage 2250

Note: Aerial Photos and chainages to be read in conjunction with 20181771M01 Coastal Chainage Overview.
Aerial Imagery Captured on the 29th of November 2018