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WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Apollo Bay, Skenes Creek & Marengo CIP

Issues and Opportunities Paper: Coastal

Tract Consultants Pty Ltd

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23 June 2019

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Dear Danielle

Issues and Opportunities Paper: Coastal

We are pleased to present our report enclosed for the coastal component of the Issues and Opportunities Paper for the Apollo Bay, Skenes Creek and Marengo Community Infrastructure Plan (CIP). If you have any queries, please do not hesitate to contact me on (08) 6555 0105.

Yours sincerely

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1 INTRODUCTION

Water Technology has been engaged by Tract Consultants Pty Ltd (Tract) to assess coastal processes and hazards, and the suitability of locations for new infrastructure proposed in Tract's forthcoming Apollo Bay Community Infrastructure Plan (CIP). Specifically, the focus areas are Marengo, Apollo Bay, and Skenes Creek (see locality plan in Figure 1-2) bounded by the polygons supplied by Tract in Figure 1-1. Water Technology has reviewed previous reports that assess coastal processes in the area and has summarised the relevant information below. Utilising analysis of inundation extents conducted by Water Technology for the Department of Sustainability (Water Technology, 2012) the areas are re-analysed with respect to the specific areas of interest. A site visit was conducted on the 7th of June 2019 to investigate those areas in detail and capture GPS located images to assist with our recommendations and advice.

It should be noted that areas immediately outside of the nominated focus areas have locally identified coastal hazards that would impede foreshore redevelopment. Any plan to modify areas outside these focus areas should make due consideration to these coastal hazards.

FIGURE 1-1 FOCUS AREAS OF THIS STUDY (SUPPLIED BY TRACT)

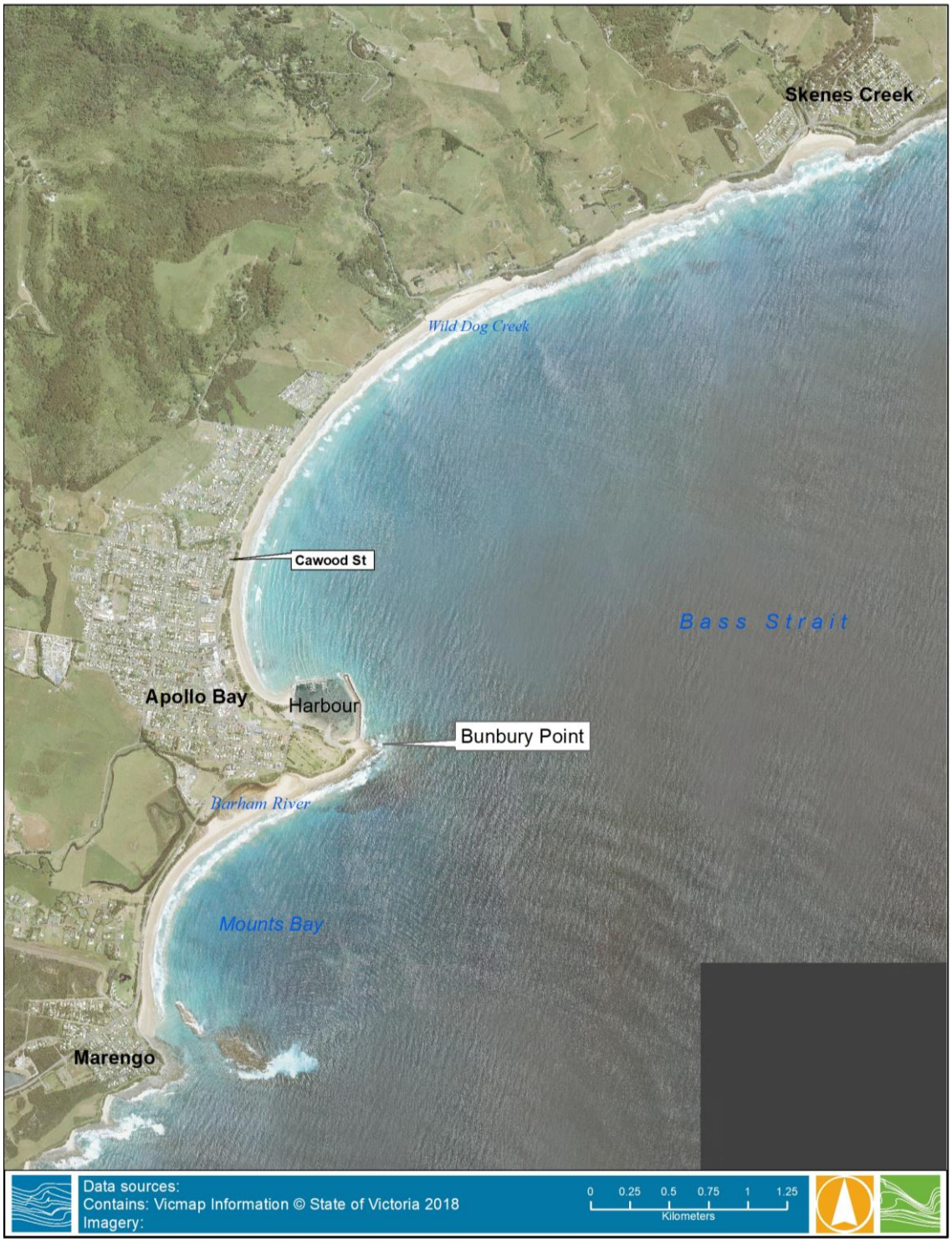

FIGURE 1-2 LOCALITY PLAN OF SKENES CREEK, APOLLO BAY, AND MARENGO AREAS WITHIN THE CIP

2 COASTAL PROCESSES

2.1 Desktop Review

There has been a significant amount of previous work in the area that covers all three of the locations in Figure 1-1. They are as follows:

- Vantree Pty Ltd (1996) Apollo Bay Coastal Processes
- Vantree Pty Ltd (1997) Mounts Bay Beach: Report on Coastal Erosion
- Coastal Engineering Solutions (2005) Apollo Bay Sand Study
- GHD (2009) Apollo Bay Sand and Dredging Options Study
- Water Technology (2012) Coastal Hazards Management Plan - Skenes Creek to Apollo Bay
- Water Technology (2013) Apollo Bay Harbour Coastal Hazard Vulnerability Assessment
- Water Technology (2017) Marengo to Wild Dog Creek Sand Management Plan
- GHD (2018) Apollo Bay – Coastal Protection Study

Water Technology reports from 2012, 2013, and 2017 are particularly useful for this assessment as they specifically address coastal inundation with respect to the latest available LiDAR data (VIC coast Digital Elevation Model (DEM)).

2.2 Geomorphology and Sediment Transport

Apollo Bay is located at the foot of the Otway Ranges which consist of uplifted Cretaceous sedimentary formations reaching elevations of approximately 300 m above sea level behind Apollo Bay. The Cretaceous sediments are rich in feldspar rather than quartz and therefore the erosion of these formations does not supply appreciable quantities of sand sized sediments to the coastline. The littoral sediments comprising the sand bars, beaches and dunes in the region are therefore derived from sediments drifted shoreward from the floor of Bass Strait following the end of the last glacial phase and subsequent marine transgression. The main features of the coastal geomorphology and processes of the study area are displayed in Figure 2-1 and discussed below.

Mounts Bay beach is a component of a Holocene barrier that has built out across the floodplain of the Barham River by longshore drifting of sediment. The Great Ocean Road extends along the crest of this Holocene barrier formation. Behind the present-day barrier, a series of abandoned lagoons, tidal channels and early barrier formations indicate the present barrier most likely formed recently following relative sea level fall during the late Holocene (<5,000 years before present).

Between Apollo Bay and Wild Dog Creek, a continuous, crenulate shaped bluff exists behind the present-day shoreline, indicating the location of an earlier shoreline cliff that most likely occurred along this coastline during relatively higher sea level conditions of the mid Holocene (6,000-7,000 years before present). The relative fall in mean sea levels since the mid Holocene has facilitated the development of the present-day dune and beach system seaward of this earlier coastline.

The beach systems within the study area are composed of medium to fine grained, calcareous sand. Previous analysis undertaken by CES (2005) estimated that the net sediment transport potential is approximately 80,000m^3/year towards the north-east.

Following construction of the Apollo Bay Harbour, the longshore transport around Point Bunbury was captured by the breakwater and Harbour. The construction of the harbour also created a wave shadow along the beach in its immediate lee to the north. In the lee of the harbour, wind-blown sand caused a build-up of the shoreline.

The reduction in wave energy along the shoreline in the lee of the breakwater meant the sand was not transported out of the system once brought in by the wind. In addition to this, local changes to wave directions due to wave diffraction around the breakwaters has resulted in a reduction in the potential north-east longshore transport of sand. The reduction in the longshore sediment supply along the Apollo Bay shoreline has resulted in significant accretion of sand in the southern corner of the beach at Apollo Bay, extending north to approximately Cawood Street. This accretion has been further enhanced by regular sand bypassing of the Harbour entrance which has deposited sand within the wave shadow zone in the lee of the Harbour.

The disruption of the longshore sand transport continuity along the beach at Apollo Bay caused by the construction of the Harbour has contributed to long-term shoreline recession observed along the beach at Apollo Bay beyond Cawood Street to the north of the Harbour.

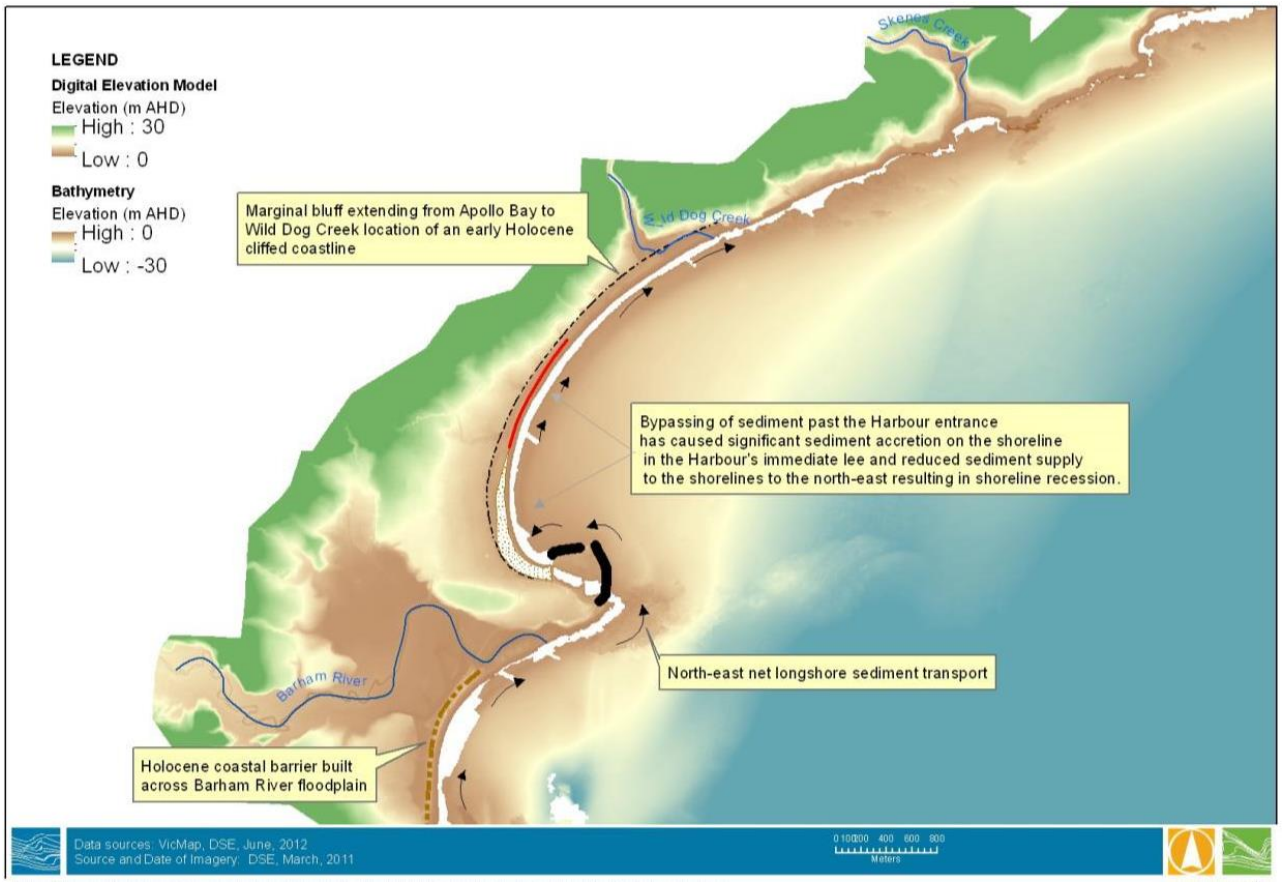

FIGURE 2-1 OVERVIEW OF COASTAL PROCESSES AND GEOMORPHOLOGY (WATER TECHNOLOGY, 2012)

2.3 Historical Shoreline Change

The shoreline between Marengo and Skenes Creek has been dynamic in recent decades, exhibiting long-term patterns of change associated with the construction of Apollo Bay Harbour and short-term localised erosion as a result of storm events.

2.3.1 Construction of the Apollo Bay Harbour

The construction of the Harbour in the 1950s changed sediment transport patterns of the area as outlined in Section 2.2. There has been significant shoreline advancement of the coast in the town centre to Cawood Street (Figure 2-2). Rates of advancement averaged 0.8 metres per year at times and have stabilised from 1980s onwards (CES, 2005). Recent stabilisation is due to a reduction in the sediment capture by the harbour

as it had 'filled up', as well as equilibrium between bypass operations supplying sediment to the nearshore and erosion.

Erosion from Cawood St further north to Wild Dog Creek has occurred as a result of the sediment trapping in lee of the Harbour (Water Technology, 2012). Although there is evidence that the area has stabilised, recent storm activity has eroded as much as 10,000 m^3 from the shoreline between 2007 and 2016 (Water Technology, 2017). Dune re-nourishment has been employed along this stretch of coast in 2019 to protect against further erosion events.

Wild Dog Creek Groyne serves to trap sediment moving north and has developed a stable dune 315 m long and 35-40 m wide (Water Technology, 2017).

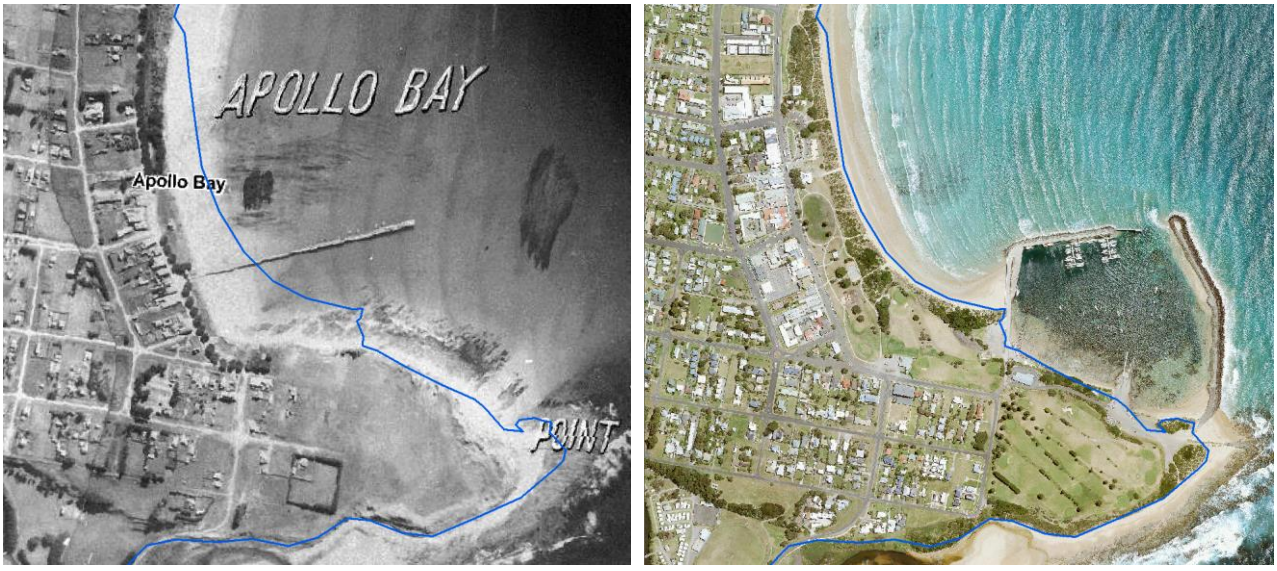

FIGURE 2-2 APOLLO BAY COASTLINE BEFORE HARBOUR CONSTRUCTION (LEFT) COMPARED TO 2014 (RIGHT). BLUE LINE REPRESENTS THE COASTLINE AT APPROXIMATELY 2.5 M AHD (VIC COAST LIDAR, 2007).

2.3.2 Marengo and Mounts Bay

Marengo lies at the southern end of Mounts Bay, which has experienced consistent erosion of its southern dune foreshore since the 1950s. It is hypothesised that net sediment transport to the north, leading to 65 m of shoreline advancement in the vicinity of the Barham River mouth, has caused erosion due to lack of sediment delivery to the area from further south of Marengo. The dunes in the area of interest for the CIP to the south of the Bay experienced a net loss of sediment in the 1940s, resulting in shoreline retreat of 21 metres (CES, 2005). This area has since stabilised and was not outlined as vulnerable in Water Technology's 2017 report.

2.3.3 Skenes Creek

The Skenes Creek area is relatively stable, although detailed long-term mapping has not been conducted for the area. Water Technology (2012) found that the area is resilient to erosion due to fencing, formalisation of beach access, and revegetation of dune areas. The creek intersecting the beach is dynamic and since 2014 has moved along the foreshore to the south-west. This has scoured the foredune in front of beach access paths and made access to the beach difficult for beachgoers.

2.4 Wave Climate

The wave climate offshore of Apollo Bay is high energy and southwest dominated, as storms from the Southern Ocean track west to east and produce strong west-southwest winds in the swell window of Apollo Bay. The Average Recurrence Interval (ARI) of significant wave heights 5.5 km offshore of Apollo Bay, where depths are approximately 45 metres, were analysed by GHD (2018) using publicly available wave hindcast data from the Centre for Australian Weather and Climate Research (CAWCR) (Table 2-1). The wave model data indicates that 94.5% of waves are from the south-west (5-6 metre Hs corresponds to an ARI of 1-10 years), the remainder (5.5%) are produced by south and south-east storms, which can also produce waves in the order of 5-6 metres, but at a longer ARI (10 to 50 years).

TABLE 2-1 AVERAGE RECURRENCE INTERVAL SIGNIFICANT WAVE HEIGHTS FROM THE SOUTHWEST AND SOUTHEAST

ARI (years)	Hs from all directions (m)	Hs from SE (m)	Hs from SW (m)
1	5.3	3.8	5.3
10	6.3	4.9	6.3
50	7.0	6	6.9
100	7.2	6.5	7.2

2.5 Storm Tide

The term *storm tide* refers to coastal water levels produced by the combination of astronomical and meteorological ocean water level forcing. The meteorological component of the storm tide is commonly referred to as *storm surge* and collectively describes the variation in coastal water levels in response to atmospheric pressure fluctuations and wind setup. Estimates of extreme coastal water levels (storm tides), including the impact of projected sea level rise, have been developed by the CSIRO (2009) for different planning and sea level rise scenarios and are displayed in Table 2-2 for Apollo Bay.

TABLE 2-2 10-YEAR ARI AND 100-YEAR ARI STORM TIDE LEVELS INCORPORATING MEAN SEA LEVEL RISE SCENARIOS

ARI at Apollo Bay	Existing (m AHD)	2030 High (m AHD)	2070 High (m AHD)	2100 High (m AHD)
10	1.10 ± 0.12	1.30	1.71	2.13
100	1.42 ± 0.13	1.63	2.04	2.46

2.6 Coastal Erosion and Inundation Risk

2.6.1 Apollo Bay

The areas predicted to be inundated by the present day to projected 2100 100-year ARI Storm Tide are shown in Figure 2-3. The levels inundated represent areas where topographical LiDAR levels provided by the Department of Sustainability and Environment (DSE, 2009) are below the projected storm tide.

Inundation due to storm tides at Apollo Bay within Tract's area of interest is expected to be minimal, with dunes providing sufficient protection in their current form. This is due to the lower wave energy in lee of the Harbour breakwaters and gently sloping nearshore bathymetry that dissipates refracted wave energy. Although the risk

of inundation will increase with further dune retreat, the nature of the present infrastructure and land use results in a medium risk outlook for the area (Water Technology, 2013).

North of Cawood Street, outside of Tract's supplied area of interest, the inundation risk is significantly higher due to exposure to higher wave energy and lower dune crests. As such, dune re-nourishment and stabilisation works have recently been conducted in the area.

GHD (2018) provided an estimation of dune erosion in 2018 due to storm events in June and found that between 6.7 and 18.1 m^3/m of erosion had occurred, coinciding with a foreshore retreat of up to 1 m. With sea level rise this rate of recession would increase. Long-term recession of the Apollo Bay Foreshore Reserve was assessed by Water Technology (2013) based on the Bruun Rule (1962). Rates of recession for sandy shorelines can be in the range of 40-80 m for predicted sea level rise over the coming century. This amount of shoreline recession would return the coastline to its position prior to Harbour construction (Figure 2-2) unless hard coastal defences and/or increased sand nourishment were utilised. According to updated calculations of shoreline recession based on Water Technology (2012) methods, the rate of shoreline recession over the next 10 years would be between 1 m (almost certain) to 4 metres (rare) (GHD, 2018). Erosion risk calculated by Water Technology (2012) for almost certain, unlikely, and rare events is presented in (Figure 2-4).

2.6.2 Marengo

Marengo has not been assessed in detail in previous reports due to resilience provided by the coastal cliffs around its headland.

Water Technology (2012) assessed the inundation risk to the area bordering Marengo and Mounts Bay and found that the carpark and dunes within the CIP study area would be inundated in cases where peak storm tide inundation and wave runup reached between 3.9 and 4.6 m (AHD), based on a 100 year ARI storm tide and corresponding significant wave heights of 5 – 8 m (Figure 2-5). Analysis of updated LiDAR with the same elevations from the Water Technology (2012) report, indicates that inundation would not cover the entire carpark area (Figure 2-6).

Erosion risk previously calculated by Water Technology (2012) for almost certain, unlikely, and rare events is presented in (Figure 2-7).

Both inundation and erosion risk increase significantly to the north of the Tract area of interest. With recent erosion requiring dune re-nourishment and stabilisation in the area.

2.6.3 Skenes Creek

As discussed above in Section 2.3.2, Skenes Creek is relatively stable. Water Technology's (2012) assessment of historical coastal impacts show erosion of access paths due to large storms as well as inundation risk to existing infrastructure and assets including carparks, toilet blocks, and the caravan park (Figure 2-8). Potential areas for future infrastructure upstream of the bridge are low-lying and inundate in 10-year ARI events. A more realistic assessment of inundation for areas north of the bridge is to consider storm tide inundation without wave runup due to its sheltered location (Figure 2-9).

Corresponding erosion risk calculated by Water Technology (2012) is presented in (Figure 2-10).

FIGURE 2-3 APOLLO BAY INUNDATION AND RISK. ASSETS AT RISK INCLUDE CAR PARKS AND LOW-LYING AREAS OF THE INNER HARBOUR

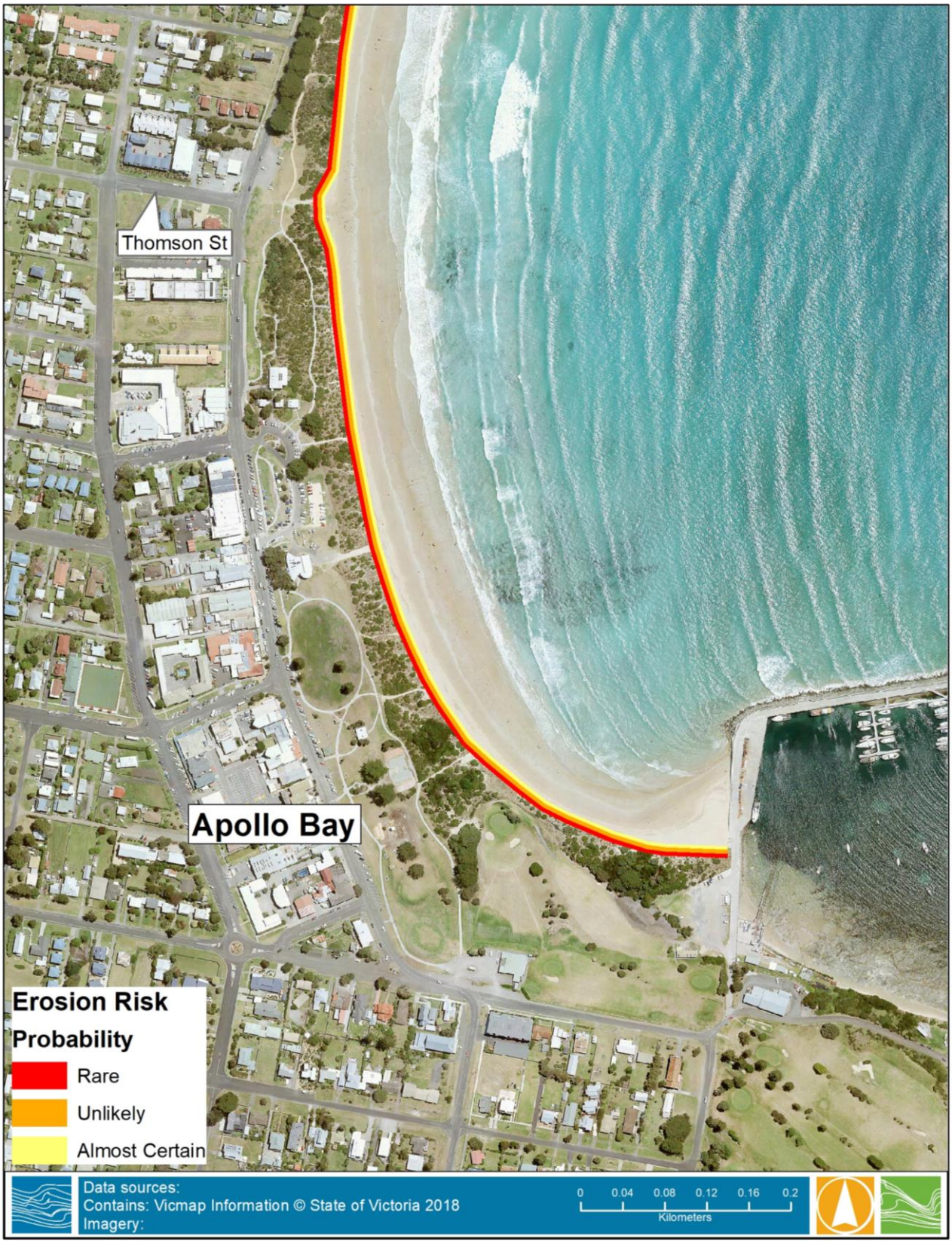

FIGURE 2-4 APOLLO BAY EROSION RISK (WATER TECHNOLOGY, 2012)

FIGURE 2-5 MARENGO INUNDATION AND RISK, EXISTING CAR PARK ASSETS AT RISK ARE SHOWN (ADAPTED FROM WATER TECHNOLOGY, 2012)

FIGURE 2-6 MARENGO INUNDATION FROM STORM-TIDE AND WAVE RUNUP ACCORDING TO THE UPDATED 2007 LIDAR SURVEY.

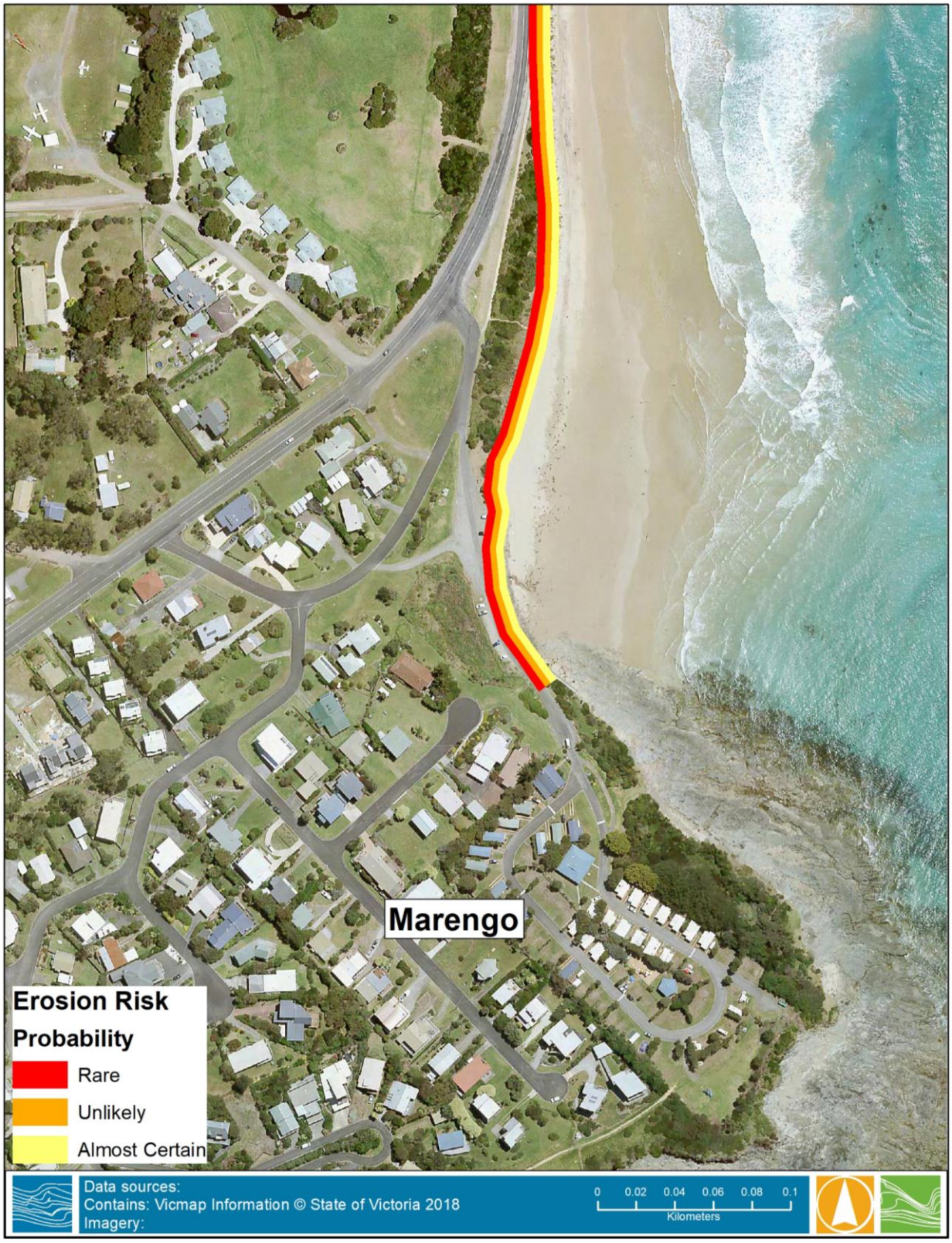

FIGURE 2-7 MARENGO EROSION RISK (WATER TECHNOLOGY, 2012)

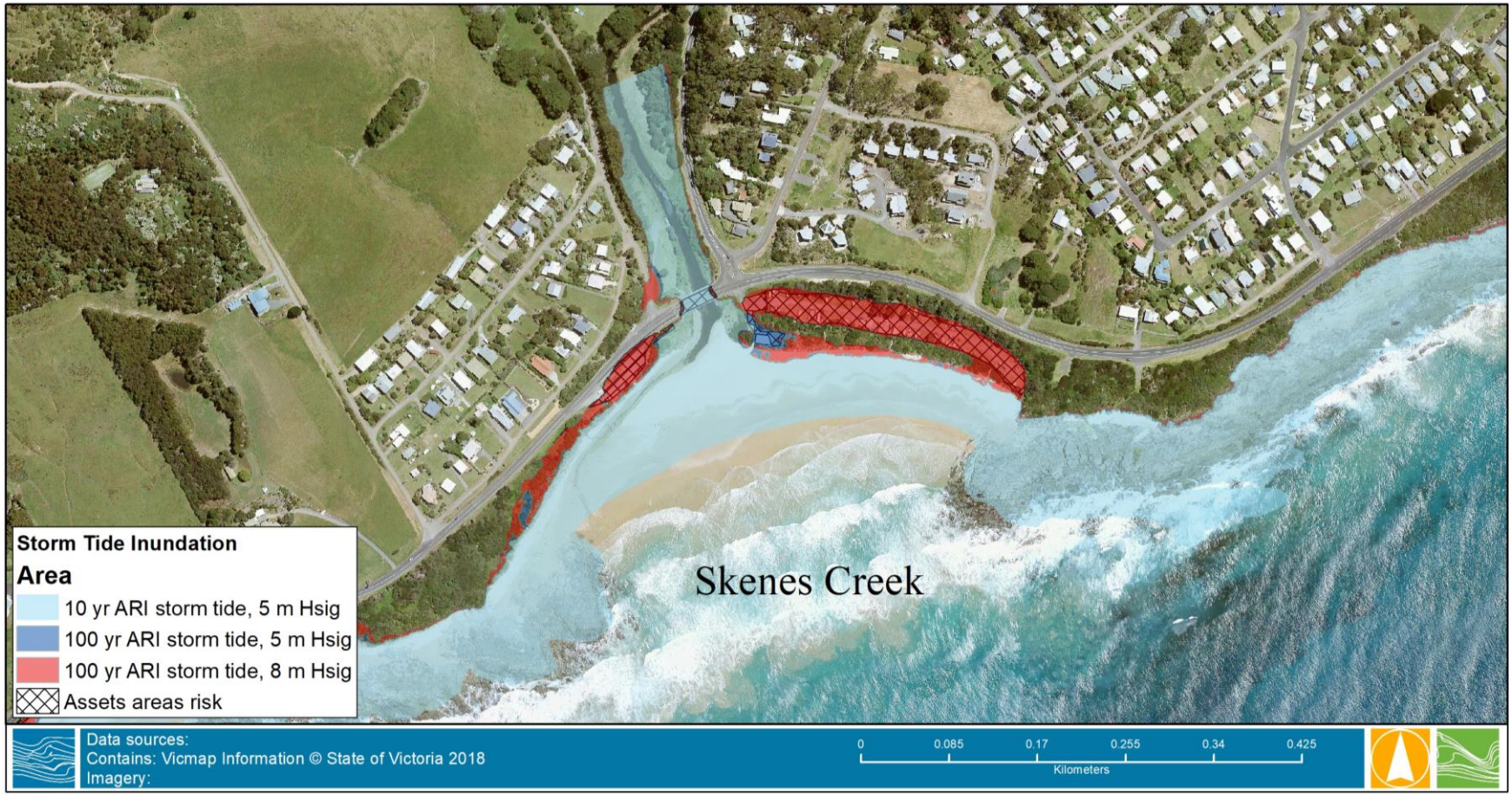

FIGURE 2-8 SKENES CREEK INUNDATION AND RISK TO ASSETS (ADAPTED FROM WATER TECHNOLOGY, 2012).

FIGURE 2-9 SKENES CREEK INUNDATION DUE TO STORM TIDES ONLY.

FIGURE 2-10 SKENES CREEK EROSION RISK (WATER TECHNOLOGY, 2012)

3 SITE INVESTIGATION

A site investigation of the area was conducted on the 7th of June 2019 to determine the landscape characteristics in each of the areas supplied by Tract, and to gain a greater understanding of the coastal processes and issues at the sites.

Sites are discussed below based on the GPS located photos taken during the site visit. All of the photo locations are presented in (Figure 3-1), and those presented in this report are labelled accordingly in their section below. Each area has a number of un-labelled photos that are not discussed in this report, although these will be supplied to the client in an ArcGIS online geodatabase (with free login access for the duration of the project).

FIGURE 3-1 ALL SITE VISIT PHOTO LOCATIONS

3.1 Apollo Bay Foreshore

The site investigation focused on the area between Thomson St in the north to the Harbour in the south (Figure 3-2). A total of 23 photo locations were captured in this area of interest.

FIGURE 3-2 APOLLO BAY SITE VISIT PHOTO LOCATIONS. LABELLED POINTS ARE DISCUSSED IN THIS REPORT.

3.1.1 Thomson Street (Figure 3-3)

- The coastline at Thomson street, whilst quite flat and low-lying, is above the inundation extents produced by Water Technology in 2012 (Photo 1). This location is suitable for coastal infrastructure from an inundation perspective.
- Erosion was observed adjacent to the beach access track, and stormwater discharge (Photo 2).
- Boulders have been placed on the beach, although these are haphazard and would require additional works to provide sufficient erosion protection. At present these rocks could potentially be exacerbating the erosion.

FIGURE 3-3 PHOTO POINTS AT THOMSON ST. LABELS ARE CORRESPONDING NUMBERS ON FIGURE 3-2 (PHOTO POINTS 1 & 2).

3.1.2 Apollo Bay Foredune (Figure 3-4)

- The foredune at Apollo Bay is scoured at its toe along most of its length (photos 3-6).
- This scouring should be monitored to pre-empt any loss of protection afforded by the dunes. Vulnerability of developments within the Apollo Bay Foreshore Reserve would increase significantly if the dunes were compromised.

FIGURE 3-4 SCOURING OF THE APOLLO BAY FOREDUNE

3.2 Apollo Bay Harbour

Apollo Bay Harbour location photos include the Harbour together with nearby Bunbury Point and carpark (Figure 3-5).

- The Harbour Breakwaters are generally in good condition (photos 7-9). The inner face of the eastern breakwater was assessed by Water Technology in 2018 (Water Technology, 2018) and found to have fretting of the road edge and slumping of the rear face due to wave overtopping. Repair of the inner face was recommended and should be conducted before further development of the area.
- Areas near to the dunes are protected by narrow stone walls. These walls may not have been picked up by the LiDAR, and thus the inundation mapping may be conservative in this area. We recommend *in-situ* survey/review of final design drawings of the Harbour to rectify storm tide and wave runup barriers within and around the Harbour (photo 10).
- There is erosion to the inner Harbour access ramp to the beach, and to the dunes at the Harbour's south-eastern beach (photos 11 & 12). Considering the protection afforded by the Harbour walls, this is most likely due to carpark runoff (access ramp) and storm tides/loss of vegetation/wind erosion/currents due to seiching (dune). The dune to the west of the inner-boat ramp is well vegetated and showing no signs of erosion.

- This area would benefit from some targeted coastal management, that would provide the dual function of improving the amenity and minimising the erosion issue.

FIGURE 3-5 APOLLO BAY HARBOUR SITE VISIT PHOTO LOCATIONS

FIGURE 3-6 APOLLO BAY HARBOUR (PHOTO POINTS 7-12)

3.2.1 Bunbury Point and Car Park (Figure 3-7)

- The beach at the northern end of Mounts Bay (Bunbury Point) is stable, with no indication of erosion (photo 13)
- The Bunbury Point Groyne is currently holding sand , with one section close to shore that is in need of urgent repair (photos 14 & 15). At present, the structure could be outflanked during a storm event. The groyne was originally designed as a sand trap for later sand bypassing to prevent sand build-up within the harbour. Although the groyne has not recently been used in this way, any development plan of the area should consider this function.
- The car park and grass area in front of the Apollo Bay Sailing Club both represent good development opportunities, lying above the predicted storm-tide levels up to 2010 (photos 16-18). Erosion risk is low here considering its protection by Harbour Breakwaters and its present condition.
- Erosion within the Harbour has not been considered in previous reports but with coastal processes affecting the south-eastern dune accelerated erosion is possible. An inner-harbour processes study is recommended.

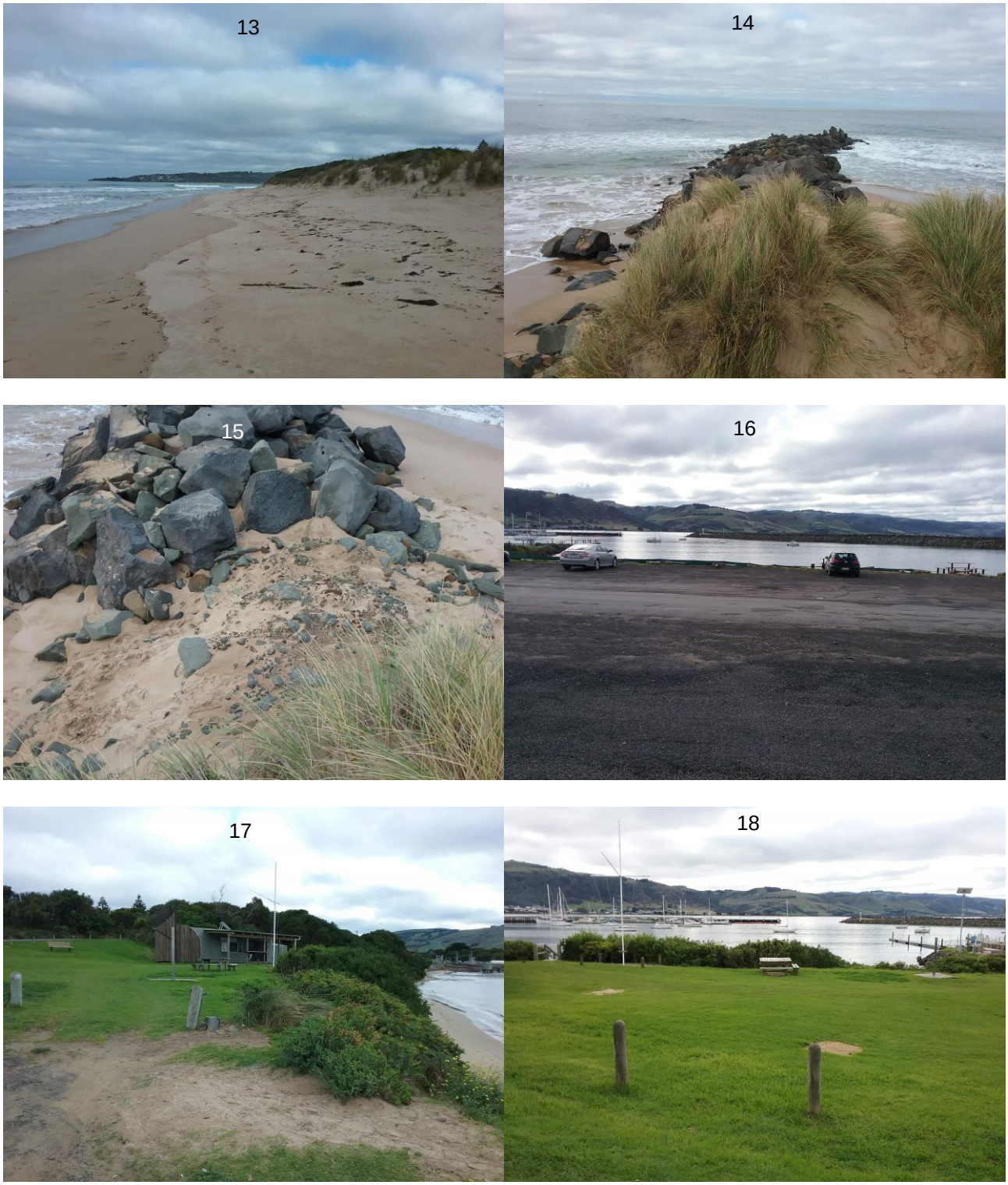

FIGURE 3-7 BUNBURY POINT AND CAR PARK

3.3 Marengo

Marengo is well protected by coastal cliffs along the headland. An area of vulnerability lies where Mounts Bay Beach and Marengo meet. The car park here would be rarely inundated (greater than 100-year ARI - Figure 2-5). The area slopes up from the coast and the latest LiDAR data suggests that most of the carpark would be above the rare inundation line (Figure 2-6). An *in-situ* survey referenced to a local (AHD) benchmark would be required to confirm the exact elevation of the carpark before determining potential infrastructure risk. Marengo photo locations are presented in (Figure 3-8)

FIGURE 3-8 MARENGO PHOTO LOCATIONS WITH LABELLED POINTS DISCUSSED IN THIS REPORT.

3.3.1 Marengo photo points (Figure 3-9)

- Coastal cliffs protect the Marengo headland (photo 19)
- The dune to the north of the carpark is currently stable, showing no signs of recent erosion (photo 20)
- The carpark slopes up away from the shoreline providing increased resilience (photo 21)
- The shoreline is protected by a revetment that is presently in good condition (photo 22)

FIGURE 3-9 MARENGO PHOTO POINTS

3.4 Skenes Creek

Skenes Creek provides a number of opportunities for new development, although a balance is required between inundation risk and resilience/cost of infrastructure. The picnic area to the north of the bridge is within the “almost certain” inundation zone for storm tide and wave runup (Figure 2-8). Although a better indication of risk for this area is considering storm tide only owing to its protection from wave action (Figure 2-9).

Skenes Creek photo locations are presented in Figure 3-10.

FIGURE 3-10 SKENES CREEK PHOTO LOCATIONS

3.4.1 Skenes Creek photo points (Figure 3-11)

- The car park is exposed to erosion risk and inundation risk from a combination of storm tide and wave runup. There are two picnic areas at each end of the carpark, with the ground sloping down towards the creek. The eastern picnic area is low-lying, while the western picnic area is at a higher elevation and could house infrastructure of greater value/lower resilience (photo 23 – low-lying picnic area, photo 24 – upper picnic area).
- The picnic area upstream of the bridge on the western bank of Skenes Creek slopes down, transitioning to higher risk at its far side towards the creek. The area closest to the bridge is elevated above the predicted 2100 storm tide levels (photo 25).
- The dune in front of the caravan park is stable at present, showing establishment of new vegetation (photo 26)
- The access path from the toilets to the beach is also in good condition (photo 27)
- The access paths and steps to the beach from the large car park area are subject to erosion and variability due to the Skenes Creek channel. Improvements to beach access would require a study into options with further consideration of the long-term coastal processes of the area (photo 28).

FIGURE 3-11 SKENES CREEK PHOTO POINTS CORRESPONDING TO NUMBERED LABELS IN FIGURE 3-10

4 SUMMARY

Water Technology has presented the historical assessment of coastal processes and hazards and conducted analysis of readily available data to improve understanding and decision making with respect to the scope of the CIP.

It was found that a number of coastal areas are available to new infrastructure developments in the CIP, but each must be considered with respect to the likelihood of inundation and exposure to wave action throughout its design life. Within some asset areas, the landscape characteristics were such that the slope would favour infrastructure of greater value/lower resilience in sub-areas, and this should be considered while planning developments. If infrastructure were to be placed in vulnerable areas, adaptation to the prevailing conditions should be considered, such as raised structures or those that are highly resilient to coastal flooding. Examples of these areas are as follows:

- Apollo Bay – Bunbury Point carpark/inner harbour near sailing club (described in Section 3.2 of this report)
- Marengo – Carpark at southern end of Mounts Bay (Section 3.3)
- Skenes Creek – Main carpark and picnic area upstream of the bridge (Section 3.4).

The spatial files and photo points in this report are provided in an online database to facilitate sound decision-making throughout the planning phase of the CIP.

Consideration for coastal protection works are recommended at Thomson St, the Bunbury Point Groyne, and Skenes Creek access stairs if these areas are to remain long term. Additional survey/review of final design drawings are required in areas that are not well resolved by previous LiDAR surveys; these include:

- Marengo carpark
- Harbour barriers

The Bunbury Point Groyne has reached capacity and was originally designed to be used in sand bypassing operations for the Harbour. Development opportunities should consider this original purpose.

If Tract were to extend their areas of interest to Mounts Bay and or Apollo Bay north, the erosion and inundation risks increase significantly, with capital works having recently been conducted to mitigate hazards in those areas.

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