City of Victor Harbor

Victor Harbor Coastal Management Study

FINAL REPORT

December 2013

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OC 13/0514 Victor Harbor Coastal Management Study

Moved: Cr B Bond Seconded: Cr T Telfer

1. ***That the Coastal Management Study as presented be adopted by Council to guide future works and funding applications for the Victor Harbor Coastline.***

2. ***That the 30 year expenditure forecast be incorporated into Council's Draft 10 Year Capital Works Program at its next review.***

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Executive Summary

Australian Water Environments, with Coastal Environment Pty Ltd, was engaged by the City of Victor Harbor (Council) to prepare a Coastal Management Study for the section of Encounter Bay coast between Police Point and the Bluff boat ramp. This study has been undertaken in response to ongoing community concerns about the impacts of recent storm damage on coastal dunes abutting the Esplanade, sand depletion abutting Franklin Parade and odour issues relating to the Inman River mouth.

The study has identified the existing coastal processes and historical and projected coastal recession and the projected 2050 and 2100 climatic conditions and the threats and hazards these place on assets and infrastructure, during a 1 in 100 average recurrence interval storm event.

The study was undertaken using a risk based approach and provides an initial framework for managing these threats and hazards into the future including further studies and monitoring to gain a better understanding of the triggers and timeframes for implementing adaption responses.

The key threats and hazards identified were:

- Accelerated erosion and recession under sea level rise;
- Increased erosion and overtopping of foredune along the Esplanade between the Inman River and Police Point and associated vegetation and fencing and at localised breach points under the 2050 scenario;
- Increased damage to beach pedestrian steps particularly within the foredune between Inman Street and Police Point, and abutting Franklin Parade;
- Damage and inundation of Encounter Bikeway path particularly in locations close to the coast where there is little existing rock protection and land is low lying;
- Damage and inundation to Franklin Parade carpark adjacent Fell Street, and in the Esplanade at King Street under the year 2100 scenario;
- Damage and inundation to Franklin Parade in low lying areas and locations where there is currently no rock protection;
- Damage to stormwater outlets along coastal edge;
- Potential damage to Aboriginal heritage site near the Caravan Park;
- Inundation of the Victor Harbor Caravan Park - 80% inundation in the 2050 scenario and complete inundation in the 2100 scenario;
- Potential inundation of private Caravan Park west of Bay Road and Municipal offices under the 2100 scenario from wave breach and overtopping of the Inman River banks;
- Increase in Encounter Lakes lake levels (Lake levels likely to rise commensurate with sea level rise due to submarine pipe connection with Encounter Bay); and
- Threat to Hooded Plover nesting area and high conservation value vegetation abutting Inman River.

There are various management options available to address these threats and hazards including:

- Continue with the existing soft sand nourishment measures after storm events, as well as using the mix of seaweed and sand (to bury at the back of beach, on the dune crest and immediately landward of the scarp crest), for the short to medium term;
- Protect the Esplanade foredune with a rock sea wall focusing on higher risk and low lying areas in minimum 250m lengths - by the year 2050 and when funds permit;
- Extend and upgrade the rock revetment wall along Franklin Parade focusing on higher risk and low lying areas in minimum 250 m lengths - by the year 2030 and when funds permit - noting that there are some areas that will require action in the short term.
- Raise sea walls along the Esplanade and Franklin Parade - by the year 2100;
- Progressively review the risk associated with continued operation of the Victor Harbor Caravan Park as sea level rises;
- Continue to enforce Council's Development Plan provisions in order to regulate development within the coastal hazard buffer;
- Beach and foredune access controls; and
- Protect and upgrade stormwater outlets.

Adaptation and protection measures will be expensive and Council is encouraged to identify and secure funding sources, including the option of establishment of a special rate under the provisions of the Local Government Act.

1 Scope of Assessment

The City of Victor Harbor (Council) has received funding from the South Australian Coast Protection Board (CPB) and the Federal Government's Natural Disaster Resilience Grant Scheme to undertake a Coastal Management Study along the 4.6 kilometre (km) section of coast between Police Point and the Bluff Boat ramp. The study is aimed at identifying and evaluating alternative long term management strategies to address a number of coastal issues along this section of coast, identify when intervention should be undertaken and assist in informing Council's 10 year capital works program.

The study area is shown in Figure 1, Appendix B.

The coastal issues along the section of coast issues include:

- An increase in the intensity of storm damage and erosion since the 1990's which is impacting on Council infrastructure;
- Extensive sand replenishment and use of wrack and sand groynes to act as a buffer against further dune loss in worst affected areas (with mixed results);
- Concerns over the impacts of the training groynes installed at the Inman River mouth on sand supply to the Esplanade Beach;
- Community concerns over sand and sea weed deposition in the Inman River and associated flow and odour impacts;
- Community concerns about limited beach access to the beach due to existing infrastructure and groynes;
- Impacts of sea level rise; and
- Community concerns about the damaging wave impacts on the beach near King Street, perceived to be caused by a gap in the offshore reef.

The Coastal Management Study assessment included the following components:

- Site visit and appraisal by the study team to identify current levels of erosion and potential contributing factors, issues, hazards and infrastructure at risk;
- Liaison with key government stakeholders to receive background and historical information;
- Community consultation with focus groups, elected members and the broader community to identify issues and possible management strategies;
- Determining historical coastal regression and projected coastal erosion rates for the year 2050 and 2100;
- Developing a conceptual model and understanding of the actual coastal processes;
- Investigation of stormwater interface issues including possible impact on seagrass loss and contribution to wave energy;
- Investigation of Inman River interfaces and impacts on seagrass deposition;
- Identifying and assessing impacts of sea level rise based on year 2050 and 2100 scenarios;

- Assessing risks to coastal development and infrastructure;
- Identifying, assessing and costing management strategies and options and intervention triggers using a Risk Management approach including:
    - Stormwater quality improvements;
    - Access control;
    - Engineering responses to manage the dunes;
    - Engineering responses to manage the Inman River mouth;
    - Engineering responses to the gap in the reef;
    - Vegetation control; and
    - Planning controls setbacks and buffer distances.
- Preparation of preliminary, draft and final reports and presentation of outcomes to elected members and the broader community.

2 Existing Context

2.1 Regional Setting

Victor Harbor is situated approximately 80 km south of Adelaide. It is a popular holiday and tourist destination due to its sandy beaches, mild climate, beautiful landscape, its rich natural and heritage values, as well as its close proximity to other attractions and Adelaide. Victor Harbor is also a sought after place to live, with its high standard of living, relaxed lifestyle, and strong sense of community. Its popularity is reflected in its significant population growth and high rate of retirees moving into the area.

Since the late 1990's the foreshore of Encounter Bay has become affected by storm damage and erosion. This has become more intense in recent years and is now affecting Council infrastructure in several locations. The study area incorporates the section of coast from the head of the Causeway (Police Point) to the Bluff Boat Ramp on Franklin Parade (a total length of 4.6 km).

2.2 Aboriginal & European Heritage

2.2.1 State and Local Heritage Places

State Heritage Places are protected under both the *Heritage Places Act 1993* and the *Development Act 1993.*

2.2.1.1 State Heritage

A search of the Heritage Places Database and listed under the SA Heritage Register identified the following sites of State Heritage in the vicinity of study area (others exist in the region but are not as close to the study area).

Encounter Bay Region

This area comprises the islands and marine environment of Encounter Bay, approximately 100 km of coastline up to the high water mark, and several public reserves. It is described as being significant for its high levels of biodiversity and geodiversity, importance to the Narrindjeri people, historic associations with the exploration of Australia and the settlement of South Australia, and its aesthetic landscape/seascape. The region contains sites of State and Local significance which are described below.

Causeway, Screwpile Jetty and Breakwater

These sites are located at Flinders Parade/Esplanade and are significant because of the port facilities that were built there to serve as the ocean port for the River Murray trade. It is a State Heritage Place in the SA Heritage Register.

The Bluff (Rosetta Head) Historic Site, including the Jetty & Whaling Station Site

This site is listed in the SA Heritage Register due to its historical significance for transport (water) – Jetty and Maritime industry as a whaling station. It is a State Heritage Place in the SA Heritage Register.

Fountain Inn

This was the first hotel built in South Australia and is situated at 66 Franklin Parade, Yilki, Encounter Bay. It is a State Heritage Place in the SA Heritage Register.

Whalers House Museum, Franklin Pde, Encounter Bay, SA, Australia

This registered site is situated on Franklin Parade, Encounter Bay. Its heritage significance is not available.

The Soldiers Memorial Reserve (not State Heritage listed but has historical significance)

This area is not listed on the Register of National Estate (RNE) itself but it is associated with the state heritage listed 'Victor Harbor Soldier's Memorial Gardens'. It is situated immediately adjacent to the Causeway on the western side. It was established to expand the existing Soldier's Memorial Gardens which is listed on the RNE. It was to be available to the public for recreation and community celebrations. It has been planted with Norfolk Island pine trees and Canary Island date palms in honour of those killed in war killed in the 2nd World War. The Norfolk Island pine trees are an integral part of the foreshore landscaping and represent the image many visitors have of Victor Harbor, both currently and historically. Parking within the root zone of the existing trees in the Reserve should be controlled and actively discouraged. Council will need to protect the health of the trees by managing car parking in their vicinity, to avoid compaction of the ground over their root systems.

2.2.1.2 Local Heritage

A search of the Heritage Places Database identified the following sites as having local heritage significance and listed in Council's Development Plan:

- Former Yilki Post Office, 66 Franklin Parade;
- Dwelling, 40 Franklin Parade; and
- Battye Farm Homestead, Lot 2 Battye Road - building and long-barn outbuilding previously used as a milking shed and horse.

2.2.2 Register of Aboriginal Sites and Objects

The Register of Aboriginal Sites and Objects (Register) has an entry for an Aboriginal site described as an archaeological/burial site. The records indicate that it is situated near the mouth of the Inman River, on the eastern side, however its exact location is not currently known to the Project Team. Any works in this area will need to be managed in consultation with the Department of the Premier and Cabinet-Aboriginal Affairs and Reconciliation Division (DPC-AARD) who is responsible for administering the Register.

All Aboriginal sites and objects are protected under the Aboriginal Heritage Act 1988 (the Act), whether they are listed in the Register or not. Land within 200 metres (m) of a watercourse (particularly the River Murray and its overflow areas) in particular, may contain Aboriginal sites and objects.

It is an offence to damage, disturb or interfere with any Aboriginal site or damage any Aboriginal object (registered or not) without the authority of the Minister for Aboriginal Affairs and Reconciliation (the Minister). If the planned activity is likely to damage, disturb or interfere with a

site or object, authorisation of the activity must be first obtained from the Minister under Section 23 of the Act. Section 20 of the Act requires that any Aboriginal sites, objects or remains, discovered on the land, need to be reported to the Minister. Penalties apply for failure to comply with the Act.

2.2.3 Other heritage information

Inman River and Kent Reserve area

The Encounter Bay area contains sites of Aboriginal cultural significance such as hunting and gathering and story places. Ramindjeri people continued to reside in the Encounter Bay area camping in such places as the banks of the Inman River and in fringe camps at Victor Harbor.

According to the Inman River Inman River Estuary Action Plan by SKM (2010), the Inman River Estuary has the following historical significance:

- Remnants of old stone wall on the Kent Reserve side of the river mouth;
- Middens at Kent Reserve;
- Marjorie Thripp family - one of last to camp at Kent Reserve; and
- Monument erected in Kent Reserve (i.e. on the western side of the Inman River) – the monument commemorates one of the last camping grounds of the Ramindjeri, an Encounter Bay tribe of the Narrinjeri Aborigines.

There is an Aboriginal site near the Inman River which is protected under the Aboriginal Heritage Act 1988. Refer to the description of 'Register of Aboriginal Sites and Objects'.

2.3 Planning and Development

2.3.1 Current Development

2.3.1.1 Inman River to Police Point

This portion of the study area comprises residential dwellings and the Hotel Victor abutting the north side of the Esplanade, the Visitor Information Centre, Mini golf and Kiosk at Police Point a public toilet and the Victor Harbor Caravan Park abutting Inman Street.

2.3.1.2 The Bluff Boat ramp to Inman River

This portion of the study area comprises residential dwellings (many as holiday homes and holiday rentals), a cafe and Whalers Inn accommodation and restaurant abutting the west side of Franklin Parade and two public toilets.

2.3.2 Future Development

The study area is largely developed and no major changes in land use other than infill is anticipated.

2.3.3 Planning Framework

2.3.3.1 Coastline - Coastal Erosion, Flooding and Sea level rise standards and protection policy, South Australian Coast Protection Board, January 1992

This document establishes standards for managing sea level rise.

2.3.3.2 Coast Protection Board Policy Document, August 2002

The Coast Protection Board Policy Document sets the framework for managing coastal hazards and protection works, regulating development including setting standards for setbacks and floor levels and, conservation of coast and marine habitats.

2.3.3.3 Coastal Planning Information Package

This information package by the Department of Water and Natural Resources (DEWNR) provides a summary of the planning process for assessing coastal developments referred to the Coast Protection Branch.

2.3.3.4 City of Victor Harbor Development Plan

The Council provides some guidance to development in coastal areas through its objectives and principles of development controls in its Development Plan. A summary of the most relevant objectives and principles of development controls issues contained in Council's Development Plan (consolidated 10 January 2013) is provided below.

Coastal Areas- Objectives

Objective 30: Preserve and manage the environmentally important features of coastal areas, including mangroves, wetlands, dune areas, stands of native vegetation, wildlife habitats and estuarine areas.

Objective 34: Development only undertaken on land which is not subject to, or can be appropriately protected from, coastal hazards such as:

(a) inundation by storm tides or combined storm tides and stormwater;
(b) coastal erosion; or
(c) sand drift.

Objective 35: Development located and designed to allow for changes in sea level due to natural subsidence and probable climate change during the first 100 years of the development. This change to be based on the historic and currently observed rate of sea level rise for South Australia with an allowance for the nationally agreed most-likely predicted additional rise due to global climate change.

If the coast is retreating, the foreshore, dunes, and wetlands contained in any coastal reserve could retreat also, unless they are prevented by natural or man-made features. Hence any erosion buffer should be additional to the coastal reserve.

Objective 36: Development which will not require, now or in the future, public expenditure on protection of the development or the environment.

Objective 37: Developers bearing the costs of protecting private development from the effects of coastal processes or the environment from the effects of development rather than the community.

Low-lying land which is now or in the future, subject to inundation by storm tides or stormwater should not be zoned or developed for urban/tourist development unless environmentally sound mitigation and protection works are formally and securely guaranteed by the Council or the proponents of development.

Erosion mitigation works should only be considered in those instances where:

(a) a buffer cannot be provided;
(b) the works will not have an adverse effect on adjacent coastal areas and processes; and
(c) the works are guaranteed by the Council or the proponent.

The storm tide, stormwater and erosion protection requirements need to be based on an anticipated sea level rise due to global warming of 0.3 m between the year 1991 and 2050. Development should also be capable of being protected against a further sea level rise, and associated erosion, of 0.7 m between the year 2050 and 2100. This rise is based on the historic and currently observed rate of sea level rise for South Australia with an allowance for the nationally agreed most-likely predicted additional rise due to global climate change.

Applications for the development of land which is at risk from storm surge and stormwater flooding or erosion should contain:

(a) sufficient technical information to demonstrate that the proposed development will be protected from flooding or erosion;
(b) the design of any coastal protection measures which are to be included and an assessment of the effect of such measures on the beach and adjacent coast; and
(c) evidence, where appropriate, of financial guarantees or other arrangements to ensure that all future costs (including storm damage, future protection, environmental restoration and site restoration in the event of non-completion) will either be met by the developer or future owners, or have been accepted as a future commitment by a local Council or other appropriate agency.

Objective 42: To redesign and redevelop coastal living areas which do not satisfy environmental, health or public access standards for coastal areas.

There are numerous urban coastal settlements which have been developed without due regard given to flooding, erosion, public access or environmental requirements. Such areas should only be developed further if they are within a zone of predominantly urban character and satisfy the coastal development policies. Development in unsuitable locations, including holiday houses on public foreshores, may need to be moved to alternative sites in due course.

Coastal Areas- Principles of Development Control

Environmental Protection

151 Development, including flood, erosion and wave protection measures, should not adversely affect the ecology of coastal areas, the seabed or coastal waters by pollution, significant loss of habitat, interference with coastal processes or any other means.

152 Development should not be located in delicate or environmentally sensitive coastal features such as sand dunes, wetlands or important remnants of native vegetation.

153 Development should not, nor be likely in the future to, adversely affect the ecology and stability of environmentally sensitive coastal features.

161 Development should not preclude the natural geomorphological and ecological adjustment to changing climate, sea level or other conditions. For example landward migration of coastal wetlands should not be prevented by embankments. Development should be designed to allow for new areas to be colonised by mangroves and wetland species and for removal of existing embankments where practical.

Maintenance of Public Access

169 Development adjacent to the coast should not be undertaken unless it has or incorporates the provision of a public reserve, not including a road or erosion buffer provided in accordance with principle of development control numbered 182, of at least 50 m width between such development and the toe of the primary dune or the top edge of the escarpment, unless the development relates to small-scale infill development in a predominantly urban zone.

Hazard Risk Minimisation

176 Development should not occur on land where the risk of flooding is unacceptable having regard to personal and public safety and to property damage.

177 For the purposes of assessing coastal developments the standard sea-flood risk level for a development site is defined as the 100-year average return interval extreme sea level (tide, stormwater and associated wave effects combined), plus an allowance for land subsidence for 50 years at that site.

178 Land should not be divided for commercial, industrial or residential purposes unless a layout can be achieved whereby roads, parking areas and adequate development sites on each allotment are at least 0.3 m above the standard sea-flood risk level, unless the land is or can be protected in accordance with principle of development control numbered 181.

179 Commercial, industrial or residential development should only be undertaken where:

(a) building floor-levels are at least 0.25 m above the minimum site level of principle of development control numbered 178 (i.e.: 0.55 m above the standard sea-flood risk level), unless the development is or can be protected in accordance with principle of development control numbered 181; and

(b) there are practical measures in accordance with principle of development control numbered 181 available to the developer, or subsequent owners, to protect the development against a further sea level rise of 0.7 m above the minimum site level determined by principle of development control numbered 178.

180 Buildings to be located over tidal water or which are not capable of being raised or protected by flood protection measures in future, should have a floor level of at least 1.25 m above the standard sea-flood risk level.

181 Development which requires protection measures against coastal erosion, sea or stormwater flooding, sand drift or the management of other coastal processes at the time of development, or which may require protection or management measures in the future, should only be undertaken if:

(a) the measures themselves will not have an adverse effect on coastal ecology, processes, conservation, public access and amenity;

(b) the measures do not now, or in the future require community resources, including land;
(c) the risk of failure of measures such as sand management, levee banks, flood gates, valves or stormwater pumping, is appropriate to the degree of the potential impact of a failure; and
(d) adequate financial guarantees are in place to cover future construction, operation, maintenance and management of the protection measures.

182 Development should be set-back a sufficient distance from the coast to provide an erosion buffer which will allow for at least 100 years of coastal retreat for single buildings or small-scale developments, or 200 years of retreat for large-scale developments such as new towns, unless:
(a) the development incorporates private coastal works to protect the development and public reserve from the anticipated erosion, and the private coastal works comply with principle of development control numbered 181; or
(b) the Council is committed to protecting the public reserve and development from the anticipated coastal erosion.

183 Where a coastal reserve exists, or is to be provided in accordance with principle of development control numbered 169, it should be increased in width by the amount of buffer required.

184 The width of an erosion buffer should be based on:
(a) the susceptibility of the coast to erosion;
(b) local coastal processes;
(c) the effect of severe storm events;
(d) the effect of a 0.3 m sea level over the next 50 years on coastal processes and storms; and
(e) the availability of practical measures to protect the development from erosion caused by a further sea level rise of 0.7 m per 50 years thereafter.

185 Where there is inadequate area to provide the necessary erosion buffer to development on land at risk from long-term coastal erosion (for example small-scale infill development including land division), such development should not occur unless:
(a) the Council has committed itself to erosion protection measures which may be necessary along this section of the coast; or
(b) a legally binding agreement is included on the freehold certificate(s) of title(s) that protection measures will not be built and that any building will be transportable and will be removed when threatened by erosion or storm surge flooding; or
(c) a legally binding agreement is included on the freehold certificate(s) of title(s) that protection measures that comply with principle of development control numbered 181 for coastal development will be built by the land owner(s) when required.

Conservation

Objective 58: The conservation, preservation, or enhancement, of scenically attractive areas including land adjoining water and scenic routes.

Principles of Development Control:
262 Stormwater discharge points should be located and constructed so as to prevent soil erosion.

Specific Policy Areas

The Residential (Encounter Bay) Policy Area 1 and Residential (Yilki) Policy Area 4 do not include any details on specific building set back distances, provision for buffers for erosion and sea level rise.

2.4 Geological and Geo-morphological Background

2.4.1 Physographic Setting

The study area is a long, sandy embayment bounded by bedrock headlands at The Bluff to the west Causeway and sand spit at Police Point in the shelter of Granite Island to the east. The beach alignment varies through 90 degrees, aligned almost north south on the northern side of The Bluff boat ramp and curving to an east west alignment on the western side of Police Point. The total beach length is approximately 4.5 km. Throughout the embayment, the alignment is controlled by the outcropping granite headlands at Granite Island and The Bluff. Locally the beach alignment is influenced by the protection provided by the exposed offshore reefs (which are variable in depth and distance from the shoreline) and the localised occurrence of exposed bedrock at or immediately adjacent to the shoreline. The beach embayment is generally sheltered from the southerly and south westerly southern ocean swells which shape the more exposed shoreline of the Coorong further to the east.

From the Bluff boat ramp to Kent Reserve (approximately 2.8 km), the beach is straight and protected by an exposed, wave cut sandstone shelf. The beach alignment is parallel to Franklin Parade, indicating the stability of this beach shape as the waterline undulates in response to areas of exposed near shore reefs. The sandy beach area is narrow with little sand exposed above mean sea level and exhibits a steep back beach escarpment that, for most of the length of Franklin Parade, is protected by an exposed rock rubble wall. While little information is available on the construction of this wall, Council advises that much of it was built over 30 years ago and sections were upgraded following the construction of the back beach cycle/pedestrian track in 1995. That it was constructed initially would suggest previous episodes of beach erosion, extending to the present day back of the beach.

At Kent Reserve there is no rock revetment and the beach alignment is controlled by the seaward extension of the rock shelf at the shoreline and outcrops of low reefs extending shore normal more than 1.5 km. This reef area reduces wave energy and results in a build-up of sand along the reef at the shoreline during calm periods and as sand is available and moving alongshore. During storms, this temporary sand storage may be eroded. This section of the beach fluctuates in width over time in response to the prevailing conditions. In recent years, sand from this location has been sourced for nourishment of more eroded sections of the beach to the east. The rock reef and change in alignment from Kent Reserve to the Inman River entrance provides a sheltered area of shoreline, visible on the earliest aerial photography (in the 1970s) as a safe mooring haven for small sailing boats.

Modification to the mouth of the Inman River has constrained the entrance location with rock training walls and the entrance when it breaks out, no longer meanders to the north behind the beach. Anecdotal information indicates that the realignment of the river's mouth has resulted in some localised changes in the entrance behaviour, downstream depths and velocities, with sand

accumulation and seaweed movement up the river. Without any available monitoring data it is difficult to determine the impact of the realignment has had. Notwithstanding this, the realignment is not considered to have a significant effect on the alongshore sediment processes. The old channel has recovered and infilled, possibly resulting in the trapping of some sand from the active beach system. This is borne out by recent surveys on the coast undertaken by DEWNR. This is likely to be a short term impact on the coast.

East of the river entrance to Police Point (approximately 1.3 km) the beach is straight, curving seaward at the eastern end to the sand tombolo underneath the Granite Island Causeway. This sand spit is located on the shallow reef area joining Granite Island to the mainland. The beach between the Inman River and the Causeway is affected by the occurrence of rock outcrops (near Island Street) and some wave focussing across the reefs (seaward of King Street). At some locations along this section rock can be seen outcropping in the shallow beach face at low tide and seagrasses are growing near the low tide mark. The shape of the beach closely reflects the meandering shape of the Esplanade which is separated from the high water mark by a vegetated reserve approximately 30 m to 40 m in width. This symbiosis in the beach and road alignment is a strong indicator that the beach shape has not altered significantly over the period of European settlement.

No detailed inshore bathymetry showing the bed levels is available. The bathymetry is complex with a line of reefs causing waves breaking on low tides in a line between Granite Island and The Bluff, approximately 1 km seaward of the high water mark. This reef system breaks most waves on low tide and the bigger wave on the high tides, providing a generally sheltered shoreline through the study area under present day sea levels. Isolated reefs and exposed bedrock are present throughout the study area. Near shore profiles (surveyed by DEWNR since 1981) show a gently sloping, predominantly rock foreshore at slopes of 1:70 to 1:100 for approximately 300 m from the shoreline.

2.4.2 Geology

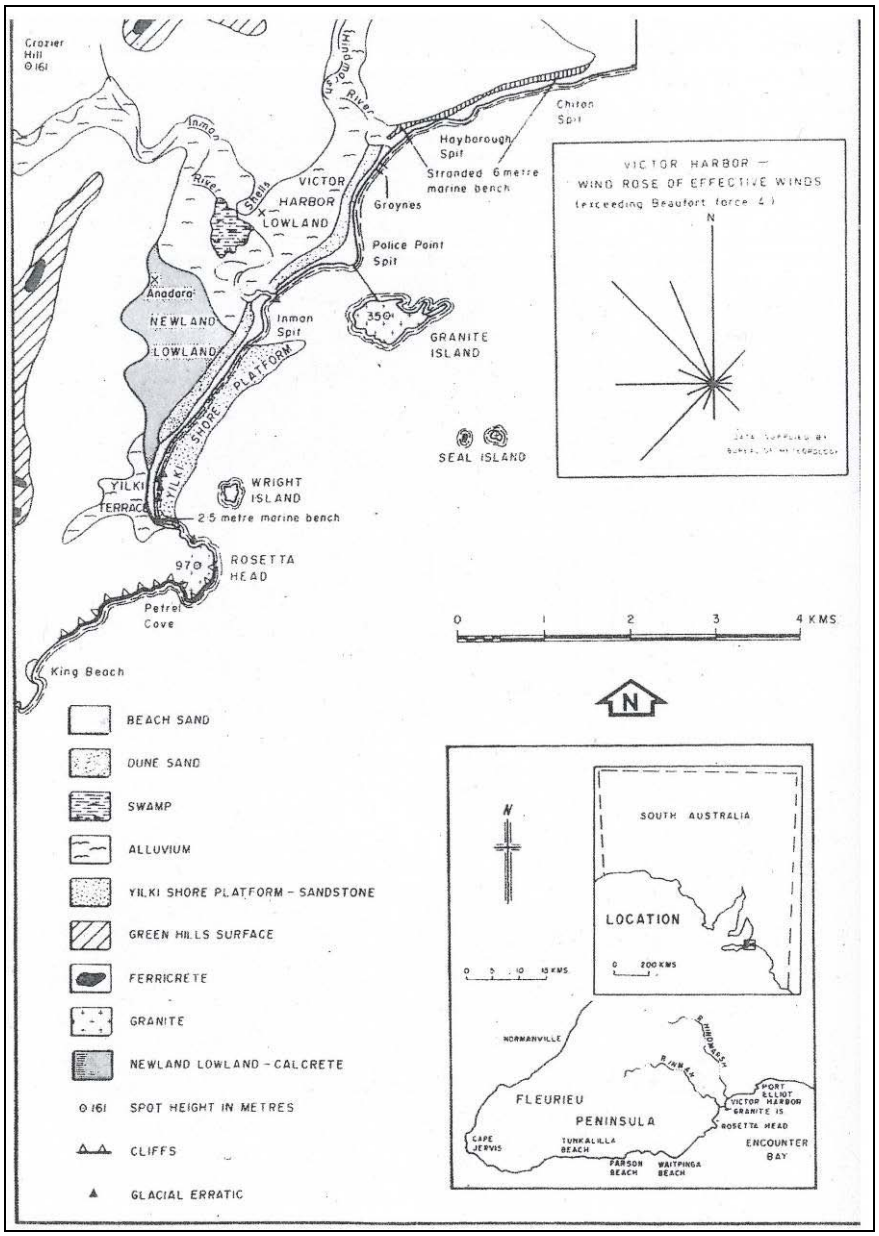
No specific assessment of the local or regional geology has been undertaken for this project. Previous assessment of the foreshore area (e.g. Bourman 1989) delineates the surface geology of Encounter Bay and includes assessment of the stability of the sand spit at Police Point. The surface geology is shown in figure 2-1 below.

Magryn (2006) while not directly addressing the geology of the region, draws upon previous technical studies by others (e.g. John Chappell Engineers 1997 and 1998) and on available historical aerial photographs, beach profiles and beach pole measurements to infer the local morphological changes and potential sand transport mechanisms through the area. He notes that “there is not a major along shore drift of sediment, and that some on shore and offshore sand movement occur”. He also notes that “north of Police Point there is a net northerly drift of sand at the boat ramp and adjacent to the Causeway, but that there is not a major along shore drift of sediment”.

The Field Geology Club of South Australia provides some information of the glacial geology of Encounter Bay and The Bluff as well as the Inman Valley. It identifies the outcrops of granite in a line running east west and including Granite Island, Wright Island and The Bluff (Rosetta Head) and other exposed reef and small islands. These were covered by glaciers during the Permian age (approximately 300 million years ago), which moved westward across the existing shoreline, depositing distinctive granite boulders from Port Elliot and Victor Harbor along the southern shoreline, as far northward as Hallett Cove and along the eastern shoreline of the Yorke Peninsula. These deposits are visible today at the base of The Bluff and along the more recently eroded rock

shelf at the base of the cliffs to the west. The Inman River valley is also of glacial origin, carved out by an ice sheet moving westward and evident some 30 km up the valley at Normanville. The valley formed was some 16 km wide and it was within this broad valley that glacial features were first identified on the Australian mainland in 1859. The glacial deposits in this valley have been subsequently reworked, resulting in the rolling upper catchment landscape and infilled lower valley and low lying areas between the Inman and Hindmarsh Rivers that exists today.

The lack of detailed subsurface geology, particularly landward of the existing shoreline is an impediment to the accurate prediction of the likely rate of recession of the shoreline into the future, particularly given the scenario of a rising sea level. The presence of any resistive substrate will exert control on the shoreline movement, halting recession at some locations and possibly accelerating it at others. In the absence of this information, determination of future hazard zones landward of the beach must be considered carefully. For particular future projects and locations, detailed geotechnical/geological investigations may be warranted.



Source: Bourman 1989

FIGURE 2-1 SURFACE GEOLOGY OF ENCOUNTER BAY AND VICTOR HARBOR

2.5 Inman River

Water quality and odour in the Inman River has been the subject of community debate for many years arising from a range of factors. A number of studies have been undertaken to inform causal factors and remediation strategies.

The Victor Harbor wastewater treatment plant (WWTP) was upgraded and relocated in 2005 to address some of the issues.

On the basis of historical aerial photographs taken in 1959, 1976, 1985, 1989 and 1995 it appears that the mouth of the river to Encounter Bay entered the sea approximately 50 m east of Inman

Street via a meandering channel running in an easterly direction along the alignment of the coast. The Caravan Park was evident in the 1980 and 1989 photographs.

In a 1997 photograph, the river mouth was located approximately 150 m further west with a rock revetment training groyne provided along its eastern bank in its current location to redirect the mouth entrance. The river mouth was allegedly realigned away from the southern boundary of the Caravan Park in 1997 due to erosion of the northern bank and concerns about flooding of the southern portion of the Caravan Park.

A 0.5 m – 1 m high flood protection bund was subsequently constructed along the southern and south western sides of the caravan park which also supports the Encounter Bikeway.

An aerial photograph in 2010 shows the remnants of the original meandering channel.

2.6 Vegetation

There is a limited amount of planted native vegetation along the foredune between Inman Street and the Causeway which has been replaced by Council after erosion events.

Exotic Canary Island pines and Norfolk Island pines have been planted in the foreshore reserve abutting the Esplanade as part of the Soldiers Memorial Reserve.

The banks of the Inman River contain native vegetation of high conservation and biodiversity value as outlined in the Inman River Estuary Action Plan 2010.

The dune abutting the Inman River mouth between the south edge of Kent Reserve and Inman Street contains native and planted grasses and shrubs.

The foreshore along Franklin Parade contains Norfolk Island Pines abutting the Encounter Bikeway shared path.

2.7 Recorded Changes to the Beach and Coast

2.7.1 Historical Photographs

A range of vertical aerial photographs is available covering the area and dating back to approximately 1945, a period of approximately 65 years. The earlier photographs tend to be at a small scale and generally lower image quality, making qualitative comparison between dates of photography difficult. While no detailed photogrammetric plotting has been undertaken from these photos, their close examination and in particular observation of beach changes, provides strong evidence of the stability of the shoreline and fragile dune system over time. In particular, comparison of the current perceived areas of high erosion (such as the area between Albert Place and Island Street) suggest minimal changes have occurred in the location of the waterline and seaward dune face over the intervening period of 75 years. There is some recession of the dune face and concurrent narrowing of the beach width, but this is limited to a few metres over the intervening 60 year period. Given the activities that have been undertaken along the foreshore of Encounter Bay, to address erosion, alter the Inman River entrance, access the shoreline (for drainage , boating and pedestrians), the observed change mainly falls within the anticipated accuracy of such measurements.

There is a tendency for beaches around Australia to experience recession over recent decades and there are reasons for this.

- There has been a general tendency to trap sand at locations along the shoreline where erosion is perceived or is a threat to fixed assets. This may take the form of hard protection works (such as seawalls) which effectively lock up sand stored in the foredunes or soft management (such as dune restoration works) which slows down the movement of sand along the shorelines and generally slows the alongshore sand supply;
- Increased urban development and the construction of major infrastructure (such as breakwaters, dredged channels etc.) has at many locations intercepted the alongshore movement of sand and so reduced the available sand supply, resulting in erosion of foreshores downdrift from the works;
- Urban development within catchments including damming of rivers and catchment changes has either reduced the overland flows (and hence sediment moving down the rivers to the coast) or has trapped sediment in dams or altered river channels; and
- An ongoing increase in sea level which has been measured on tide gauges over the past 100 years (currently at low rates). As sea level rises there is a landward migration of active beach systems at locations where the beach is not backed by bedrock. Current sea level is causing a general recession of sandy beach areas and this will increase should the observed trend continue into the future.

Available vertical aerial photography of the study area is listed in Table 2-1 below.

TABLE 2-1 AERIAL PHOTOGRAPHY SUMMARY

Photo Date	Scale	Details
27th March 1949 (B&W)		
13th March 1959 (B&W)		Survey 340Frame 2644, 2646, 2648: Survey 353 Frame 2105
16th Jan 1976 (Colour)	1:10,000	Survey 1885, Frame 13, 14, 15, 16, 17, 20, 21, 22, 24, 25,
15th Feb 1985 (Colour)		Survey 3214, Frame 100
6th Jan 1989 (Colour)	1:40,000	Survey 3959 SA Lands, Frames 122, 124, 152
11th March 1997 (Colour)		Survey 5301 DENR, Frame 35, 36
6th October 1999 (Colour)		Survey 5726, Frame 26
7th October 1999 (Colour)		Survey 5728, Frame 155
28th September 2000 (Colour)		Survey 5870 Frame 283, 285
13th March 2003 (Colour)		Google Earth
20th July 2003 (Colour)		Google earth
31st December 2004 (Colour)		Google Earth
30th Jan 2005 (Colour)		Survey 7015, Frame 171
26th April 2006 (Colour)		Google Earth
1st September 2010 (Colour)		Google Earth
20th November 2010 (Colour)		Google Earth

While all of the vertical aerial photography provides an insight into the overall beach behaviour, the assessment undertaken for this project has relied on the longest available time frame, relying

particularly on the 1949, 1976 and 2010 photography. As with all sandy beaches there is a localised response to prevailing weather conditions and beach management measures. It is common to see short term fluctuations in beach position during storm events with erosion escarpments forming and moving landward up to 10 m over short periods of time. Recovery of the beach face takes considerably longer, depending on the availability of alongshore sand supply and weather. Erosion occurs over time frames of days or weeks while recovery may take months or years.

Undeniably, the photography indicates a reduction in the sediment available within Encounter Bay, which is currently expressed as slow, ongoing recession of the foreshores and a narrowing of the beach width. However, the rates are low and are not presently posing a significant risk to infrastructure. Based on the observed historical rates of change there is the opportunity to manage present day beach erosion using soft management approaches with minimal impact on the beach in the short term.

2.7.2 Beach Profiles

Survey profiles covering the back beach area and extending offshore for 300 m to 400 m have been collected on an irregular basis by the DEWNR since approximately 1987. This data collection has been undertaken as part of a state-wide data collection program. Since 2010 there has been an increase in the frequency of the data collected in response to community concerns relating to erosion of the beach. In the absence of any photogrammetric assessment based on the vertical aerial photography, these selected surveys provide an important data set, showing through controlled survey the changes that have occurred to the beach and near-shore over an extended time period. As the time series of these survey increases into the future their value in interpreting beach behaviour will increase.

Profiles have been collected at selected locations along the beach using a combination of ground and bathymetric survey, providing a continuous profile from a base location approximately 80 m to 100 m landward of the intertidal zone, to a depth around -7 m Australian Height Datum (AHD) approximately 500 m from the base line. The length and final depth of each profile varies.

The locations of the profiles are shown below whilst approximate location and dates included for each survey profile are as shown in the following table.

Source DEWNR

FIGURE 2-2 SURVEY PROFILE LOCATIONS WEST OF POLICE POINT

TABLE 2-2 SURVEY PROFILE LOCATIONS

Profile Number	Location	Survey Dates
620004	South of Coral Street, aligned to shore normal to east	
620009	Police Point Causeway	
620008	North of Wills St, aligned to south angled across embayment	2003, 2006, 2009, 2011, 2012
620024	King St, shore normal	
620006	South of Island St, shore normal	1987, 1989, 2003, 2006, 2009, 2011, 2012
620011	Inman St, shore normal	
620012	Centre of Caravan park, shore normal	
620013	North side Inman River entrance, shore normal	
620014	South side Inman River entrance, shore normal	
620015	Kent Reserve, north end Franklin Parade, shore normal	
620016	Seaward tip Kent Reserve, shore normal along rock reef	
620007	Kent Reserve at Kareena Avenue, shore normal	1987, 1989, 2006, 2009, 2011, 2012

Detailed plots of survey profile numbers 620008, 620006 and 620007 have been examined and provide information on the beach changes over the past 35 years.

2.7.3 Recent Surveys and Modelling

In addition to the vertical aerial photography and shore normal beach profiles, DEWNR has recently undertaken detailed surveys of the area surrounding the Inman River entrance. The objective of these surveys is to provide detailed, quantitative data on the changes to the back beach area on the eastern side of the river entrance in an effort to better assess the impact of the training works on changing the sediment transport along this section of the beach. Specifically, the objective is to focus on the changes to the sand levels (and hence volumes) on the beach west of the Inman River mouth to Police Point. At present this assessment is in the preliminary stage with two dates of survey data available for comparison. For each date a digital terrain model (DTM) is established of the land surface (landward of the High Water Mark) in the form of x, y and z coordinates, defining the dune heights and back beach heights over a grid area. These surveys can then be compared by overlaying various survey dates and then plotting contours of the change in level for each date (isopachs) which essentially defines the changes in the beach over the intervening period.

The first comprehensive onshore survey data set was obtained from an aerial LIDAR survey undertaken by Photomapping Services for Geosciences Australia and covering the area from The Bluff to the Murray Mouth in early September 2011. This aerial survey is reported in Photomapping Services (2011) and the data collected was reduced and corrected to a 1 m triangulated grid of the area of coverage. Quoted accuracy for the reduced survey data was 0.1 m vertical and 0.3 m horizontal. This broad survey of the study area was used as the base data set for computation of present and future ocean inundation extent.

This base survey has been supplemented by ground survey of the area between the Inman River entrance and the Police Point, undertaken by DEWNR in July 2012 and repeated in February 2013 and also by Council for a 300 m section of the beach west of Police Point. The ground survey has not been overlain against the LIDAR data which was only recently obtained. DEWNR has undertaken a preliminary isopach analysis of the two ground survey dates as shown below in the figure below. The results of this analysis shows areas of accretion (blue tones) and areas of erosion (orange tones) along the beachfront over the intervening 6 month period covered by the surveys. No clear trend is evident from this short data as yet but this analysis will become increasingly valuable over time, highlighting those sections of the beach under erosion threat and allowing a comparison of the overall beach sand volumes over time.

Source DEWNR

FIGURE 2-3 SURVEY ISOPACHS - INMAN RIVER ENTRANCE TO POLICE POINT, JULY 2012 TO FEBUARY 2013

The isopachs highlight the erosion of the beach face immediately north of the Inman River entrance, seaward of King Street and adjacent to Police Point over the six month period covered. Corresponding accretion of the beach face seaward of Island Street and from Wills Street to Albert Place occurred over the same timeframe.

The high area of accretion to the north east of the Inman River entrance (shown as a large blue area on the isopach diagram above) suggests a high level of accretion in this area between the survey dates which is unlikely. This beach section incorporates the old river channel and a pond of exposed groundwater that could not be surveyed. The suggested accretion on the plots is likely to be an anomaly, reflecting different survey approaches to this isolated lagoon area, rather than actual sand accretion. This anomaly can be checked and if necessary corrected in future data plots.

2.8 Infrastructure

2.8.1 Public Infrastructure

The subject coast contains a range of Council and State Government owned assets, as indicated in Figure 2 in Appendix B.

Infrastructure includes:

- Beach access stairs ramps and boardwalks;
- Treated pine fencing at top of dune east of Island Street to the Causeway;
- Existing sand groynes east of Island Street;
- Inman River and rock training groyne at mouth;
- Playgrounds;
- Three public toilets;
- Bluff boat ramp;
- The Causeway jetty to Granite Island;
- Carparks;
- Public roads;
- Encounter Bikeway from the Esplanade main carpark to the boat ramp;
- Visitor Information Centre and Kiosk,
- Mini golf;
- Council stormwater drainage outfall pipes;
- Soldiers Memorial and associated Norfolk Island trees and Canary Island Palms in Soldiers Memorial Reserve; and
- Park furniture including park benches, picnic tables, rubbish bins.

2.8.2 Beach Access

2.8.2.1 Pedestrian Access Ramps

There are 22 formal Council owned access stairs and boardwalks providing pedestrian access to the coast.

2.8.2.2 Maintenance Vehicle Access Ramps

There is one formal maintenance vehicle access ramp leading to the beach adjacent to the Causeway.

2.8.3 Sand Groynes

There are nine lateral sand bag groynes installed between Island Street and the Causeway with a section of longitudinal sand sausage placed in front of the fore dune in the vicinity of King Street.

2.8.4 Encounter Bikeway

The Encounter Bikeway within the study area is a shared path currently extending from the west end of the Esplanade carpark opposite the Hotel Victor to the Bluff boat ramp.

The alignment generally follows to the coastal side of the Esplanade and Franklin Parade except between Inman Street and Kent Drive where it heads inland near the caravan park to cross a footbridge over the Inman River.

2.8.5 Causeway Jetty

The Causeway Jetty (owned by Department of Planning, Transport and Infrastructure (DPTI)) provides vehicular and pedestrian and tram access between Police Point and Granite Island.

3 Coastal Processes

3.1 Past Studies of the Coast

3.1.1 DEWNR Beach Profile Recession Surveys

DEWNR has been monitoring changes in the coastal and beach profile at five monitoring sites between 1987 and 2011. Two sites are located west of Inman River and two between Police Point and the Inman River mouth. There are also sand depth poles to monitor changes in sand depth.

3.1.2 Foreshore Protection Study

The 'Foreshore Protection Study Police Point Inman River outlet to Hindmarsh River Outlet' by Magyrn and Associates (2006) focused on management measures to address the storm damage arising from the 2004 storm surge event and sand loss along the Esplanade section of the coast and the wave overtopping of the existing rock revetment wall adjacent to Soldiers Memorial Garden. The resultant treatments involved installing sand bag groynes along the coast, sand replenishment and sand drift fencing east of the Inman River mouth to Police Point, and sand bag groynes along the coast abutting Soldiers Memorial Gardens between Police Point and the Bowling Club.

The effectiveness of the sand bags in trapping the sand on the coast has been questioned. It has been suggested that their effectiveness would be improved if they were made longer and extended further out to sea. Whilst this may result in a small increase in the effectiveness, the primary reason for their lower than desirable performance is a lack of sand supply. The amount of sand movement along the coast is simply too small for this technique to be effective.

3.1.3 Southern Fleurieu Coastal Action Plan and Conservation Priority Study

This study was commissioned by Adelaide and Mount Lofty Ranges Natural Resources Management Board (AMLRNRMB) in 2007 for the section of coast between Sellicks Beach and Hindmarsh Island to understand and facilitate the conservation protection and maintenance of the coast's natural resources and develop management strategies to address threats to high conservation assets.

3.1.4 July 2012-March 2013 Beach Monitoring

DEWNR's Coast Protection Branch, in conjunction with Council, has been undertaking monthly surveys of sand movement along the Esplanade section of coast east of the Inman River mouth since the May 2012 storm event. A model was generated to identify areas of sand accretion and depletion.

3.1.5 Victor Harbor Foreshore Coastal Park Open Space Plan

This study by Berchervaise and Associates (2004) was commissioned by Council and Planning SA to identify an overall coastal park as a future basis for management and development of the foreshore as a leisure tourism asset for the local community and visitors. It highlighted the importance of the Inman River and coastal reserve abutting the Esplanade and the importance of the Encounter Bikeway shared path as a key linkage.

3.2 Tides

Australian tidal authorities have adopted the 20 year tidal datum epoch from 1992 to 2011 (inclusive) as the basis for calculating tidal datum and the associated tidal planes. A table showing the tidal constituents through this period, reduced to both chart datum and Australian Height Datum, is shown in Table 3-1 below.

TABLE 3-1 TIDE LEVELS FOR VICTOR HARBOR

Level	Chart Datum (m)	AHD (m)
Lowest astronomical tide	0.021	-0.564
Mean Sea Level	0.705	0.120
Australian Height Datum	0.585	0.000
Mean Higher High Water	1.177	0.592
Highest Recorded	2.090	1.505

Source: National Tidal Centre

Along the coast of Encounter Bay it is anticipated that tidal currents would be low and predominantly shore normal, having negligible impact on sediment transport at the beach face or in the near shore region. While these tidal currents may have the potential to entrain and move bare sand on the sea bed which is stirred by waves, they do not contribute significantly to the alongshore sediment transport rates at the shoreline.

3.3 Winds

Historical average wind data and humidity recorded at 9am and 3pm from the Bureau of Meteorology (BOM) weather station at Victor Harbor has been analysed to confirm typical wind speeds and directions for Encounter Bay and the periods of highest humidity.

The results are summarised in Table 3-2 below.

TABLE 3-2 WINDS

Time	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
9am wind speed (km/hr)	14.8	12.6	13.4	13.1	13.1	13.4	15.2	16.9	18.3	17.4	17.0	16.8
3pm wind speed (km/hr)	21.6	19.3	18.4	17.0	17.0	17.1	20.1	22.4	23.0	20.5	21.8	22.6
9am humidity (%)					79	82	81	75	72	67		
3pm humidity (%)					66	69	67	63	63	59		

The results indicate that the potential for storm surge and wave action under winds is higher in the months May- October.

An examination of historical wind roses indicates that for the months of May to September the prevailing wind direction at 9am is from the west and north-west with 20-30% of wind speeds above 40 km/hr. The corresponding prevailing wind and speed at 3pm was from the west and south with 20% of winds above 40 km/hr. The strongest wind speeds from the south occur in September and October.

3.4 Waves

3.4.1 Swell Waves

Swells are long period ocean waves, generated in deep water by strong winds often at distances of many hundreds of kilometres from the shoreline where they eventually make landfall. For the shoreline of Encounter Bay, ocean swells are generated in the Southern Ocean. The local foreshores are generally protected from the swells approaching from the west to wouthwest by the Fleurieu Peninsula and Kangaroo Island but exposed to those swells from the south west to south east quadrant. The predominant regional swell direction is reflected in the long sweep of the Coorong to the north of Encounter Bay which is not modified by bedrock headland or receiving local sheltering from nearby islands and reefs. There, the predominant alignment of that coastline is to the prevailing south west waves.

At Victor Harbor the coastal alignment is different, controlled by the closely spaced bedrock headlands which contain the beach. The embayment is sheltered by The Bluff and adjacent rock reefs to all swell directions to the west of south. Further sheltering is provided by Granite Island, reducing significantly the impact of those waves for south-east to easterly directions. The predominant exposure of the embayment is to swells approaching from the south to south-east quadrant. This relatively narrow swell window and subsequent wave transformation as the waves refract, diffract and attenuate due to bottom friction across the reefs and in shallow water over the seagrasses, results in considerable reduction in the wave heights as they approach the shoreline of Encounter Bay.

The swell waves that propagate from the Southern Ocean to the South Australian coast have long wave periods of 12-16 seconds. While storm conditions within the Southern Ocean generate waves in excess of 11 m in height, (e.g. 1994 storms which are the worst recorded) they are significantly reduced by refraction and diffraction as they approach Encounter Bay, reaching the shoreline with low wave heights, depending on the state of the tide at the time. Most waves break and re-break across the reefs within the bay, with the only substantial wave conditions at the shoreline occurring around high tide when offshore and inshore water depths are greatest. There are no detailed wave studies or wave measurements showing the frequency and heights of these storm waves at the shoreline.

3.4.2 Sea Waves

Sea waves are those waves generated by winds associated with local storms, in this case originating close to the coast and at this location with wind directions occurring from south to east. They are generally of short wave period and quite steep, frequently with white caps as partial breaking occurs. They approach the shoreline generally from the direction of the wind. These sea waves generally contain less energy than the longer ocean swells and at the shoreline the impact of the

two separate wave conditions is combined. Often they will be approaching from different directions resulting in a confused surf at the shoreline. Because of the more persistent approach direction of the swells and their greater energy, the net resulting sediment movement under these combined waves will usually be from south-east to north-west along the shoreline of Encounter Bay.

3.5 Inman River

3.5.1 Inman River Estuary Action Plan

The AMLRNRMB commissioned SKM to prepare an estuary management plan for the Inman River estuary in 2004 to develop a better understanding of the natural resources and community values of the Inman River estuary and recommend the development of management plans.

The Action Plan identified the key natural values as:

- Swamp Paperbark vegetation;
- Threatened birds;
- Remnant vegetation containing floral diversity and threatened species;
- Good habitat for migratory birds and waders;
- Fish species; and
- Estuary mouth opening that facilitates fish passage to and from the estuary.

Key Community values were identified as:

- Water and flow;
- Mouth Management;
- Flora and fauna; and
- Planning and recreation.

Recommended management actions included:

- Improve water quality and enhance in-stream ecology;
- Investigate surface and groundwater flows;
- Review mouth opening arrangements;
- Heritage protection and biodiversity conservation measures;
- Bank stabilisation and revegetation;
- Monitor beach erosion; and
- Add protection provisions for the dune and mouth area in Council's Development Plan.

3.5.2 Flood Levels Adjacent Inman River Mouth

Discussions with Coastcare representatives indicate that the Inman River water levels overtop the banks during major flood events by up to 1 m which coincides with the bund levels constructed around the southern and western perimeter of the Caravan Park.

3.5.3 Water Body South of Caravan Park

There is an existing water body within a natural low point located in the original river alignment south of the Caravan Park which, based on discussions with local Coastcare representatives, contains groundwater that rises and falls with the tide. This water body, based on observations by AWE, also receives stormwater runoff from the Caravan Park and the Inman Street drainage catchment.

3.6 Storm Surge

Based on information provided by DEWNR-CPB and the 2006 Foreshore Protection Study, the 1 in 100 Average Recurrence Interval (ARI) storm surge water level is 1.75 m AHD at Victor Harbor.

3.7 Bathymetric and Survey Data

The general physiographic setting of the Encounter Bay/Victor Harbor study areas is described in section 2.4. While navigation survey information for deep water adjacent to the study area is available from the AUS hydrographic charts, these do not provide detailed information on the bathymetry of the nearshore area, particularly in depths less than 20 m, as they are generally prepared for the purpose of shipping navigation. This coastline which at the time was referred as the “unknown Coast”, was first charted by Matthew Flinders in 1802 on his epic voyage around Australia. He met with the French navigator Nicolas Baudin at Encounter Bay in April 1802 and between them they explored, surveyed and mapped 3,700 km of the southern coastline from Ceduna to Robe. Flinders’ mapping of the coastline was completed in 1802, for the first time disproving the existence of a navigable passage from south to north through the South Australian gulfs. However, the charts were not published until some 12 years later after Flinders returned to England.

Within the embayment, some information on the inshore bathymetry out to about 10 m depth is shown on beach profiles collected by DEWNR and discussed in more detail in Section 2.7.2. The alignment and shape of the shoreline is determined by the existing bedrock geology. The shore normal profile off Kent Reserve (Profile 620007) shows that for 150 m from the shoreline there is an almost flat bedrock shelf at or around the low tide level. The reef drops away gradually to a depth of around 5 m below AHD some 400 m from shore. This flat, wave cut rock shelf appears to extend all along the shoreline from the Bluff to Kent Reserve.

East of the Inman River, the shore normal profile (Profile 620006) extends out with a gently sloping near-shore reef for some 250 m from the shoreline to a depth of -2.5 m below AHD. For the next 150 m seaward the reef dips more steeply, reaching a depth of 6.5 m below AHD some 400 m from the shoreline. While no detailed survey information is available beyond these profiles, observation of the wave behaviour and examination of vertical aerial photography indicates a line of shallower reef running from the centre of Granite Island west to The Bluff and which is shallow enough to cause breaking of most waves on low tide. This reef is irregular in height and at the higher points appears to be at a depth of around -2 m to -4 m AHD around one kilometre from the shoreline. This reef in conjunction with the shallow reef adjacent to the shoreline provides protection to the back beach area from storm wave attack.

At Police Point, the mainland is shallowly connected to Granite Island with a sand spit extending seaward across this shallow (bedrock) connection. This feature is a major control on both the beach

shape of Encounter Bay to the west and the movement of sand around Police Point and along the coast to the north and west. There is a change in the alignment of the coast at Police Point of some 90 degrees.

3.8 Climate Change Impacts

3.8.1 Sea Level Rise

Various scenarios for potential sea level rise to the year 2050 and year 2100 exist, based on the findings of the Intergovernmental Panel on Climate Change (IPCC), CSIRO and other researchers. These are reviewed regularly. To facilitate the incorporation of appropriate and consistent consideration of future sea level rise in planning and decision making, the South Australian Government requires allowance for sea level rise of 0.3 m by year 2050 and 1.0 m by year 2100 to be made.

The impact of these scenarios on the subject coastline is shown in Figures 2 and 3 in Appendix B. These figures show the areas of inundation assuming that no intervention is in place.

Allowing for storm surge wave set up and wave run up, abutting land and existing infrastructure and assets up to 2.65 m AHD and 3.35 m AHD is likely to be potentially impacted by inundation and wave forces by year 2050 and 2100 respectively. (This assumes no mitigation measures have been established). However with continued recession of the fore dune along the Esplanade, any sea defence systems along this section of coast may need to be designed for 3.35 m AHD and 4.05 m AHD respectively.

This would indicate that without any mitigation measures in place, all assets and infrastructure below the above levels would be potentially impacted by inundation including the existing fore dune between Inman Street and the Inman River mouth. Likewise, the southern section of the Council Caravan Park and sections of the Encounter Bikeway shared path would also be subject to increased inundation under storm surge. In addition, the Visitor Information Centre and Kiosk could also be impacted under the 2100 scenario.

3.8.2 Tidal Inundation of Inman River and Abutting Areas

By the year 2100 tailwater levels at the mouth of the Inman River would reach the level of the southern and northern banks, increasing the potential for increased inundation of Kent Reserve, the adjacent Encounter Bikeway shared path, Council's Municipal offices, and the two caravan parks. This assumes no mitigation measures are in place.

3.8.3 Groundwater Rise

The groundwater along the foreshore is quite shallow and appears to be hydraulically linked to the sea through the existing sand aquifer.

The standing water in the water body south of the Caravan Park appears to rise and fall with the tide and at the time of a site visit on 3 April 2013 was estimated to be sitting at RL 0.9 m AHD.

With sea level rise an increase in local groundwater level would also be expected which may impact infrastructure and vegetation.

4 Project Site Impacts and Key Issues

4.1 Variability in Alongshore Sand Supply

There is limited survey or sediment information available to assess the alongshore supply of sand to and rates of sand movement through Encounter Bay. The available information (particularly wave climate and bathymetry) is not adequate to enable meaningful numerical modelling of sand transport rates.

While there have been some activities undertaken to address recession of the shoreline, such as beach nourishment, foreshore protection and shore normal protection structures, the impact of these activities has not been monitored in sufficient detail to enable either an estimate of the net alongshore sand transport rate nor its variability. It is clear from observations and review of the photographs and survey data available, that the alongshore transport is from south to north through the embayment and also that there are only relatively small amounts of sand involved. It is also apparent that the volume of sand stored within the embayment is minimal, with a likely reduction of the alongshore supply of sand to the embayment from the coastline to the west over recent decades. This is not surprising and is consistent with observations around much of the Australian mainland.

The foreshores are now starved of sand with an apparent ongoing loss of sand from the overall beach compartment over time. There is more sand moving from the beaches and out of the system over time (around Police Point or possibly offshore across the reefs) than is either moving into the system around The Bluff or is being generated within the embayment from the breakdown of shell or other sources. This is a relatively common scenario which will be exacerbated in the future as sea level rises. Without intervention, the likely scenario for the foreshores of Encounter Bay is one of ongoing foreshore recession into erodible back beach sediments, exposure of areas of existing rock substrate and loss of sandy beach areas.

To the west of The Bluff is a section of rocky cliffed coastline, with small pocket beach embayments containing small deposits of sand. Observation of this coastline shows that it is a high energy coastline, exposed to the prevailing wave climate. Sediment can be observed moving under waves along this shoreline and onshore /offshore through the strong and persistent system of rip cells. There is no hard evidence (detailed survey, surface sediment mapping, etc.) to show that this sand supply moves around the base of The Bluff and ultimately into the sheltered western end of Encounter Bay. There is no obvious build-up of sand against the headland with limited sand storage in Petrel Cove and along the cliffs west of The Bluff at present, again suggesting a low supply rate to this area. That there is no sand build up suggests that sand is moving from time to time around the headland and either into deep water or moves across the near-shore reef and onto the shoreline adjacent to and eastward of the boat ramp. This would occur infrequently rather than on a continuous basis, and would follow storm events (capable of transporting sand offshore beyond the headland and then to the east), and when a sufficient store of sand has accumulated adjacent to the headland. Anecdotal evidence from long term residents suggests there has been a reduction in the sand store at Petrel Cove beach and along the western cliff beaches over recent decades. Inspection of the available aerial photography shows sandy patches across the shallow reef area on the eastern side of The Bluff and into the boat ramp. The dredged channel to the boat ramp and the low points in the reef are filled with sand.

Sediment transport along the shoreline within Encounter Bay is driven by waves which break at the shoreline at an angle. The majority of the alongshore sand movement is occurring inshore of the wave breaks and along the near-shore rock shelf. From the boat ramp at The Bluff a narrow sand beach and dune barrier extends east along the rock shelf to Kent Reserve where the shore normal reef forms the next significant control on the foreshore alignment.

Examination of the historical aerial photography shows fluctuations in the sand volumes stored along Kent Reserve, in the shelter of the rock reef. These volumes vary in response to storm events, from time to time feeding sand along the beach to the east, before again trapping the natural supply of sand from the west as the beach recovers. The natural trends along this beach section have been further masked by beach nourishment activities with sand sourced from Kent Reserve used to both nourish the beach to the west, seaward of Franklin Parade and to the east, seaward of the Esplanade. The records detailing the time, location and volumes of these nourishment episodes are sketchy. On at least one occasion, additional sand has been imported to the embayment for nourishment from an external onshore quarry, further masking the natural trend in beach response.

The Inman River is located to the east of Kent Reserve, in the sheltered area in the lee of the rock reef and sand spit. In the recent past the mouth was untrained and the river meandered to the north, opening across the beach when water levels in the river were sufficiently high and coastal wave conditions permitted. In approximately 1997 Council decided to train the river mouth using two tipped rock training walls to constrain the entrance location to the south end of the beach. This resulted from concerns relating to the erosion of the landward entrance channel embankment around Inman Street/Esplanade, potentially threatening the roadway. The old area of the entrance channel and beach seaward of the caravan park was allowed to recover naturally and some sand would have been trapped in this area, filing low sections of the earlier river channel. The volume of sand trapped at this location would appear to be small, based on the available survey information with back beach areas remaining quite low. No substantial foredune trapping sand has formed along this section of the beach; nor is it likely to. The amount of sand released by scour of the entrance during floods has probably decreased since the entrance was trained. Correspondingly, the volume of sand trapped in the entrance channel following floods has also decreased. There are concerns amongst local residents that the entrance training has increased the propensity for the movement of seagrass wrack into the entrance, particularly following flood periods and when the entrance is open. This is probably correct as the tidal flow velocities through the trained entrance are likely to be higher while the entrance is fully open and the path for movement of the wrack more direct. The works have not affected the volume of wrack within the overall beach embayment. Removal of the training walls is considered unlikely to significantly affect the alongshore movement of sand through the beach compartment, nor to alter the sand volumes stored within the embayment.

Since the relocation of the Victor Harbor WWTP it is understood that flows into the river have reduced. Drought conditions and the installation of several farm dams have also contributed to the reduction in flow. Water has become stagnant in the lower pools, resulting in Council mechanically dredging the mouth several times a year to allow water to flow. A study to identify inflows, including groundwater into the catchment, is to be commissioned by the AMLRNMB.

Further east along the Esplanade, there remains the remnant of a fragile and narrow dune system seaward of the Esplanade. Again there is a perception that this narrow dune buffer is eroding at a significant rate, particularly over recent years. This perception has been enhanced by actions over recent decades that have resulted in a reduction of the narrow buffer seaward from the Esplanade. These include widening of the roadway and the addition of parking on the seaward side, fencing and planting of the landward edge of the buffer together with the addition of fixed access ways, dune works and beach protection measures.

Close examination of the vertical aerial photography suggests that the location of the back of the beach has not varied significantly since the earliest photography, and is at most locations within a few metres of the location in 1949 and 1976. The changes are within the reasonable accuracy that can be obtained from the measurements taken directly from the photos without detailed rectification and photogrammetric plotting. Similarly, examination of the shore normal survey profiles collected by DEWNR does not show any significant recession of the dune face. The landward section of survey profile number 620006 opposite Island Street, shows a fluctuating movement of the face of the escarpment (typified by the 2 m AHD contour) of around 4 m in total over the period of 25 years of measurement from 1987 to 2012. The landward most location of the dune face at this location was in 2006 while the most seaward location was in 1989. A similar result occurs if the mean water mark or the dune face crest are selected, indicating that, at this location, the dune has been quite stable over the period of survey with periods of accretion and erosion.

A similar picture emerges from survey profile number 620008 near Wills Street, just south of Police Point. Here the fluctuations of the dune face over the shorter period of survey from 2003 to 2012 are around 3.5 m with the landward most location occurring in 2006 and 2012 and the seaward most location in 2011. Again, examination of the location of the mean sea level mark and dune crest show limited fluctuations.

At Police Point, there is a body of sand extending seaward in the form of a sand spit, underneath the Causeway. Sand stored in this shoal is delicately balanced. It is deposited by the wave action wrapping around Granite Island and approaching on some occasions more strongly from the south to the west of Police Point, and on other occasions from the east on the eastern side of the Causeway. Studies undertaken by Magryn (2006) suggest a reduction in the size and extent of this sand spit over time. Earlier studies by Bourman (1989) suggest the spit to be quite stable over time. Both of these assessments are valid over the time periods they were looking at. If considered over the totality of the vertical aerial photography available to the present, the spit appears to be stable, occupying a similar area today that it did in the earliest photos. However, the location of the spit fluctuates to either side of the Causeway and in length under the prevailing storm wave conditions, possibly over periods of several years. For example, over the period from 2000, there was a reduction in the area of this shoal, presumably in response to particular weather conditions resulting in the eastern side of the spit being removed. The shoal over that period appears to reduce in size. The shoal has subsequently recovered over a period of 5 years or more and now extends as far seaward towards Granite Island as it did in the 1940s. This spit may impact the available sand store on the beach between the Inman River mouth and Police Point, acting in effect as a “one way valve” controlling sand movement out of the study area. Sand eroded from the spit and moving to the north and east is effectively lost to the study area, there is no mechanism to naturally move sand from the northern and eastern side of Police Point back into the embayment. Sediment transport along the beach on the eastern side of Police Point is to the north under all wave conditions. The sand that moves off this shoal and along the beach fronting Hindmarsh Road cannot

naturally return to the Encounter Bay beaches. When this shoal at Police Point is depleted by storms, then it can only re-establish through the easterly movement of sand under waves, along the beach to Police Point. As the sand spit re-establishes, there is likely to be a corresponding reduction in the sand stored on the beach face further to the west until the delicate balance is restored.

4.2 Coastal Erosion and Recession

4.2.1 Current Erosion Pattern and Contributors

Over recent decades the foreshore of Encounter Bay has been relatively stable. Natural fluctuations in the location of the face of the dune and the beach width always occur in response to the prevailing weather conditions and the available sand stored in the system at the time. The response to erosion of the western end of the beach (Kent Reserve to The Bluff) is an indication that there is a deficit of sand within the embayment and that long term losses may be occurring in response to sea level rise and reducing supply. However, these losses are currently having minimal impact on the overall beach stability. Where assets are not at risk and beach protection works have not been constructed along the eastern end of the embayment (between the Inman River entrance and Police Point), again the beach has been relatively stable with only minor overall recession. The erosion that occurs tends to be focussed on hotspots where the offshore reef is lowest and the dunes most exposed. At present, these locations are opposite King Street and south to Island Street along the Esplanade.

Along this section of the beach, activities have focussed on restabilising the dune face to its previous more seaward location. This work to increase the sand store in the dune and to raise the level of the dune crest, together with the presence of low key protection works and fixed access ways, focuses attention on the back beach erosion that occurs. Similarly, further to the east, where the foredune is more substantial towards Wills Street, any erosion of the dune results in a higher erosion escarpment and a perception of severe erosion.

The current dune works are effective, ensuring a store of sand at the locations where it is most needed to resist recession of the foreshore during storm events while minimising wave overtopping and damage to the dune vegetation. However, it must be remembered that this erosion is a key function of the narrow dune system which ensures the maintenance of a sandy beach cover to the nearshore rock reef.

For planning purposes the recession rate of the unprotected foreshores of the study area is estimated at 0.1 m/year over recent decades. This rate is recommended for future short term planning. It must be recognised that as sea level rise accelerates under climate change, these historic rates will increase.

Council has trialled the mixing of seagrass wrack with the existing sand from the beach face and then placing this against the escarpment to reduce the wave impact and erosion against the scarp. To date these trials appear successful with cheap and effective disposal of the wrack on site and have shown no adverse impacts. The potential advantages and disadvantages of this technique are described below.

Potential advantages:

- Easy and cheap way to deal with excess wrack compared to removing it from the beach and disposal offsite.

- Reduces the potential for odour problems as wrack decays on the beach above the waterline.
- Provides an increased volume of sand/wrack mix to protect the scarp face and build the dune crest.
- As the wrack breaks down it will provide additional nutrients to assist vegetation regrowth on the dune face and crest.

Potential Disadvantages:

- Wrack will continue to break down over time, reducing the bulked volumes initially placed at the back of the beach or above the erosion scarp.
- Odour problems may still be experienced as the wrack decays and particularly if the material is again eroded and exposed on the beach.
- During erosion some discolouration of water in the surf zone could be expected as the detritus and fines from the broken down wrack are washed away. This discolouration should be minor and short term with no anticipated ongoing adverse impacts.

4.2.2 Dune Stability

The existing dune system throughout Encounter Bay is generally depleted, providing a narrow and sensitive buffer to back beach erosion and minimising storm wave overtopping. That the dune system only recovers slowly following erosion events and does not build to a substantial height is evidence of the low sand volumes available within the study compartment. When erosion occurs during storms, the beach surface is lowered and the wave erosion of the dune may result in a substantial, near vertical escarpment at the back of the beach. This may result in an unstable slope, restricting access across the dune face and, in severe instances posing a risk to persons on the beach, fences, and beach access steps should the escarpment collapse. Where protection structures have not been constructed, the dune system appears quite resilient and stable, eroding and recovering in response to the ambient weather conditions.

4.2.3 Historical Regression

While limited information is available to accurately determine the historical erosion trends for the Encounter Bay foreshores, the geomorphological setting suggests a receding bedrock controlled coastline under current sea level. The foreshore is fringed by a shallow wave cut platform extending seaward from the waterline. Sand deposits occupy low lying portions of the reef. There is a small back beach barrier surviving in places at the back of the beach. The embayment is generally sediment deficient with little sand supply from the west and some potential sand loss to the east and offshore under infrequent storm conditions. Alongshore sediment transport through the embayment is at low rates under the sheltered wave climate.

The western portion of the embayment fronting Franklin Parade has a narrow beach area overlying a shallow rock platform. Erosion of the back beach area has from time to time threatened Franklin Parade, resulting in the construction of a tipped rock revetment at the back of the beach to protect the road.

Along the Kent Reserve foreshore, the back beach is further protected by an extensive rock reef which extends seaward from the shoreline at shallow depth. In this location, sand moving alongshore at the shoreface zone can become trapped, building the back beach dune seaward. It

may be then eroded during storms, releasing stored sand to the beach system which can then be transported to the east. This sand store has also been used over recent years as a source for artificial beach nourishment to both the east and west. Over recent decades the aerial photography shows that the back beach location has fluctuated with periods of erosion and accretion. Over the total period of photo record there has been little net movement of the back beach.

The Inman River to Police Point embayment (east of Kent Reserve) still has a narrow dune buffer at the back of the beach, separating the foreshore from the Esplanade and the residential development landward. This narrow dune is under stress from encroachment from the landward side and episodic and isolated erosion of sections of the dune. The face of the dune at present is close to its landward most location over much of this beach section. However, close examination of the historical photo record and available survey information suggests that there has been little change in the beach location since the 1940s, with periods of erosion and accretion resulting in movement of the dune face of around 5 m.

Overall, the embayment is considered to be sediment deficient and under stress as a result of the slow measured rate of sea level rise and other factors. The beach is sheltered by offshore reefs and stabilised by shallow bedrock at the shoreline. The sand volume within the embayment is small and likely to be decreasing. Over the period of historical record (approximately 60 years), the beach has remained relatively stable with some fluctuations. The current risk to infrastructure and development located landward of the beach is low. The tendency is and will continue to be for recession of the current shoreline.

4.2.4 Predicted Regression to Year 2050 and Year 2100

Future planning requires an understanding of the likely future development of the shoreline. There are strong arguments that sea level will continue to rise at accelerating rates for possibly several centuries. The South Australian Government requires future planning and development to accommodate a sea level rise of 0.3 m to the year 2050 and to be able to adapt to accommodate a further 0.7 m rise by the year 2100.

Under present sea level conditions the shoreline location throughout the study area is relatively stable. However, this is unlikely to be the case as sea level rise accelerates into the future. The Encounter Bay/Victor Harbor foreshore is somewhat unique. While located on an exposed shoreline with potential for severe offshore storm wave conditions, the alignment of the coast is determined by the local geology and the shoreline is sheltered by an extensive offshore reef system, islands and an underlying rock shelf. While at present this protects and maintains the beach and back beach area, it will make it extremely vulnerable to wave attack when sea level rises. This will result in two main impacts:

- The increase in water levels will result in a decrease in the sheltering of the foreshore as waves break on the shallow offshore reefs. With an increase in water depths of 1 m to the year 2100, potentially waves of an extra 1 m wave height will pass across the reef without breaking and approach the shoreline; and
- The higher water levels and consequently higher storm surge levels will allow the larger waves penetrating the reef to attack the current low dune cap at a higher level with resultant significant increases in potential storm wave erosion, wave overtopping and back beach inundation.

It is not feasible to provide an accurate estimate of the likely extent of the back beach recession that would occur to the year 2050 and 2100 with a sea level rise of 0.3 m and 1.0 m respectively, given the paucity of data on the offshore bathymetry and wave conditions (for numerical modelling) and of the back beach morphology (including sediment extent, type and bedrock levels). As at present, the shape and alignment of the shoreline will continue to be determined by the local geology and the changing wave energy along the beach. The changes to the wave energy at the beach and the corresponding foreshore erosion and inundation will be significant and progressive.

By the year 2100, higher sea level will allow significantly large waves to pass unbroken over the offshore reefs, breaking closer to the shoreface rather than further from shore on the rock shelf. For example with a 1 m sea level rise, the wave conditions at low tide would be similar to those that currently occur on a high tide. The wave conditions at high tide would significantly increase and would be breaking at the shoreline with increased run-up and impact on the foredunes. Wave energy is proportional to the square of the wave height. An increase in wave height across the reefs of 50% (say from 2 m to 3 m) would result in an increase in the wave energy at the shoreline by 125% or more than double. This is not an unlikely scenario for the Encounter Bay foreshores by 2100. Without considerable intervention works it is likely that the shoreline will undergo substantial, progressive recession and realignment.

Other impacts resulting from climate change may include subtle changes to the offshore wave climate (height and direction), and increases in frequency and severity of storm events. These changes are as yet not well defined.

While it is generally accepted practice to estimate/compute the likely extent of foreshore changes for differing sea level rise scenario, for reasons outlined, this cannot be meaningfully done for the Encounter Bay foreshores at present. The most commonly employed approach is through the application of the “Bruun Rule” which effectively relates the prevailing wave climate to the near-shore beach slope. Simple application of this approach is based on a number of assumptions that make it unsuitable for application within the study area:

- The beach cross section is considered as a 2 dimensional element with alongshore controls exerting an influence on the profile shape;
- The incident wave climate is well defined;
- The near-shore beach profile is free to adjust to changes in water level and wave conditions (i.e. it is a sandy, erodible profile, not bedrock controlled); and
- The back beach area comprises sandy, erodible substrate.

None of these assumptions are realistic within the study area. Common application of this approach around exposed, open beaches on the Australian coast give widely varying results, commonly showing a recession of the back beach between 50 and 100 times the sea level increase or recession of the shoreline by 15 m to 30 m by 2050 (for a 0.3 m sea level rise) and 50 m to 100 m by year 2100 (for a 1 m sea level rise). Actual local rates may be higher or lower than these values. Without intervention and in the absence of bedrock control, such rates of recession would place infrastructure throughout the study area (such as beachfront roads, carparks, stormwater assets, access ways etc.) at risk by year 2050. By year 2100 ongoing recession would also impact on beach front residential development, sewerage and power supply services. These rates and scenario outlines are not a prediction of future foreshore behaviour but merely serve to illustrate the need to better understand the likely future consequences of climate change and the urgency for better

definition and of the potential hazard and future risk which may result in the absence of long term planning. The consequences and extent of future inundation may be more significant, given the extent of existing low lying foreshore and estuarine development.

It is emphasised that within the study area, present day hazards and risks to development are low. For the future management of Encounter Bay, it is essential that data collection efforts increase into the future, facilitating better assessment of potential future climate change impacts on the study area. Locally, data efforts would include regular and comprehensive collation of wave and water level data, bathymetric survey and onshore geology. These must be integrated with a program of shoreline monitoring (extending and continuing existing efforts) and regular review aimed at informing future planning and adaptation efforts.

4.3 Stormwater Discharge and Seagrass Impacts

4.3.1 Environmental Framework

The Stormwater Management Authority (SMA) has prepared guidelines to inform water quality and discharge performance objectives for stormwater networks in South Australia together with a framework for mitigating impacts.

A Stormwater Management Plan (SMP) was prepared for Victor Harbor by KBR (2005). The SMP indicated that Encounter Bay would be declared a marine protected area with the potential for Inman River also being declared a Marine Protected area. Strategy 1 of the SMP's water quality management strategies recommended the installation of gross pollutant traps (GPT) on all stormwater outlets to the coast and the consideration of a floating boom on the Inman River in order to protect the biodiversity with the marine environment.

Marine Parks were declared by the South Australian Government in 2009 with a habitat protection zone being declared for Encounter Bay and 2 km up the Inman River in 2012.

4.3.2 Existing Water Quality Measures

The subject coast has several stormwater outlets to the sea and it is understood that eight GPT's have been installed along Franklin Parade one at Inman Street and one into the Inman River near the High School. Additional GPT's will be required along the stormwater outlets along the Esplanade and the Inman River estuary to protect the marine habitat and estuary biodiversity.

4.4 Inman River Impacts

4.4.1 Flow Regime

It is understood that flows in the Inman River have reduced since the relocation of the Victor Harbor WWTP. The recent drought and the installation of several farm dams in the upstream catchment have also impacted on flows. Water has become stagnant in the lower pools with Council having to mechanically dredge the mouth with excavators at least three times annually to allow water to flow. It is understood that the AMLRNMB is commissioning a study to identify inflows including groundwater into the catchment.

4.4.2 Odour

Odours are evident within the river mouth and abutting the Caravan Park from both seaweed accumulation and algae growth. Water has become anoxic resulting in algal bloom production and further odour.

4.4.3 Sand Accretion

The modifications to the Inman River entrance through the construction of training walls are discussed in Section 2.4 and 2.7.3. While the shortening of the entrance channel and the subsequent infill of part of the meander channel east of the entrance may have resulted in the trapping of some sand from the active beach system, the volumes accumulated are negligible in terms of the overall beach behaviour. Although there appears to be some sand accumulation in the river, there is no monitoring data available to confirm if this process is as active as it may have been immediately after the river was realigned. There is at present no information confirming an ongoing build-up of the low dune to the east of the new channel. The beach is relatively narrow at this location and there is no visible evidence of windblown sand swamping the existing vegetation as it is blown inland.

4.4.4 Biodiversity and Habitat

The Swamp Paperbark vegetation located on the banks of the Inman River affords considerable habitat value for wading birds.

Hooded Plovers are shorebirds which are listed as vulnerable under the South Australian National Parks and Wildlife Act (1972). They can be found at the beach adjacent to Kent Reserve and their nesting areas are located in the low level vegetation on the dune. Information signs are placed on the beach advising the public of the nesting areas.

4.4.5 Flooding of Caravan Park

By the year 2100 tailwater levels at the mouth of the Inman River may increase the potential for inundation of the Caravan Park and possibly inundation of the Municipal offices. This is due to overtopping of the Encounter Bikeway shared path during river flood events and due to water backing up from the water body to the south of the Caravan Park.

4.5 Seagrass Accumulation

Seaweed accumulates along the subject section of coast on a regular basis throughout the Autumn to Spring period.

4.6 Native Vegetation

The fore dune between Inman Street and Police Point contains native and planted vegetation at the crest of the dune which is being eroded and damaged by coastal erosion. Some of this vegetation has also been impacted by a drainage scar near King Street and also from construction of a former maintenance access track to the beach east of Inman Street.

The fore dunes between the Inman Mouth and Inman Street and to the south of Kent Reserve contain a mixture of native and weed groundcovers which provide stability to the dune.

4.7 Current and Future Hazards and Risks to Address

Based on the assessment, a site appraisal and discussions with key stakeholders and community groups, the key issues, assets and hazards which need to be addressed are summarised as follows and outlined in Figure 4, Appendix B:

- Coastal erosion and sand movement, particularly the protection of the coast and fore dune between the Inman River mouth and Police Point and effective means of dissipating wave energy;
- Ineffectiveness of sand groynes east of Inman Street;
- Inundation from sea level rise and storm surge in the year 2050 scenario - Section of foreshore adjacent dune near the carpark at the Information Centre, King Street, Council Caravan Park, Inman River, Kent Reserve, Franklin Parade at Whalers Road and Ridgeway Street;
- Inundation from sea level rise and storm surge in the year 2100 scenario - dune near the carpark at the Information Centre, Esplanade and foreshore adjacent King Street, Council Caravan Park, Inman River, private caravan park adjacent Council offices, Kent Reserve, sports oval, Franklin Parade from Bluff boat ramp to Tabernacle Road, Tabernacle Road and parts of the Encounter Lakes development;
- Coastal erosion and sand movement particularly between Fell Street and Tabernacle Road;
- Protection of the Encounter Bikeway shared path;
- Inundation of the Council Caravan Park from a 1 in 100 ARI year flood event in the Inman River and spring tide and sea level rise;
- Managing flows in the Inman River to reduce sand bar build up and seaweed related odours;
- Beach pedestrian access points;
- Groundwater rise commensurate with sea level rise and infrastructure and Council Caravan Park may cause salinity impacts;
- Water quality and odours from Inman River; and
- Increased lake levels at Encounter Lakes and inundation potential along lake frontage.

4.8 Natural Resource Assets

There are a number of natural assets along the subject coast, including:

- Hooded Plover nesting area on the fore dune adjacent to Kent Reserve;
- Existing rock shelf in tidal zone - important marine habitat and bird roosting area; and
- Existing foredunes.

5 Community Consultation

The community highly values the coastal environment at Encounter Bay and is interested in its future management. The community was considered to be a source of interesting historical knowledge of the coastal changes experienced over time, and would likely appreciate the opportunity to be involved in the project and play a role in the area's future.

AWE developed a community consultation strategy with Council, with the aim of consulting the community at the beginning of the project and again later as the project progressed.

The first round of consultation provided the opportunity to inform people of the project and to gather information on the local issues, such as the history and nature of coastal process, dune stability, and their aspirations for the project. This first round of consultation is described below.

5.1 Consultation Activities

Project Information Sheet and Feedback Forms

A Project Information Sheet was prepared to provide the community with an overview of the project, its objectives and the key issues. It also explained the community consultation process and encouraged people to provide feedback via completing and returning the Feedback Form. The Feedback Form provided the opportunity for people to provide information to the Project Team on what they thought were the main issues and their aspirations for the project. This information would then be collated, analysed and used to build up a wealth of knowledge, and contribute to informing the development of appropriate management strategies.

A copy of the Project Information Sheet and Feedback Form is provided in Appendix A.

Distribution of project material and advertising of the project was undertaken by these methods:

- The Project Information Sheet and Feedback Form was placed on Council's website;
- Copies of the Project Information Sheet and Feedback Form were available at the Council office;
- Advertisements were placed in the 'The Advertiser' and the Victor Harbor 'Times' to advise people of the project and where they could find out more information;
- The consultation material and an invitation to meet with the project team was sent to some community based interest groups and businesses, including:
    - Victor Harbor Coastcare;
    - South Coast Dune Care;
    - Police Point businesses (mobile food van holders, Amusements, Causeway Mini Golf, Causeway Kiosk owner);
    - Victor Harbor Progress Association;
    - Some interested individuals as advised by Council and other community group representatives; and
    - Council Elected Members.

Initial consultation with Community interest groups and Elected Members

A meeting was held with some community based interest groups and some Elected Members at the Victor Harbor Civic Centre on 28 March 2013. The meeting provided the opportunity for the Project Team to introduce the project and to gain the community's perspective on local and historical issues. Issues relating to past and potential management strategies were also discussed.

A meeting was also held at the Victor Harbor Civic Centre on 28 March 2013 with the Council's Mayor and an Elected Member to discuss the same issues.

Some of these key interest groups also walked along the Encounter Bay coastline with the Project Team on 3rd April 2013 to observe and discuss issues.

5.2 Community Feedback

Initial feedback from meeting with community interest groups and Elected Members

The types of feedback and comments raised at the meetings held with community interest groups and Elected Members is summarised below:

- Very concerned about coastal foreshore erosion in the vicinity of King Street and the Causeway. This area was considered to be of greater risk of erosion compared to the area between Kent Reserve and the Bluff which is more sheltered (except near Fell Street where erosion/scouring of the dunes have occurred);
- The main threats to the coastline were considered to be the impact of waves on the foreshore and loss of dunes, particularly during king tides and storms. The impact of future sea level rise was also discussed. Also, it was seen that stormwater outlets had caused artificial gullies through the dunes from draining stormwater from the road to the beach, e.g. near King Street;
- The main consequences/impacts of dune and foreshore erosion were – road damage, inundation and damage to the carpark adjacent the foreshore in Victor Harbor, inundation and damage to houses, loss or recreation areas (pathways, picnic areas), heritage sites, Norfolk Island Pines and Canary Island Palms (important role in creating a sense of identity), loss of dune vegetation, unsafe beach access;
- Another important issue was to manage public access to beaches;
- Beach access – access stairways are often swept away during storms. Currently trialling an eco-friendly stairway near the Causeway. It may be useful to reduce the number of access points to beaches and identify the beaches most suitable for swimming;
- The Encounter Bikeway path is very popular and is an important asset to protect;
- The need for a buffer between the waves and the road (i.e. dunes) was raised, particularly between King Street and the Causeway;
- The timeframe for action was discussed. Many thought urgent action is necessary (i.e. protection of the dunes), while another person was of the opinion that such urgency was not necessary yet;

- Information on the physical attributes of the coastline and the observed changes over time was discussed, including areas of scouring, sand loss and where waves had over topped the dunes to the Esplanade and Franklin Parade;
- There was discussion about the changes to the Inman River, and the impacts of the installed rock wall near the river mouth to divert the channel. There was concern about the health of the Inman River, such as the build up of seagrass and associated odour problems, and channel siltation;
- Information about past and current management measures was discussed, such as groynes/sand sausages and sand replenishment program, including their success and failure;
- There was also some discussion about their aspirations for future management of the coastline, such as an offshore reef, continuation of sand replenishment, properly installed and monitored groynes; and
- There was some frustration about the lack of information from the Council to the community about these issues.

Feedback Forms

The community provided feedback via the returned feedback forms. Twelve completed feedback were received. An overview of the main issues raised is provided below.

Concerns and observations:

- Erosion of the foreshore was seen as a problem and this has become worse over the last 5 – 15 years;
- The first priority is to protect the foreshore, especially between King Street and the Causeway as this is where erosion is most noticeable compared to areas towards the Bluff;
- Climate change induced sea level rise, erosion of the rock barrier at Inman River mouth, and powerful wave action has contributed to the erosion issues between King Street to the Causeway;
- The bike path has been damaged in some areas;
- Public access to beaches, such as stairways, are often damaged during storm events;
- The impact of dune erosion could potentially cause damage and loss of infrastructure, roads, carparks, the reserve area, tourist developments, and inundation of houses;
- Not enough revegetation to protect dunes has occurred;
- There have been no sightings of the bird ‘Hooded Plovers’ near Kent Reserve since Council has been removing sand in that area;
- Changes to the Inman River’s outlet/channel have caused seaweed to build up in the river and this is causing odour problems. These changes have also resulted in loss of vegetation and sand on the eastern side of the river mouth;
- The existing trial measures (groynes/sand sausages) are not working well;

- Frustration of lack of foresight by Council and State Government in addressing beach erosion; and
- "Reef Watch' has collected data relating to the issues along the coast which may be useful for this study.

Aspirations and considerations for future management measures:

- Urgent action is now required, particularly to protect the foreshore;
- Water quality needs to be improved in the Inman River so to protect the water in Encounter Bay;
- Amenity of the beaches for swimming purposes is not as high a priority than saving the foreshore;
- Continue the sand replenishment program, particularly in the lower lying areas near King Street, as these dunes need to be built up higher;
- Fencing off the low lying dune/beach areas to prevent public access and to assist in erosion control;
- Build up the height of the coastal bike pathway (Encounter Bikeway);
- Protection of sand dunes requires a combination of a wall (sand or hard), removal of the barrier at the Inman River mouth and continued sand dumping measures;
- Develop a hard wall along the beach;
- Build up the height of the low lying reserve west of the Causeway near Wills Street to protect it from sea level rise impacts, and grass the area so that it improves local amenity values;
- Review the performance of past measures, as these don't seem to have worked very well.
- The 'Point' (Kent Reserve) and foreshore need sand to help control erosion;
- Need to find a balance between environmental care and development; and
- Frustrated about lack of scientific solutions to the problems and lack of information to the community about management measures.

5.3 Future Community Consultation

A second round of consultation will be held with the community later in the project. This will provide the opportunity for the public to comment on the recommended management measures. This will be in the format of a public forum of some type, as well as feedback forms. That feedback will help in the decision making process for determining the most appropriate management measures.

6 Risk Assessment

6.1 Risk Assessment Process

In order to inform the development of adaptation and management options and responses a risk assessment was undertaken in accordance using the approach outlined in AS/ NZ S ISO AS31000:2009 Risk Management - Principles and Guidelines. Initial risk descriptors and ratings were developed based on assets potentially at risk. The approach is also consistent with AS 5334-2013 Climate Change Adaptation for Settlements and Infrastructure-A Risk Based Approach.

A half day risk workshop was conducted on 7 May 2013 with key stakeholders in Adelaide at AWE's offices to validate the assets considered at risk, the risk category type and risk ratings and potential responses.

Workshop participants included representatives from the following organisations:

- Council;
- Project Consulting Team;
- DEWNR (Coastal Management);
- AMLRNRMB; and
- DPTI (Marine).

The agreed risks were assessed against environmental social and economic categories.

The outcomes of the workshop are contained in Appendix C.

6.2 Assets at Risk

Assuming no intervention is undertaken, the following areas are considered to be at risk of damage or loss due to coastal erosion:

- Foredune and associated fencing along the Esplanade between the Inman River and Police Point;
- Vegetation at top of foredune along the Esplanade;
- Beach pedestrian steps particularly within the foredune between Inman Street and Police Point and abutting Franklin Parade;
- Encounter Bikeway shared path particularly in locations close to the coast where there is little existing rock protection and land is low lying (i.e. Franklin Parade and abutting Council Caravan Park);
- Norfolk island Pines and Canary Island Palms in Soldiers Memorial Reserve;
- Playgrounds paths and park furniture abutting the coastal reserve;
- Public toilet adjacent to Encounter Bikeway shared path along Flinders Parade at Whalers Road;
- Carpark off Franklin Parade adjacent Fell Street;

- Low lying areas and locations where there is currently no rock protection along Franklin Parade;
- Stormwater outlets along coastal edge; and
- Aboriginal heritage site near Council's Caravan Park.

The following assets are considered to be at risk of damage or loss due to storm surge, wave action and sea level rise related wave overtopping and inundation:

- Victor Harbor Caravan Park - 80% inundation under 2050 conditions and complete inundation under year 2100 conditions and stormwater inundation from back up in stormwater outlet;
- Victor Harbor private Caravan Park west of Bay Road and Municipal offices - potential inundation under 2100 conditions from wave breach from Inman River banks;
- Foredune and associated fencing along the Esplanade between the Inman River and Police Point - erosion of dune and inundation at localised breach points near King Street;
- Vegetation at top of foredune along the Esplanade;
- Beach pedestrian steps particularly within the foredune between Inman Street and Police Point, as well as abutting Franklin Parade;
- Encounter Bikeway shared path particularly in locations close to the coast where land is low lying (i.e. from Inman Street to Charles Street and Tabernacle Road to Raminjeri Crescent);
- Norfolk Island Pines and Canary Island Palms in Soldiers Memorial Reserve abutting King Street;
- Playgrounds and park furniture in Kent Reserve;
- Public toilet adjacent to Encounter Bikeway shared path along Franklin Parade at Whalers Road - inundation under 2100 conditions;
- Carpark off Franklin Parade adjacent Fell Street and carpark on the Esplanade at King Street – inundation under 2100 conditions;
- Low lying areas and locations where there is currently no rock protection along Franklin Parade - inundation under 2100 conditions between Tabernacle Road to Raminjeri Crescent;
- Stormwater outlets along coastal edge; and
- Encounter Lakes - Lake levels likely to rise commensurate with sea level rise due to submarine pipe connection with Encounter Bay.

6.2.1 Consideration of Beach Access

There are several timber pedestrian access ramps and steps leading to the beach at present some of which have been damaged or destroyed several times from wave action and erosion in recent years. Lightweight timber structures are highly vulnerable to wave uplift forces under wave action storm surge conditions. Council recently replaced a damaged access point adjacent to the Esplanade carpark with a shorter recycled plastic step structure but in the process cut into the existing dune removing sand and vegetation, thereby compromising the integrity of the for dune.

There are other timber steps located between Inman Street and King Street which have been partially undermined from the May 2012 storm event potentially becoming unstable and compromising public safety.

There is a former maintenance vehicle beach access point cut through the fore dune to the east of Inman Street which has caused an erosion scar in the fore dune and damaged roots of dune vegetation. It is understood this has been used by vehicles involved in sand replenishment and seaweed collection and that the recently constructed concrete ramp at Police Point is now used for that purpose, however the lateral sand groynes may impede movement of vehicles.

6.2.2 Consideration of Stormwater Outlets

There is an inconsistent treatment provided at coastal stormwater outlets some with headwalls, some without, some with modern tidal flaps, some with old tidal flaps and some without. Very few have erosion control such as rock riprap or reno mats at the outlet leading to erosion of the beach.

Only eight of the twenty eight outlets have GPT's.

Some of the inverts are located below the level of the beach which is compromising the hydraulic performance of the outfall drain.

6.2.3 Consideration of Vegetation

The existing vegetation along the fore dune between Bartel Boulevard and Police Point is playing a vital role in maintaining the integrity and stability of the fore dune.

6.2.4 Sand Replenishment Program and Dredging of Inman Mouth

Council's existing sand replenishment program involves the placement of sand (either from Kent Reserve or quarry) to the beach and dunes adjacent King Street and Fell Street. It is a temporary but useful treatment and is relatively inexpensive.

Council undertakes dredging at the mouth of the Inman River to enable water to flow out to sea. This involves mechanical excavation of the sandbar at the Inman mouth up to three times a year.

6.3 Summary of Risks (without any intervention)

Whilst all of the above assets at risk under the 2100 scenario, not all are under immediate threat. The following summarises the anticipated timeframes under which the key assets highlighted above are expected to become under threat.

Present conditions

- Damage to rock revetment along Franklin Parade;
- Damage to beach access;
- Damage to Encounter Bikeway;
- Erosion risk from wind where dunes are not vegetated
- Erosion to the foredune near King Street from overland stormwater flows from the Esplanade catchment resulting in the potential for dune instability;
- Potential damage to stormwater outlets; and

- Erosion of beach face and dunes.

Under year 2050 sea level rise scenario

- Existing foredunes east of Inman River and abutting the Esplanade will suffer continued localised erosion from storm surge arising under sea level rise. This may result in increased wave overtopping, potential accelerated recession of the coast and damage to landward assets.
- Requirement for upgrade of Franklin Parade seawall and elevation of the crest level;
- The Hooded Plover nesting area on the foredune to the south of Kent Reserve will be threatened and possibly lost due to erosion from higher waves.
- Loss of sandy beach;
- Loss of dune buffer fronting the Esplanade;
- Loss of heritage Norfolk Island Pines and palms;
- Increasing hazard/damage to carparks and roads;
- Loss/damage to stormwater outlets, access ways along beach front;
- Storm overwash to roadways; and
- Increased flooding of estuary foreshores.

Under year 2100 sea level rise scenario

- Failure of Franklin Parade seawall without significant upgrade;
- Loss of beaches and access;
- Inundation of the Esplanade;
- Potential damage to private development landward of the Esplanade;
- Damage to stormwater, sewerage, power supply infrastructure;
- Significant inundation of low lying estuarine areas (Inman River, Caravan Park, Encounter Lakes); and
- Possible major coastal realignment at Kent Reserve and Police Point.

6.4 Triggers for Intervention

The progressive increase in risk exposure lends itself to a progressive and staged response strategy.

An outline of a potential response strategy follows.

Present conditions

- Rationalise beach access ways as and when damaged;
- Remove existing sand groynes and continue beach stabilisation works seaward of the Esplanade, focussing on erosion hotspots and low key intervention works;
- Re-assess stormwater infrastructure at the back beach;

- Increase data collection and monitoring of beach changes including engineering survey of Inman River bank and low points on Bay Road; and
- Prepare and adopt long term management plan including engineering and planning adaptation measures.

To provide 1 in 100 ARI protection under 2050 scenario

- Prepare and approve strategy for upgrade of Franklin Parade seawall. Implement progressive upgrade as damage increases;
- Review caravan park operations and facilities as inundation risk to caravan park increases;
- Prepare and approve strategy for Implementation of seawall protecting the Esplanade. Implement construction as threat to the road increases, sacrificing the narrow dune buffer;
- Ongoing beach nourishment to continue from external sand sources as appropriate;
- Progressive withdrawal and rezoning of areas that cannot be defended (increasing inundation risks); and
- Redesign of beachfront services to acknowledge future protection line.

To provide 1 in 100 ARI protection under 2100 scenario

- Upgrade and elevate seawalls along Franklin Parade and the Esplanade as required; and
- Continue to implement withdrawal and rezoning of not defendable areas which aren’t to be defended as risk increases (inundation frequency and depth).

7 Management Options

7.1 Consideration of Management Techniques

A range of management techniques were considered to determine their suitability for this section of coast. An overview of the methods and their suitability is provided below.

The following structural management options were considered for future control of beach erosion, recession and/or inundation at Victor Harbor. Each would have differing relative effectiveness and may need to be implemented over differing time frames. Individual options would form a part of an overall strategy for the study area. It is likely that some mixture of these options may be employed at different locations along the beach and over varying timeframes as climate changes and sea level rises.

The options tabulated below are structural options only and in a final management strategy these may be used jointly with planning options and development controls (such as property repurchase, setbacks, foundation requirements, elevated floor levels, relocating development and utilities, back-zoning, etc.). Structural options that are not considered appropriate for this location are not included (e.g. do nothing, configuration dredging, beach drainage etc.)

Protection works generally work in two main ways:

- Shore parallel structures which are designed to reduce the wave climate at the shoreline or to protect the back of the beach against erosion or inundation, (Table 7-1).
- Shore normal structures that act to realign the beach, usually by trapping a natural alongshore movement of sand, (Table 7-2). This facilitates a sand buffer to be built up seaward of areas to be protected. This buffer is then eroded during storms and replaced again by the natural alongshore sand movement. Where inadequate sand movement is occurring then sand may need to be replaced by beach nourishment using imported material.

TABLE 7-1 CONSIDERATION OF STRUCTURAL MANAGEMENT OPTIONS - SHORE PARALLEL STRUCTURES

Possible Management Response	Purpose	Comment
Beach nourishment	To maintain the sand buffer on the beach seaward of the dune crest. Accommodates normal erosion/accretion cycle.	• Requires ongoing maintenance following storms and/or sea level rise. • Sand should be sourced from outside the active beach system. • No adverse long term impacts downdrift, may be beneficial. • May be used with terminal protection structures on a receding beach.
Beach scraping	To maximise sand build up seaward of affected beach areas by removing sand temporarily from the active beach area.	• Does not increase beach volumes, merely moves sand from one location to another • May exacerbate downdrift erosion • Dependent on steady alongshore sand supply, requires regular maintenance. • Relatively cheap and can form part of regular Council activity. • Decreasing effectiveness as beach width reduces over time

Possible Management Response	Purpose	Comment
Dune revegetation and rebuilding	Uses natural dune management techniques to trap sand and rebuild eroded dune sections	• Does not increase beach volumes, merely moves sand from one location to another, bolstering dune and minimising overtopping risk. • Mimics nature and maintains aesthetic dune environment • May exacerbate downdrift erosion, delays alongshore sand transport. • Dependent on steady alongshore sand supply, requires regular maintenance. • Relatively cheap and engages community members and volunteers. • Decreasing effectiveness as beach width reduces over time
Terminal revetment (seawall)	Non erodible structure constructed along the beach to limit the landward excursion of waves during design erosion events. Variety of construction approaches can be used including sloping, vertical, rock, concrete, etc.	• Commonly used and well understood structures. Rock revetment already exists seaward of the Encounter Bikeway along Franklin Parade. • Needs to be properly designed, constructed and maintained. • Need to identify location of proposed protection e.g. existing escarpment, road edge, property boundary. • Fixes future shoreline with inevitable loss of sandy beach areas as sea level rises. • Frequently employed jointly with nourishment to enhance recreational beach. • Limits wave overtopping. • Can be upgraded and raised into the future as climate changes. • Exacerbates downdrift erosion by blocking sand supply through erosion.
Bunding/levees	Structures built outside the beach erosion zone to limit wave inundation. Generally designed to not provide wave protection but raised crest elevation at lower cost. Commonly used for flood protection.	• Relatively cheap and simple construction. • Provide protection from ocean inundation where wave and velocities are limited. • Require ongoing maintenance. • Can be built when required and are readily upgraded or raised if necessary. • Do not address drainage issues landward and may require pumping to remove inflow waters or rainfall. • Prone to catastrophic failure and flooding if breached.

TABLE 7-2 CONSIDERATION OF STRUCTURAL MANAGEMENT OPTIONS - SHORE NORMAL OR OFFSHORE STRUCTURES

Management Response	Purpose	Comment
Groynes	Shore normal structures extending from the seabed to above the high water surface. Designed to intercept the alongshore movement of sand under waves and maintain a sand buffer against erosion. Frequently used with terminal revetments and beach nourishment.	• Ineffective where alongshore sand supply is low. • Need to extend offshore beyond the wave breaking zone to be effective. • Need to be properly designed, constructed and maintained. Many variations of design including T-groynes, angled, closely spaced, etc. • May require "filling" through sand nourishment following initial construction. • High capital cost and high maintenance costs as constantly exposed to surf zone conditions. • Result in downdrift erosion and beach realignment if working properly.
Artificial headlands	Essentially a groynes with increased width to provide a useful area (park, facilities etc)	• Divides a long sandy beach into smaller compartments (not really necessary at Victor Harbor). • Significantly higher capital cost for same result as a single groyne. • High environmental and aesthetic impact (beneficial or adverse). • May require "filling" through sand nourishment following initial construction. • Result in downdrift erosion and beach realignment if working properly.
Submerged parallel offshore breakwater (inshore)	This concept is for a submerged shore parallel rock wall (or reef) near the edge of the rock shelf, several hundred metres from shore. The crest is around low water level and the purpose is to break larger waves, reducing the wave energy at the shoreline	• Insufficient data available for adequate design and costing at present. Extensive environmental assessment also required • Significantly higher initial and maintenance costs than seawall for a less reliable outcome. • Environmental and aesthetic impacts – would completely change the nature of the embayment. • Works well at low water conditions but allows larger waves to pass unbroken during peak storm surge conditions – variable performance and least effective when most required. • Very high maintenance costs due to exposure. • Need for ongoing increase in crest level as sea level rises to maintain effectiveness.
Submerged parallel offshore breakwater (offshore)	This concept is for raising and completing openings in the existing offshore reefs approximately 1 km from the shoreline. Construction is required in high energy environment and relatively deep water. The crest is around low water level and the purpose is to break larger waves, reducing the wave energy at the shoreline	• Insufficient data available for adequate design and costing at present. • Significantly higher initial and maintenance costs than inshore breakwater or seawall for a less reliable outcome. • Environmental and aesthetic impacts – would completely change the nature of the embayment. • Works well at low water conditions but allows larger waves to pass unbroken during peak storm surge conditions – variable performance and least effective when most required. • Very high maintenance costs due to exposure and location, all work to be undertaken from floating plant. • Need for ongoing increase in crest level as sea level rises to maintain effectiveness.

Management Response	Purpose	Comment
Artificial Reefs (multipurpose reefs)	Isolated reef structures can be constructed (usually submerged) to provide protection to the shoreline on their leeward side. Typically they would be constructed 100m to 200m from shore on the rock shelf. Provides shelter to a section of the beach by breaking waves on the reef and encourages the build-up of a salient (or sand spit) from the beach in the lee of the structure (similar to the causeway behind Granite Island). Can be designed for possible secondary impacts (such as surfing, habitat, etc.).	• Insufficient data available for adequate design and costing at present. • Extensive environmental assessment also required • Doesn't increase the sand in the system, may require nourishment to establish and maintain the salient to avoid adverse downdrift impacts. • Low success rate with assessments showing more than 50% world-wide fail to meet the design objectives • Significantly higher initial and maintenance costs than a seawall with a less reliable outcome. • Works best at low water conditions but allows larger waves to pass unbroken during peak storm surge conditions – variable performance and least effective when most required. • Very high maintenance costs due to exposure. • Need for ongoing increase in crest level as sea level rises to maintain effectiveness.

7.1.1 Other Considerations

There are difficulties in assessing the precise design for many of the offshore options, given the current lack of information relating to the bedrock stratigraphy and the bathymetry landward of a line jointing Granite Island and the Bluff. Within each of the broad protection structures outlined, there are a variety of design options that could be determined and a range of materials that could be used. These questions would be resolved during the final design stage.

In considering any of these options a "whole of life" design strategy and costing should be considered. Some options may have a comparatively low initial capital costs but with increasing upgrade and maintenance costs over time. Other options are likely to have high initial capital costs with possibly reduced upgrade and maintenance costs over time.

In designing for climate change adaptation it is generally considered prudent to limit initial costs and impacts so far as practical while utilising the available time to gather additional site data, obtain better estimates of the likely climate impacts and prepare detailed design and funding strategies for the final stages of the scheme. It is not considered sound management practice to implement major infrastructure spending on protection structures that may not be required for fifty or one hundred years into the future. However, it is essential that the strategy to be implemented is identified now and the planning for that implementation is put in place.

7.2 Approach

Management options need to be considered on the basis of the likelihood of risk, as outlined below.

Present Climatic Conditions

- Immediate risk to infrastructure from beach recession and inundation is low. Integrated monitoring and data collection along whole embayment to be implemented and reviewed at five yearly increments following severe storms;
- Beach is receding at isolated locations. Soft management works including ongoing dune and vegetation management to be encouraged;
- Seawall along Franklin Parade to be monitored and maintained – addition of further rock where necessary, for example at the few low lying areas that are already undercutting the Bikeway;
- Design for upgraded sea wall for 2050 (or 2100) conditions to be prepared;
- Beach nourishment to back of beach on an opportunity basis along Franklin Parade – sand to be imported from an external source;
- The trialling of disposal of wrack by burying a mixture of sand and seagrass wrack at the back of the beach, on the dune crest and immediately landward of the scarp crest could continue but should be monitored for any unexpected adverse impacts. The ratio of clean sand to detritus should be maintained at above 50 % sand by volume (uncompacted) is possible. The higher the sand ratio the less likely any adverse impacts will be reported. The sand can be obtained from scraping of the beach face seaward of the erosion scarp or by using imported sand, either from further along the beach or an external source. The placement of the sand should maintain a shore parallel alignment of the escarpment. Placement of a large volume at one location and seaward of the escarpment is likely to be quickly eroded with the sand and seagrass again separated, defeating the objective of temporary disposal;
- Council may wish to trial interim structural measures such as vertical piles but any such trial will require careful design to avoid unexpected adverse impacts;
- Kent Reserve to be maintained with revegetation works as appropriate;
- Dune seaward of the Esplanade to be maintained through dune management works and opportunity nourishment from external sources as required. When sand reserves permit, beach scraping could be used to move sand from the active beach area to the seaward dune face;
- Beach access to be rationalised along the Esplanade foreshore. Less access points and lightweight access ways (chain and board walkways?) to suit demand;
- Dune crest seaward of King Street to be elevated using imported sand at top of escarpment (max height 1 m increase); and
- Design and location for longer term protection works to be determined and preparations taken for implementation (including funding source).

For 2050 conditions 1 in 100 ARI protection

- Continue monitoring and review of foreshores of the whole embayment;
- Seawall along Franklin Parade to be progressively upgraded as required;
- Construction of back beach protection structure along the Esplanade (rock seawall?), to be implemented when trigger recession is reached. Needs to allow for implementation in timeframe that protects significant infrastructure. May be constructed in stages as appropriate, commensurate with hazards;
- Beach access to be relocated to appropriate locations (Kent Reserve, adjacent to Inman River entrance and Police Point);
- Risk of inundation to lower river and caravan park to be monitored. Caravan park operations and facilities to be reviewed as threat of inundation frequency and depth increases; and
- Ongoing redesign and upgrade of stormwater outlets/drainage.

For 2100 conditions, 1 in 100 ARI protection

- Continue monitoring and review of foreshores of the whole embayment;
- Upgrade protection structures as water depths and wave conditions increase. Increase crest elevation as appropriate to minimise overtopping;
- Consider implementing retreat strategies as risk of inundation increases; and
- Review ongoing landuse in the most affected areas.

7.3 Engineering Intervention Options

The following table provides engineering options for Council consideration. Concept designs are provided in Appendix B.

TABLE 7-3 ENGINEERING OPTIONS

AREA	POTENTIAL MANAGEMENT RESPONSE	COMMENT
Inman River to Police Point	**Option 1 -** Rock revetment sea wall located adjacent to fore dune as far landward as possible to RL 2.65m AHD initially with 1V: 3H batter to reduce wave energy run up and wave overtopping volumes with ability to increase height to 3.4 m AHD as sea level rises further with focus on high risk areas.	Expensive but longer life solution and better chance of beach recovery after storms and allows planting within rock face (Indicative Cost $2,000-$3,000/m). Refer Figures 5 and 6 Appendix B.
	Option 2 - Vertical concrete sea wall located behind fore dune within reserve to RL 3.4m AHD with rock protection on coastal side.	An expensive and longer life solution but higher wave run up and less chance of beach recovery immediately seaward (Indicative Cost-$2000/m). Refer Figure 5 Appendix B.
	Option 3 - Rock revetment sea wall located adjacent to fore dune as far landward as possible to RL 2.65 m AHD with 1V: 3H batter to reduce wave energy run up and wave overtopping volumes with parapet wall on top of wall to 3.4 m AHD to reduce wave overtopping.	Expensive with similar cost and outcomes to Option 1 but could replace parapet in future and extend for additional 0.7 m sea level rise similar to Glenelg (Indicative cost $2,500/m).

AREA	POTENTIAL MANAGEMENT RESPONSE	COMMENT
	Option 4 - Sand replenishment to build up height of fore dune at high risk areas.	Lower capital cost but short life solution requiring high maintenance cost.
	Option 5 - Rock armoured earthen levee located adjacent to fore dune as far landward as possible to RL 2.65 m AHD with 1V: 3H batter to reduce inundation from wave overtopping and sea level rise with ability to increase height to 3.4 m AHD as sea level rises further.	Moderately expense and medium life solution not as effective as Option 1 in minimising erosion but good for inundation ($1,200 - $1,900/m).
Inman River to Bluff Boat ramp	**Option 1** - Rock revetment sea wall seaward side of Encounter Bikeway shared path where no wall present and upgrade or replacement of existing rock wall in stages initially to RL 2.65 m AHD with 1V:2H batter to reduce wave energy run up and wave overtopping volumes with ability to increase height to 3.4 m AHD as sea level rises further.	An expensive but longer life solution and better chance of beach recovery after storms (Indicative Cost $2,000-$2,500/m. Refer Figure 5 Appendix B.
	Option 2 - Vertical concrete sea wall in front of Encounter Bikeway shared path to RL 3.4m AHD in high risk inundation areas.	An expensive and longer life solution but higher wave run up and less chance of beach recovery immediately seaward (Indicative Cost-$1800/m). Refer Figure 5 Appendix B.
	Option 3 - Place larger rock in front of current rock revetment wall with parapet wall to 3.4m AHD in low lying breach areas on coastal side of Encounter Bikeway shared path and construct new rock wall where none currently present.	An expensive but longer life solution and better chance of beach recovery after storms but possible less expensive than Option1 (Indicative cost $2,500/m).
	Option 4 - Raise Encounter Bikeway shared path in high inundation risk areas to 2.65 m AHD with associated retaining wall to RL 3.4 m AHD coast side with some rock protection to build up to design level.	A moderate cost option dependant on level difference with Franklin Parade verge and carriageway ($1,300/m).
	Option 5 - Sand replenishment to build up height of fore dune at high risk areas (and also continue with burying a mixture of sand and seagrass wrack at the back of the beach).	Lower capital cost but short life solution requiring high maintenance cost subject to adequate supply of sand which would need to be imported. Refer Figures 5 and 8 Appendix B.

7.4 Asset Management Options

Consideration has been given to Council's existing management practices in relation to beach access, stormwater, vegetation, sand replenishment of dunes and dredging of Inman River mouth. Recommendations for their future ongoing implementation is provided in the table below.

TABLE 7-4 ASSET MANAGEMENT OPTIONS

ASSET	POTENTIAL MANAGEMENT RESPONSE
Beach access	Close off the existing informal maintenance access to protect the fore dune and increase public safety and enable sand and vegetation to be replenished within the erosion scar at the east of Inman Street.
	Rationalise the number of pedestrian access points and avoid positioning these in areas of high wave energy.
Stormwater outlets	Repair and rock protect existing stormwater outlet structures and headwalls from wave energy and erosion and provide headwalls and erosion control on all outlets.
	Provide GPT's along all stormwater outlets along the Esplanade, Franklin Parade and the Inman River Estuary to protect the marine habitat and Estuary biodiversity.
	Replace existing low point drainage outfall swale near King Street with underground pipe reinstate erosion scare and provide new sea connection through dune or connect to existing outfall drain on south side of the Esplanade 87 m east.
	Provide upgraded tidal flap gate or Tideflex valves on all stormwater outlets along the Esplanade, Franklin Parade and the Inman River Estuary.
	Review existing stormwater outfall drainage from Council Caravan Park.
	Survey all stormwater outlets to confirm whether adequate discharge and fall arrangements from the outlet invert to the beach.
Vegetation along the fore dune between Bartel Boulevard and Police Point	An active protection and revegetation program to maintaining the integrity and stability of the fore dune.
Sand replenishment at King Street	Council's sand replenishment program has been effective in minimising erosion of fore dunes near King Street during storm events. It is an ongoing program involving considerable maintenance effort.
Use of sand and seagrass wrack mixture	The trialling of disposal of wrack by burying a mixture of sand and seagrass wrack at the back of the beach, on the dune crest and immediately landward of the scarp crest could continue but should be monitored for any unexpected adverse impacts. The ratio of clean sand to detritus should be maintained at above 50 % sand by volume (uncompacted) is possible. The higher the sand ratio the less likely any adverse impacts will be reported. The sand can be obtained from scraping of the beach face seaward of the erosion scarp or by using imported sand, either from further along the beach or an external source. The placement of the sand should maintain a shore parallel alignment of the escarpment. Placement of a large volume at one location and seaward of the escarpment is likely to be quickly eroded with the sand and seagrass again separated, defeating the objective of temporary disposal.
Dredging of Inman River mouth	Council's dredging program involves mechanical excavation of the sandbar to allow water to flow out to sea. This occurs up to three times a year and its effectiveness and purpose needs to be reviewed.

7.5 Planning Responses

Provide building setbacks and erosion buffers pursuant to the Development provisions.

Council should also consider creating specific Policy Areas in its Development Plan for the land at risk of erosion. These Policy Areas could include specific objectives, principles of development control and coastal retreat development management guidelines to manage, limit or prevent

further development occurring. This change in the Development Plan would require a Development Plan Amendment (DPA) to be initiated and close liaison and advice from the Coast Protection Board and the Department for Planning, Transport and Infrastructure. A DPA process can be initiated by either the Council or the Minister.

7.6 Funding Arrangements

The intervention measures proposed in the above sections are substantial and would involve a significant increase in capital expenditure. These works will not be required for some years into the future and hence Council has time to accumulate the necessary financial resources. It is therefore suggested that Council make provision for these works by establishing a special rate under the Local Government Act whilst also seeking contributions from potential funding partners.

7.7 Indicative Unit Costs for Major Capital Work Items

The following table provides information on the cost associated with each management measure.

TABLE 7-5 INDICATIVE UNIT COSTS

Treatment	**Capital Costs ($/500m length)**	**Maintenance Costs ($/500m length)**	**NPV whole of Life Costs (30 years) 7% Discount rate ($/500m length)**
New Rock sea wall (1-5 T imported rock on geofabric to RL 2.65 m AHD initially	$1.0M	$0.1M*	$1.31M
Sand nourishment to create 2 m high foredune on beach	$0.21M	$0.1M#	$1.34M
Concrete sea wall to RL 2.65 m AHD with rock armour	$0.9M	$0.05M*	$1.03M
Strengthen and upgrade existing rock sea wall	$0.75M	$0.05M*	$0.89M
Raise Encounter Bikeway shared path with concrete retaining wall	$0.65M	$0.04M*	$0.78M
Sand Fencing	$0.05M	$0.005M#	$0.1M

*Maintenance every five years

Annual maintenance

8 Conclusions and Recommendations

8.1 Overview

The study area within Encounter Bay is a bedrock controlled, sheltered, coastal compartment which is starved of a strong sediment supply from the coast to the west. The shoreline while relatively stable over recent decades is exhibiting gradual recession with a reduction in beach width and increasing storm erosion of the fragile dune buffer over recent years. While the current hazards and risk to development and infrastructure are readily managed through low impact intervention at present, this is unlikely to be the case as climate changes and in particular sea levels rise.

More so than at many locations where the major impact of sea level rise will be a straightforward landward recession of the shoreline, the impact at Encounter Bay is likely to be complex with very significant increase in the incident wave energy at the shoreline over time as the offshore protective reefs and near-shore rock shelf are further submerged. This increased wave energy will result in progressive recession of erodible sections of the coastline, loss of the fragile dunes and the sandy beach area in the future. Development including the beachfront roads (Franklin Parade and the Esplanade) will require substantial protection works to preserve these access routes and protect the development to landward. Precise definition of the extent of likely impacts is made more difficult by the paucity of reliable process and monitoring data. These should be a priority to facilitate the development and implementation of adaptation strategies.

Perhaps a higher risk is from the potential inundation of the estuary foreshores and low lying back beach areas as sea level rises. Increased water depths and the consequent increasing wave energy at the shoreline will result in future elevation of local water levels and inundation beyond the simple ocean increase in high tides. There are current land uses that may become non-viable into the future and a strategy needs to be developed now for their future management. Other locations will be dependent on adaptation measures, including physical protection structures, for their continued viability.

8.2 Conclusions

Based on the investigations the following conclusions are drawn:

- In general, historical coastal erosion and recession have been minimal and within typical limits. Areas of severe erosion tend to be of a localised nature;
- The offshore reef between the Bluff and Granite Island absorbs wave energy under current climatic conditions. However this will be less effective in reducing wave energy as sea level rises, leading to the likelihood of accelerated recession in the future;
- The Council Caravan Park and a small portion of Franklin Parade would be at risk of inundation from a 1 in 100 ARI event under 2050 climatic conditions;
- The Council Caravan Park, parts of the Esplanade, a 900 m section of Franklin Parade and sections of Encounter Lakes would be at risk of inundation from a 1 in 100 ARI event under 2100 climatic conditions;

- Current hazards and risks may be managed for the foreseeable future through soft management approaches and targeted interventions;
- Beach nourishment from an external source (i.e. quarry) will be beneficial to the ongoing retention of the sandy beach area and dune buffers but will require high annual maintenance costs;
- The implications of longer term climate change are significant and it would be prudent to prepare and implement a comprehensive adaptation strategy now to minimise future adverse impacts; and
- Ongoing data collection and beach monitoring is a high priority for Council in developing, implementing and reviewing this adaptation strategy into the future.

8.3 Recommendations

The following recommendations are provided for Council consideration:

- Council consider the recommended management options presented in section 7 of this report;
- Council to support and encourage ongoing soft management strategies for the beach areas and the fragile dune buffers through volunteer environmental groups, sand renourishment, continued use of the sand and seaweed mix (accompanied by monitoring to identify any undesirable effects); and vegetation replanting;
- Council commence an ongoing dialogue with the local community and key stakeholders (including State Government) to promote an understanding of future issues and strategies relating to the management of the Encounter Bay foreshores;
- Council prepare a climate adaptation strategy to minimise the worst future impacts of climate change on coastal values, development and infrastructure based on the findings of this report, including the consideration of rock seawalls and associated upgrades in high risk areas;
- Council promote and support a focussed data collection and monitoring program for the Encounter Bay foreshores and Inman River to inform coastal adaptation strategies into the future including additional engineering survey at high inundation risk areas to confirm the likely flood risk under sea level rise;
- Council identify funding needs into the future and identify and secure funding sources or streams for the implementation of coastal management and climate change adaptation strategies, including the option of establishment of a special rate under the provisions of the Local Government Act;
- Council use its Development Plan provisions to regulate development in the coastal hazard zones; and
- Every 5 years the coastline is re-examined and the recommendations arising from this Study be reviewed.

9 References

Photomapping Services 2011 “GEMDOGRE South Australian Coastal LiDAR Acquisition. Final Report for Geoscience Australia” Contract GEMDOGRE 18, 2011.

Foreshore Protection Study Police Point Inman River outlet to Hindmarsh River Outlet Nov 2006- Magyrn & Associates

Victor Harbor Stormwater Management Plan, KBR Dec 2005

Inman River Estuary Action Plan, 2010 SKM

Southern Fleurieu Coastal Action Plan and Conservation Priority Study 2002, Adelaide Mount Lofty Ranges Natural Resources Management Board

Victor Harbor Foreshore Coastal Park Open Space Plan, 2004 Berchervaise & Associates

City of Victor Harbor Development Plan, consolidated 10 January 2013

Appendix A : Community Consultation - Project Information Sheet and Feedback Form

Victor Harbor Coastal Management Study

This Information Sheet provides an overview of the Coastal Management Study, the main issues along the coastline, as well as the opportunity to have your say.

Since the late 1990's the beaches along the coastline from the Causeway (Police Point) to the Bluff Boat Ramp on Franklin Parade, have become affected by storm damage and erosion. This has become more intense in recent years and is now threatening Council infrastructure in several locations.

In consultation with the Coast Protection Board early in 2012, Council resolved that a Coastal Management Study was required to inform future management strategies for the Victor Harbor and Encounter Bay coastline west of Police Point. In late 2012, the City of Victor Harbor was successful in obtaining two thirds funding for this Strategy from both the State and Federal Governments.

Key objectives of the Coastal Management Study are to:

- Develop effective coastal management strategies between Police Point and the Bluff Boat Ramp.
- Consult with the community and stakeholders and review historical data and records when developing these strategies.
- Determine trigger points for when immediate works are required.
- Review seagrass loss and its effects on the Inman River.
- Produce a final report that documents findings, recommended strategies, concept engineering designs and cost estimates to allow Council to progressively implement and seek funding for priority works.

An assessment of existing and potential coastal management issues is now underway to identify and evaluate alternative management strategies in response to those issues. The outcomes of the Study will inform the long term management of the Victor Harbor and Encounter Bay foreshore.

Council has engaged Australian Water Environments (AWE) to lead a team of experts to undertake the Study. This involves analysing the local issues and the effects of storms and climate change induced sea level rise to the coastline.

The community highly values the natural environment at Encounter Bay and is likely to have interesting and useful information about the foreshore. Local information would help to confirm the problems and may help to scope future strategies. Targeted meetings with key community based groups as well as government agencies are being held early in the Study. The general public has the opportunity to provide information about the local area by completing a feedback form – details are on the reverse side.

city of Victor Harbor

Australian WATER Environments

Fleurieu Peninsula, South Australia

The Study

The Project Team is undertaking the following activities:

- *Site appraisal to observe the problems and performance of existing management measures*
- *We are here* → ***Liaison with Government Agencies and the community***
- *Investigate the coastal processes and the Inman River, including assessing implications of future potential sea level rise*
- *Identify a range of appropriate hard and soft engineering and retreat options to minimise the potential for further erosion, movement of sand and damage to infrastructure*
- *Undertake a risk assessment of the coastal processes and potential management strategies*
- *Refine the proposed management strategies with Council*
- *Present proposed management strategies to the community to gain feedback*
- *Finalise the Study and report to Council*

Our understanding of the key issues

The community has a strong interest in safeguarding this section of the coastline. Some of the key issues identified so far include:

- *Impact of storms and sea level rise on the coastline*
- *Performance of previous remedial works undertaken*
- *Opening of the Inman River*
- *Seaweed and odour*
- *Beach access and associated health and safety aspects*
- *Offshore reefs and relationship with beach erosion*
- *The need to consider 'hard' engineering measures and develop storm protection strategies*
- *You may have more to add?*

Have your say

Please tell us about your local knowledge of the coastal issues along this section of coastline and your aspirations for the project. Your information will help to confirm the nature and history of the problems as well as to assist in scoping management strategies. A feedback form is available from the Council office or the website http://www.victor.sa.gov.au to provide your information. ***Please do so by FRIDAY 19th APRIL 2013***

Where to from here?

Completed feedback forms from the community will be collated and reviewed by the Project Team. A range of initial mitigation strategies will be developed for Council.

A community forum will be arranged later in the year to showcase the proposed management strategies to the public and to gain feedback on these. More information on that forum will be provided closer to the time.

Your local knowledge and feedback is important!

The beaches along the Victor Harbor coastline from the Causeway (Police Point) to the Bluff Boat Ramp on Franklin Parade, have become affected by storm damage and erosion. A Coastal Management Study is now underway to examine the issues and to develop management strategies in response to those issues.

Please tell us about your local knowledge of the coastal issues along this section of coastline. Your information will help to confirm the nature and history of the problems as well as to assist in scoping management strategies.

Please complete and send this form by FRIDAY 19th APRIL 2013

Community Feedback

Please tell us of your understanding of the key issues for this section of the coastline.

.....

.....

.....

What are your aspirations for the project?

.....

.....

.....

Other information you can provide about the history and nature of the problem.

.....

.....

.....

Do you have any questions about the issues or the project?

.....

.....

.....

Project Information Sheet
Information about this Study is available at Council office at 1 Bay Road, Victor Harbor or on Council's website: http://www.victor.sa.gov.au

Community Forum
A community forum will be arranged later in the year to showcase the proposed management strategies to the public and to gain feedback on these. More information on that forum will be provided closer to the time.

city of Victor Harbor

Australian WATER Environments

Please complete and send this form by FRIDAY 19th APRIL 2013 to:

The City of Victor Harbor
Victor Harbor Coastal Management Study
Community Feedback

PO Box 11
1 Bay Road, Victor Harbor SA 5211
Email: localgov@victor.sa.gov.au
Fax: (08) 8551 0501

Appendix B : Locality Plan 2050 x 2100 Inundation Maps, Existing Issues & Asset Maps, Potential Adaptation Treatment Options Figures 1-9

LEGEND

- Index Contour (5m interval)
- Intermediate Contour (1m interval, 1-4mAHD only)
- Area Below 2.65 mAHD 2050

Data Source:

Contours and Aerial Imagery (2010) supplied by the City of Victor Harbor, DEM created by AWE from contour data supplied by City of Victor Harbor.

WITHOUT INTERVENTION

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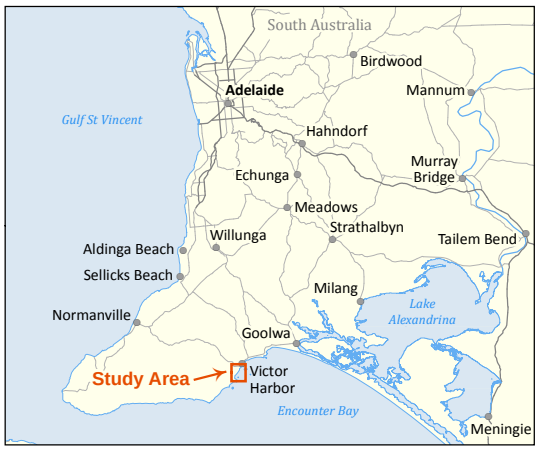
Victor Harbor Coastal Management Study

Sea Level Rise, Wave Set Up, Wave Run Up and 1 in 100 year Storm Surge Level 2050

13123 D006 Sea Level 2050 v3 130802
Last Updated: 2/08/2013

Figure 2

Armstrong Road
Inman Valley Road
George Main Road
Inman River
Victoria Street
King St
Esplanade
Police Point
Bay Road
Granite Island
Waitpinga Road
Tabernacle Road
Whalers Road
Franklin Parade
Fell Street
Encounter Bay
Battye Road
Wright Island
Rosetta Harbor
Bluff Boat Ramp
Jagger Road
The Bluff



LEGEND

- Index Contour (5m interval)
- Intermediate Contour (1m interval, 1-4mAHD only)
- Area Below 3.35 mAHD 2100

Data Source:
Contours and Aerial Imagery (2010) supplied by the City of Victor Harbor, DEM created by AWE from contour data supplied by City of Victor Harbor.

0 150 300 450 600
Metres (Scale 1:15,000 A3 Sheet)

WITHOUT INTERVENTION

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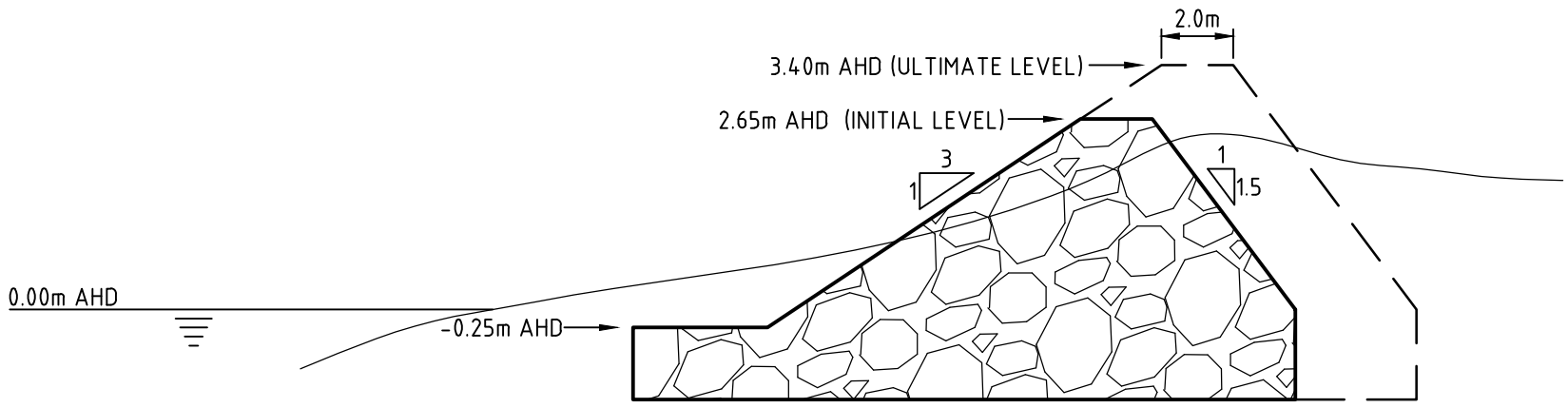
Victor Harbor Coastal Management Study

Sea Level Rise, Wave Set Up, Wave Run Up and 1 in 100 year Storm Surge Level 2100

13123 D007 Sea Level 2100 v3 130802
Last Updated: 2/08/2013

Figure 3



OPTION 1 ROCK SEAWALL (ULTIMATE TREATMENT) - SECTION A-A

Victor Harbor Coastal

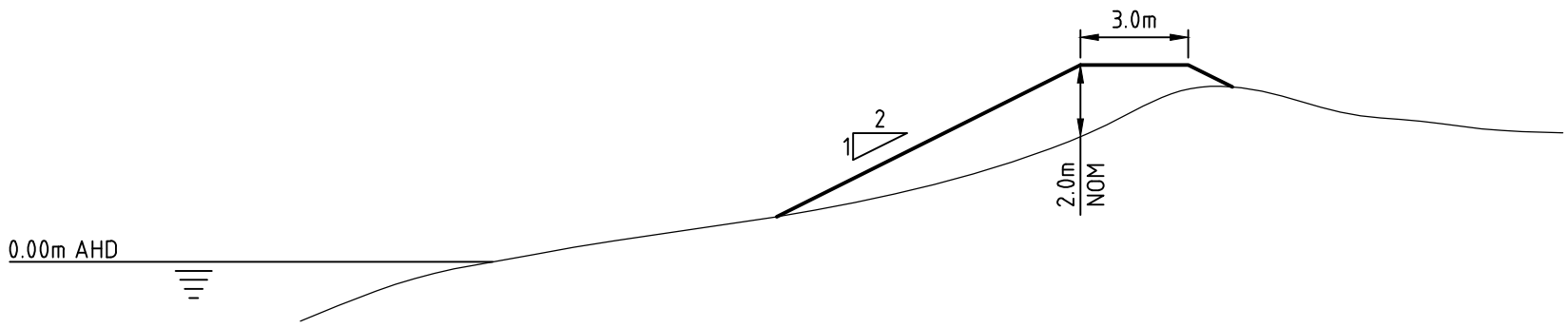
Management Study

Proposed Treatment - Police Point to Inman River

Australian WATER Environments

Job No. 13123 - 013
Last Updated: 22.05.13

Figure 6



OPTION 3 SAND NOURISHMENT
(SHORT - MEDIUM TERM TREATMENT) - SECTION A-A

Victor Harbor Coastal

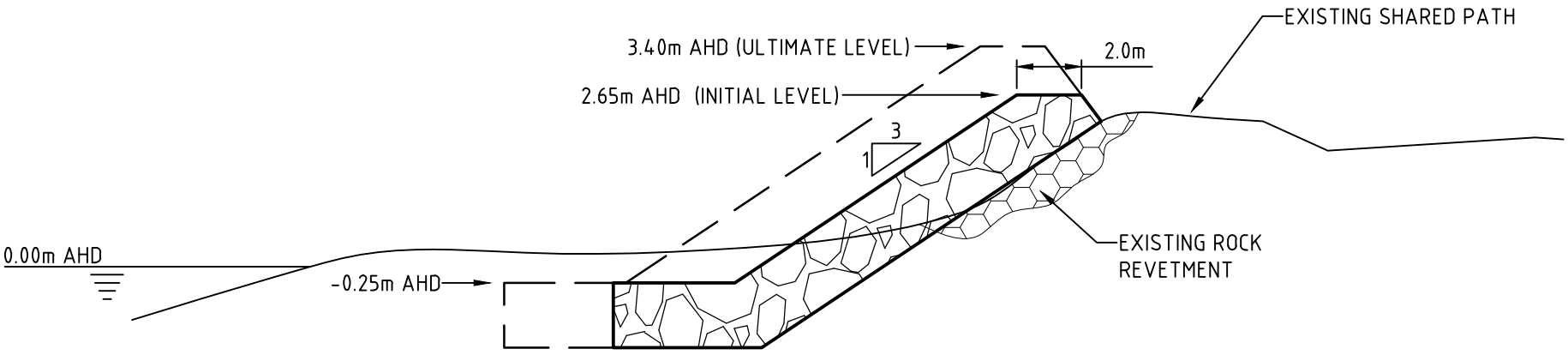
Management Study

Proposed Treatment - Police Point to Inman River

Australian WATER Environments

Job No. 13123 - 014
Last Updated: 22.05.13

Figure 7



OPTION 1 ROCK SEAWALL (ULTIMATE TREATMENT) - SECTION B-B

Victor Harbor Coastal

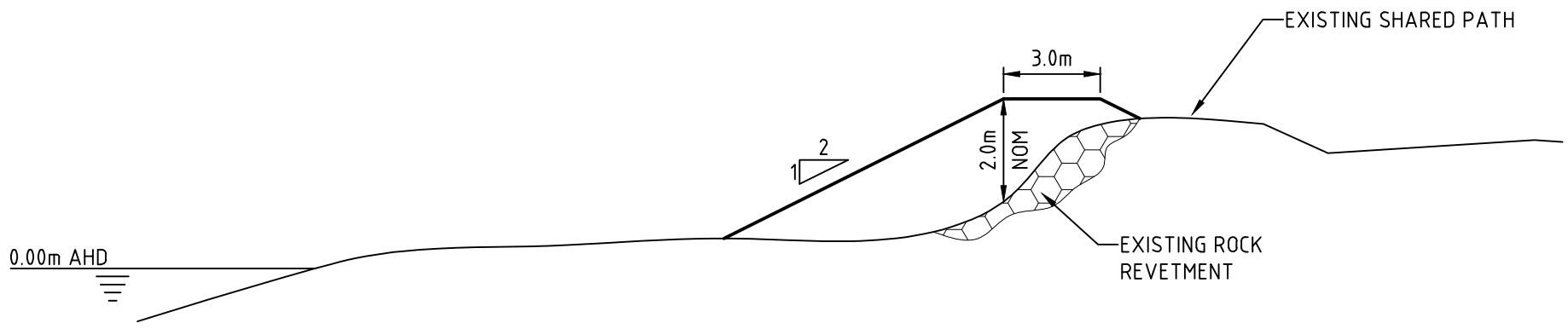
Management Study

Proposed Treatment - Inman River to Bluff Boat Ramp

Australian WATER Environments

Job No. 13123 - 015
Last Updated: 22.05.13

Figure 8



OPTION 3 SAND NOURISHMENT
(SHORT - MEDIUM TERM TREATMENT) - SECTION B-B

Victor Harbor Coastal

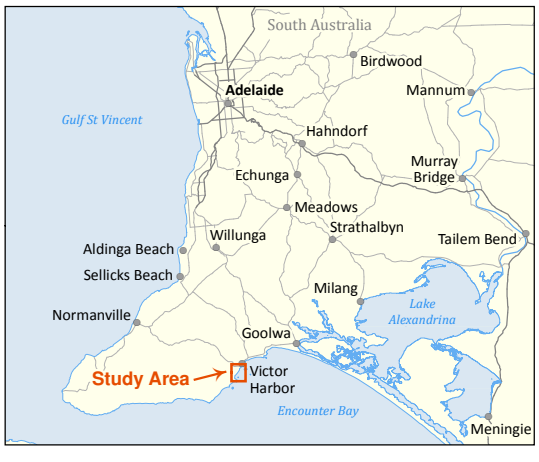
Management Study

Proposed Treatment - Inman River to Bluff Boat Ramp

Australian WATER Environments

Job No. 13123 - 016
Last Updated: 22.05.13

Figure 9



LEGEND

Study Area

Data Source:

Aerial Imagery (2010) supplied by the City of Victor Harbor, Study Area created by Australian Water Environments.

DRAFT

Australian WATER Environments

Victor Harbor Coastal Management Study

Study Area

13123 D010 Study Area v1 130419
Last Updated: 7/06/2013

Figure 1

Low point in the esplanade
Foredune subject to recent storm damage erosion
Current beach maintenance access
Erosion scar from drainage swale
Sand accretion at Police Point
Bund under bike path higher than caravan park surface
Police Point
Algae present in water
Sand replenishment area
High conservation value vegetation
Vegetation roots exposed from erosion
Excavation created by former beach maintenance access
Bund under bike path higher than caravan park surface
Low lying area vulnerable to inundation from sea level rise
Low point in caravan park
Cultural Heritage Site
Foredune higher than caravan park surface. Appears stable and accreted
Stormwater drain outlet to water body
Algae present in water
Sand bar accreted at river mouth
Groundwater and stormwater charged water body with former river alignment low lying undrained area
Granite Island
Low lying area vulnerable to inundation from sea level rise
Lake level rise with sea level rise
Sand accretion
Hooded Plover nesting area
Low lying area vulnerable to inundation from sea level rise
Low lying area vulnerable to inundation from sea level rise
Low lying area vulnerable to inundation from sea level rise
Sand replenishment area
Encounter Bay
Low lying area vulnerable to inundation from sea level rise
Low lying area vulnerable to inundation from sea level rise
Wright Island
Rosetta Harbor
Bluff Boat Ramp
The Bluff

Armstrong Road
Inman Valley Road
George Main Road
Victoria Street
King St
Esplanade
Bay Road
Waitpinga Road
Tabernacle Road
Whalers Road
Fell Street
Franklin Parade
Battye Road
Jagger Road

LEGEND

- Stormwater
- Sand Sausage
- Erosion
- Low Lying Area Vulnerable to Inundation
- Extended Low Lying Area Vulnerable to Inundation
- Hooded Plover Nesting Area
- Sand Replenishment Area

Data Source:
Contours and Aerial Imagery (2010) supplied by the City of Victor Harbor, Existing issues data created by Austrlaian Water Environments.

0 150 300 450 600
Metres (Scale 1:15,000 A3 Sheet)

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Victor Harbor Coastal Management Study

Issues and Assets

13123 D011 Existing Issues v1_4 130520
Last Updated: 20/05/2013

Figure 4

Divert stormwater to existing pit and duplicate outlet

Fill in existing swale and relocate dune

Divert caravan park stormwater to Inman Street pipe network

Priority 1

Priority 2

Priority 1

Priority 2

Priority 1

Priority 2

Priority 2

Police Point

Granite Island

Encounter Bay

Wright Island

Rosetta Harbor

Bluff Boat Ramp

The Bluff

Armstrong Road

Inman Valley Road

George Main Road

Inman River

Victoria Street

King St

Esplanade

Bay Road

Waitpinga Road

Tabernacle Road

Whalers Road

Franklin Parade

Fell Street

Battye Road

Jagger Road

LEGEND

- Coastal Side Entry Pits
- Coastal Outlet Pipes
- Gross Pollutant Trap
  - Existing
  - Proposed
- *Option 1:* *Rock sea wall constructed initially to RL2.65 mAHD with capacity to increase height for further sea level rise*
- *Option 2:* *Concrete sea wall constructed to RL 3.4 mAHD with some rock beaching on seaward face*
- *Option 3:* *Sand nourishment to beach and back beach areas up to 2m high (short-medium term solution)*

Data Source:
Contours and Aerial Imagery (2010) supplied by the City of Victor Harbor, treatment option data created by Austrlaian Water Environments.

0 150 300 450 600
Metres (Scale 1:15,000 A3 Sheet)

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Victor Harbor Coastal Management Study

Viable Adaptation Treatment Options

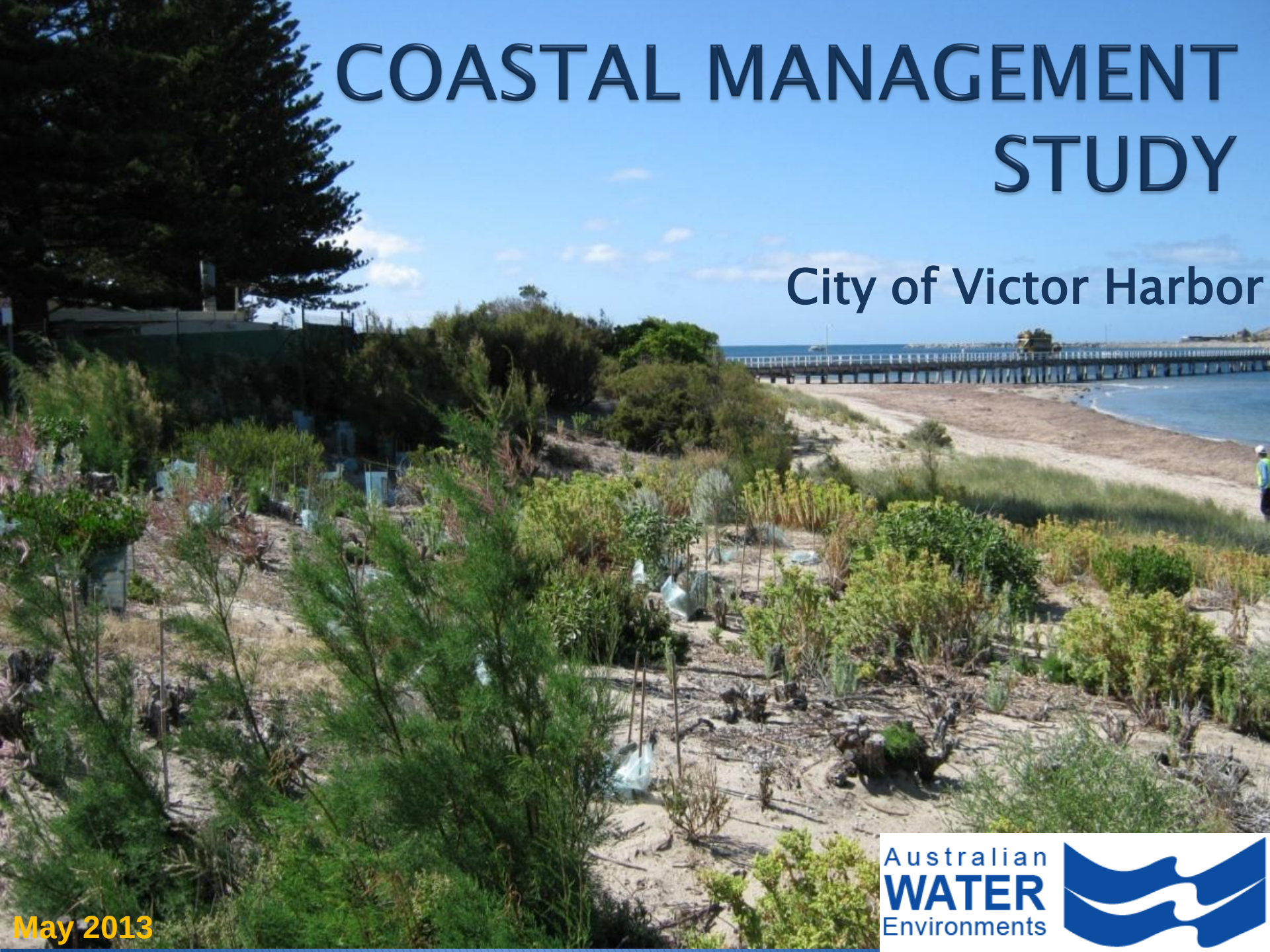
13123 D012 adaptation treatment option v1_2 130520
Last Updated: 7/06/2013

Figure 5

Appendix C : Risk Assessment and Risk Workshop Outcomes

COASTAL MANAGEMENT STUDY

City of Victor Harbor



May 2013

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Workshop Outline

- Welcome, Introductions & Apologies
- Project Update
- Risk Assessment Methodology
- Identify the issues
  - Assets of most relevance
  - Threats to the assets / hazards
- Timeframes for assessment and Likelihood
- Consequences to assets from hazards/threats
- Interim Risk Ratings
- Develop and Assess Solutions

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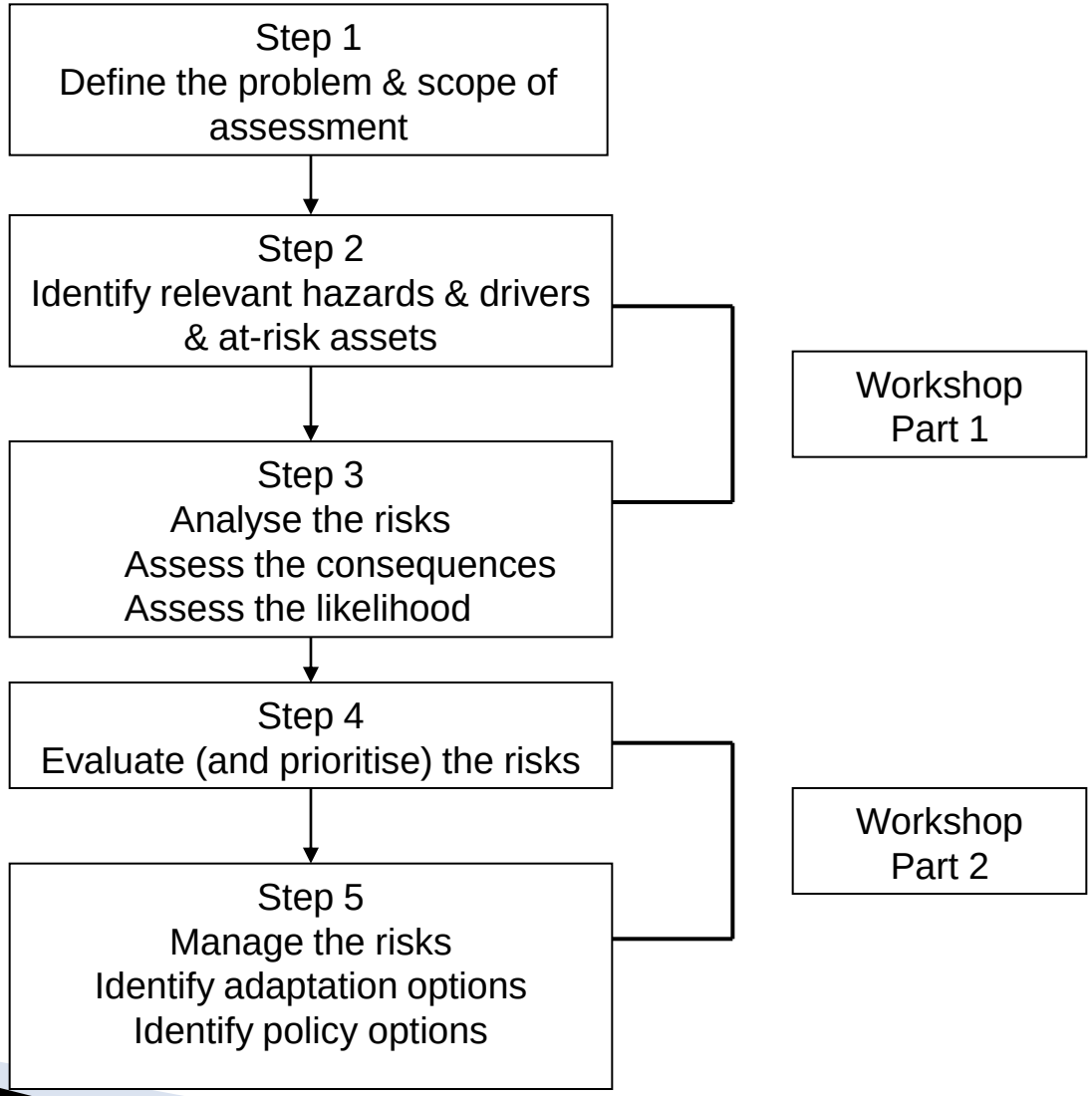
Progress thus far:

- Mapping ‘zone of influence’ = sea level rise + 100 yr ARI storm for two scenarios
- Field trip / inspections
- Evaluation of coastal processes
- Consultation with community
- Identification of built and natural assets
- Identification of potential impacts & damage

Risk assessment process:



Key terminology

- Risk:
  - The combination of the probability (or likelihood) of a hazard event occurring, and the severity of the impact (or consequence)
- Hazard:
  - A source of potential harm to people or property or the environment (eg: erosion, inundation, drought, heat stress)
- Consequence:
  - The outcome of an event, expressed qualitatively in terms of the level of impact. Can be measured in terms of direct or indirect economic, social, environmental or other impacts.
- Likelihood:
  - A qualitative (and possibly quantitative) measure of the probability, or chance, of something happening.
- Vulnerability
  - An indicator of the sensitivity of an asset (sometimes called feature) to a hazard, and its capacity for recovery.

Assets of importance and potentially at risk

- Social & Cultural
- Environmental
- Economic

- Assets map

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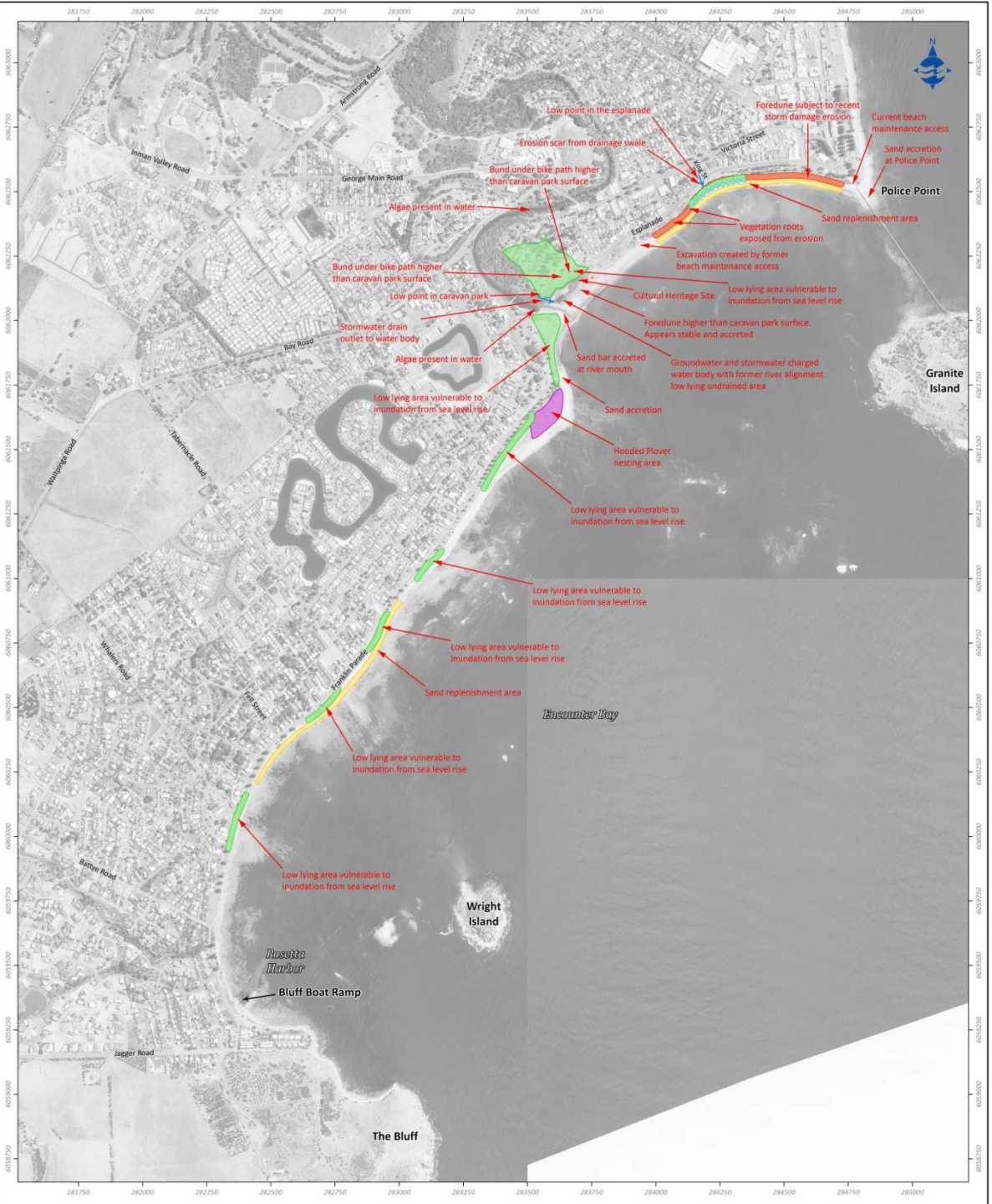

Assets Map

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Assets Table

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Environments

Threats to the assets / hazards

- Beach Erosion
- Shoreline recession
- Coastal inundation (wave set overtopping)
- Dune stability
- Tidal inundation (still water)
- Estuary condition resulting from catchment and tidal interactions
- Groundwater rise
- Reduction in rainfall

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Timeframes for assessment

- Two climate scenarios:
  Climatic conditions at 2050 and 2100
  - 1 in 100 ARI sea level with surge and run-up etc
    - Current – 2.35 mAHD
    - 2050 – 2.65 mAHD
    - 2100 – 3.35 mAHD
- Test these over what planning timeframe:
  2 years, 30, 50, 100, ultimate?
- Likelihood descriptions

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Likelihood of event occurring

Probability	Description
Almost Certain	There is a high possibility the event will occur as there is a history of frequent occurrence. The event is expected to occur in most circumstances.
Likely	It is likely the event will occur as there is a history of casual occurrence. The event has occurred several times or more in the past.
Possible	The event has occurred at least once in the past and may occur again.
Unlikely	There is a low possibility that the event will occur, however, there is a history of infrequent and isolated occurrence.
Rare	It is highly unlikely that the event will occur, except in extreme / exceptional circumstances, which have not been recorded historically.

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Likelihood of event occurring

Probability	Criteria
Almost certain	> 99% chance of the event occurring (eg the chance that a 1:1 ARI event will occur in the 30 year time frame falls in this category)
Likely	66-99% chance of the event occurring (eg the chance that a 1:25 ARI event will occur in the 30 year time frame falls in this category)
Possible	33-66% chance of the event occurring (eg the chance that a 1:50 ARI event will occur in the 30 year time frame falls in this category)
Unlikely	10 - 33% chance of the event occurring (eg the chance that a 1:100 ARI event will occur in the 30 year time frame falls in this category)
Rare	<10% chance of the event occurring (eg the chance that a 1:1000 ARI event will occur in the 30 year time frame falls in this category).

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Scenario Map 2050 climate

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Scenario Map
2100 climate

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Likelihood & Hazard Vulnerability

100 year planning horizon
2100 climate

- 1 – within current hazard area – Almost Certain
- 2 – within 2050 hazard area – Likely
- 3 – within 2100 hazard area – Possible

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Likelihood & Hazard Vulnerability

100 year planning horizon
2050 climate

- 1 – within current hazard area – Almost Certain
- 2 – within 2050 hazard area – Possible
- 3 – within 2100 hazard area – Unlikely

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Consequence Ratings – Economic

Rating	Economic	
Catastrophic	Large scale reconstruction required that is beyond the financial capacity of local or state government, necessitating disaster relief funding	Damage to property, plant and equipment, finances > $5 million
Major	Replacement of assets necessitates unplanned and unbudgeted borrowing	Damage to property, plant and equipment, finances >$2 million - $5 million
Moderate	Repairs or replacement of assets necessitates the re-organisation of capital works programs	Damage to property, plant and equipment, finances >$100,000 - $2 million
Minor	Repair and/or increased maintenance costs can generally be accommodated within capital works programs	Damage to property, plant and equipment, finances >$10,000 - $100,000
Insignificant	Minor increases in maintenance costs that can generally be accommodated within existing maintenance programs	Damage to property, plant and equipment, finances <$10,000

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Consequence Ratings – Environment

Rating	Environment	
Catastrophic	Extensive impact on environment and/or permanent/irreversible damage at the regional or state scale on habitat/s and populations. Complete loss of a species/community/habitat. Highly significant changes to threatening processes. Re-establishment of habitat unlikely to be achievable through rehabilitation / intervention (i.e. complete loss). Any impact for which the follow-on effects would severely compromise the viability of a species or community with status under national or state legislation.	Catastrophic event (e.g. habitat destruction) with national impact (e.g. Endangered species) for more than one year.
Minor	Small impact on environment with no permanent effects. Minor impact on habitat/s. Small number of wildlife deaths. Some local displacement of fauna. Minor changes to threatening processes. Minor rehabilitation required. No impact to species or communities with status under national or state legislation	Minor event (e.g. 20 lt oil spill) with localised impact (e.g. street, precinct) for less than one month

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Consequence Ratings – Social

Rating	Social		
Catastrophic	Widespread permanent impact to community services, wellbeing, finances, or culture (eg, > 75 % of community affected), or international loss, or no suitable alternative sites exist.	Many lives lost; emergency services unable to gain access for a week or more.	Long-term loss of services (e.g. water, power, telecommunications, transport, educational, health and community services) for several months; permanent loss of many people's homes; large-scale loss of employment; town is unable to support its community. Long term decline in quality of life within community.
Insignificant	Very small short term disruption to services, wellbeing, finances, or culture of the community (eg, <5 % of community affected), or neighbourhood loss, or numerous alternative sites exist.	Short term inconvenience, a small number of minor injuries, no disease outbreaks.	Short term inconvenience only. No appreciable decline in quality of life.

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Risk Matrix

Likelihood	Consequence				
	Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
Almost certain	Medium	High	High	Very High	Very High
Likely	Medium	Medium	High	High	Very High
Possible	Low	Medium	Medium	High	High
Unlikely	Low	Low	Medium	Medium	High
Rare	Low	Low	Medium	Medium	Medium

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Risk Profiles

- Spreadsheet

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Potential Solutions

- Do nothing
  - Consequences don't warranted action – or risk rating in low
- Adapt / retreat
  - Planning measures / rezoning / property acquisition
  - Build in resilience eg revegetation of dunes
- Protect
  - Technically feasible and affordable
  - Technically feasible but not affordable
  - Not technically feasible or effective

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Principles for Actions

- Actions must be consistent with Coast Protection Board Policies
- Base decision on best available information (within the constraints of the project budget) whilst adopting a continuous improvement approach
- Acknowledging the linkages between the coast, estuaries and catchment processes.
- Prioritise public expenditure towards the protection of public assets
- Adopt a risk management approach
- Maintain the condition of high value coastal ecosystems
- Maintain and improve safe public access to designated areas
- Ensure any interim measures are supportive of long term solutions

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Options Analysis – Increasing Resilience

- Beach Access
  - Pedestrian access ramps and steps
  - Maintenance vehicle beach access
  - Close off informal maintenance access
  - Rationalise the number of pedestrian access points
- Stormwater
  - Very few have erosion control
  - 8 of the 28 outlets have GPTs
  - Many inverts are located below beach level
- Vegetation
- Dune/Sand Management
- Planning Responses

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Options Analysis – Protection

Inman River–Police Point

- **Option 1**–Rock revetment sea wall located adjacent to fore dune as far landward as possible to RL 3.4m AHD with batter to reduce wave energy run up and wave overtopping volumes – **Expensive but long life solution and better chance of beach recovery after storms and allows planting within rock face**;

- **Option 2**–Vertical concrete sea wall located behind fore dune within reserve to RL 3.4m AHD– **Expensive and longer life solution but higher wave run up and less chance of beach recovery immediately seaward;**

- **Option 3**–Rock revetment sea wall located adjacent to fore dune as far landward as possible to RL 2.65m AHD with parapet wall on top of wall to 3.4m AHD to reduce wave overtopping– **Expensive similar cost and outcome to Option 1 but could replace parapet in future and extend for additional 0.7m sea level rise;**

- **Option 4**–Sand replenishment to build up height of fore dune at high risk areas– **lower capital cost but short life solution with high maintenance – subject to adequate sand supply**;

- **Option 5**–Rock armoured earthen levee located adjacent to fore dune as far landward as possible to RL 3.4m AHD – **Moderately expense and medium life solution not as effective as Option 1 in minimising erosion but good for inundation**

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Options Analysis – Protection

Inman River to Bluff Boat ramp

- **Option 1**–Rock revetment sea wall seaward side of shared path where no wall present and upgrade or replacement of existing rock wall in stages to RL 3.4m AHD with batter to reduce wave energy run up and wave overtopping volumes – **Expensive but longer life solution and better chance of beach recovery after storms**;

- **Option 2**–Vertical concrete sea wall in front of shared path to RL 3.4m AHD in high risk inundation areas –**Expensive and longer life solution but higher wave run up and less chance of beach recovery immediately seaward** ;

- **Option 3**–Place larger rock in front of current rock revetment wall with parapet wall to 3.4m AHD in low lying breach areas in front of shared path and construct new rock wall where none currently present – **Expensive but longer life solution and better chance of beach recovery after storms but possible less expensive than Option1**;

- **Option 4**– Raise shared path in high inundation risk areas to 3.4m AHD with associated retaining wall to build up to design level – **Moderate cost option dependant on level difference with Franklin Parade verge and carriageway;**

- **Option 5**–Sand replenishment to build up height of fore dune at high risk areas– **lower capital cost but short life solution requiring high maintenance effort**

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Discussion

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Summary and Close

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Likelihood of event occurring

Probability	Description
Almost Certain	There is a high possibility the event will occur as there is a history of frequent occurrence. The event is expected to occur in most circumstances.
Likely	It is likely the event will occur as there is a history of casual occurrence. The event has occurred several times or more in the past.
Possible	The event has occurred at least once in the past and may occur again.
Unlikely	There is a low possibility that the event will occur, however, there is a history of infrequent and isolated occurrence.
Rare	It is highly unlikely that the event will occur, except in extreme / exceptional circumstances, which have not been recorded historically.

Likelihood (based on a 30 year period/asset life)	
Scale	**Criteria**
Almost certain	> 99% chance of the event occurring (eg the chance that a 1:1 ARI event will occur in the 30 year time frame falls in this category)
Likely	66-99% chance of the event occurring (eg the chance that a 1:25 ARI event will occur in the 30 year time frame falls in this category)
Possible	33-66% chance of the event occurring (eg the chance that a 1:50 ARI event will occur in the 30 year time frame falls in this category)
Unlikely	10 - 33% chance of the event occurring (eg the chance that a 1:100 ARI event will occur in the 30 year time frame falls in this category)
Rare	<10% chance of the event occurring (eg the chance that a 1:1000 ARI event will occur in the 30 year time frame falls in this category).

Consequence Ratings

Rating	Social		
Catastrophic	Widespread permanent impact to community services, wellbeing, finances, or culture (eg, > 75 % of community affected), or international loss, or no suitable alternative sites exist.	Many lives lost; emergency services unable to gain access for a week or more.	Long-term loss of services (e.g. water, power, telecommunications, transport, educational, health and community services) for several months; permanent loss of many people's homes; large-scale loss of employment; town is unable to support its community. Long term decline in quality of life within community.
Major	Widespread medium term (somewhat reversible) disruption to community services, wellbeing, finances, or culture (eg <50 % of community affected), or national loss, or only a few suitable alternative sites exist.	Some lives lost; numerous serious and permanent injuries; access for emergency services is delayed by several days.	Medium term loss of, or access to, services (e.g. water, power, telecommunications, transport, educational, health and community services) for several weeks; some homes permanently lost. Significant but localised loss of employment. Widespread decline in quality of life within the community.
Moderate	Minor long term or major short term (mostly reversible) disruption to services, wellbeing, finances, or culture of the community (eg, <25 % of community affected), or regional loss, or some suitable alternative sites exist	Numerous injuries some serious and permanent, access for emergency services possible but complicated.	Disruption of, or access to, services (e.g. water, power, telecommunications, transport, educational, health and community services) for several days. People displaced from their homes for several weeks. Short term loss of employment. General appreciable decline in quality of life.
Minor	Small medium . short term (reversible) disruption to services, wellbeing, finances, or culture of the community (eg, <10 % of community affected), or local loss, or many alternative sites exist.	Some injuries but mostly not serious or permanent; emergency services are able to promptly respond.	Disruption of, or access to, services (e.g. water, power, telecommunications, transport, educational, health and community services) for a day or two; people displaced from homes for a week or so; moderate distress to some individuals. Isolated but appreciable decline in quality of life
Insignificant	Very small short term disruption to services, wellbeing, finances, or culture of the community (eg, <5 % of community affected), or neighbourhood loss, or numerous alternative sites exist.	Short term inconvenience, a small number of minor injuries, no disease outbreaks.	Short term inconvenience only. No appreciable decline in quality of life.

Rating	Economic	
Catastrophic	Large scale reconstruction required that is beyond the financial capacity of local or state government, necessitating disaster relief funding	Damage to property, plant and equipment, finances > $5 million
Major	Replacement of assets necessitates unplanned and unbudgeted borrowing	Damage to property, plant and equipment, finances >$2 million - $5 million
Moderate	Repairs or replacement of assets necessitates the re-organisation of capital works programs	Damage to property, plant and equipment, finances >$100,000 - $2 million
Minor	Repair and/or increased maintenance costs can generally be accommodated within capital works programs	Damage to property, plant and equipment, finances >$10,000 - $100,000
Insignificant	Minor increases in maintenance costs that can generally be accommodated within existing maintenance programs	Damage to property, plant and equipment, finances <$10,000

Rating	Environment	
Catastrophic	Extensive impact on environment and/or potentially permanent/irreversible damage at the regional or state scale on habitat/s and populations. Loss of a species/community/habitat requiring intervention for re-colonisation. Highly significant changes to threatening processes. Re-establishment of habitat unlikely to be achievable without extensive and substantial rehabilitation / intervention (i.e. complete loss). Any impact for which the follow-on effects would severely compromise the viability of a species or community with status under national or state legislation.	Catastrophic event (e.g. habitat destruction) with national impact (e.g. Endangered species) for more than one year.
Major	Some impact on environment with long-term effects. Large-scale death and long-term displacement of fauna. Local extinction of a population. Major impact on habitats at a district or regional scale. Significant changes to threatening processes. Extensive level of rehabilitation required; methods for rehabilitation or re-establishment may be uncertain. Moderate to major impacts on species or communities with status under national or state legislation.	Major event (e.g. Inman River contamination) with regional impact for more than one year
Moderate	Some impact on environment with no long-term effect or small impact on environment with long-term effect. Moderate, short term local impact on habitat/s. Local death and short term displacement of fauna. Significant changes to threatening processes. Moderate rehabilitation or re-establishment using known methods required. Minor impact on species or communities with status under national or state legislation, not including significant changes to threatening processes that would have a long-term impact on such species.	Major event with regional impact for between one month and one year
Minor	Small impact on environment with no permanent effects. Minor impact on habitat/s. Small number of wildlife deaths. Some local displacement of fauna. Minor changes to threatening processes. Minor rehabilitation required. No impact to species or communities with status under national or state legislation.	Minor event (e.g. 20 lt oil spill) with localised impact (e.g. street, precinct) for less than one month
Insignificant	No measurable impact on environment; inconsequential or no environmental damage. No loss of flora and fauna populations, species, communities or habitats. Little or no disruption to ecological processes.	Negligible event (e.g. noise pollution) with localised impact (e.g. street, precinct) for less than one month

Asset Table

Asset	Type
Foredune along the Esplanade between the Inman River and Police Point	Environmental/Economic
Fencing along the Esplanade between the Inman River and Police Point	Environmental
Vegetation at top of foredune along the Esplanade	Environmental
Beach pedestrian steps particularly within the foredune between Inman Street and Police Point and abutting Franklin Parade	Social
Encounter shared path particularly in locations close to the coast where there is little existing rock protection and land is low lying (ie Franklin Parade & abutting Council Caravan Park)	Social/Economic
Norfolk Island Pines and Canary Island Palms in Soldiers Memorial Reserve	Social
Playgrounds paths and park furniture abutting the coastal reserve	Social/Economic
Public Toilet adjacent to encounter shared path at Whalers Road	Social/Economic
Carpark off Franklin Parade adjacent Fell Street	Economic
Carpark on the Esplanade at King Street	Economic
Franklin Parade in low lying areas and locations where there is currently no rock protection	Economic
Stormwater outlets along coastal edge	Economic
Aboriginal heritage site south of Caravan Park and Kent Reserve	Social
Victor Harbor Council Caravan Park	Social/Economic
Victor Harbor private Caravan Park west of Bay Road	Social/Economic
Private housing and businesses behind esplanade and Franklin Pde	Social/Economic
Esplande from Inman Street to Flinders Parade	Economic
Franklin Parade from Boat Ramp to Kent Reserve	Economic
Hooded Plover nesting area	Environmental
Offshore reefs	Environmental
Tidal Reefs and tidal flats	Environmental
Bluff Boat Ramp	Social/Economic
Inman River Estuary	Environmental
Causeway Jetty to Granite Island	Social/Economic
Council Offices	Social/Economic
Beach	Environmental/Social/Economic
Seagrass	Environmental/Economic
Services infrastructure	Economic/Social
Seawalls	Economic/Social
Swamp Paperbarks - Inman Estuary	Environmental
Hospital and community infrastructure	Economic/Social

Risk Ratings 2100 Climate

Asset	Ratings		
	Consequence	Likelihood	Risk
Foredune along the Esplanade between the Inman River and Police Point	Major	Almost Certain	Very High
Fencing along the Esplanade between the Inman River and Police Point	Minor	Almost Certain	High
Vegetation at top of foredune along the Esplanade	Moderate	Almost Certain	High
Beach pedestrian steps particularly within the foredune between Inman Street and Police Point and abutting Franklin Parade	Moderate	Almost Certain	High
Encounter shared path particularly in locations close to the coast where there is little existing rock protection and land is low lying (ie Franklin Parade & abutting Council Caravan Park)	Major	Likely	High
Norfolk Island Pines and Canary Island Palms in Soldiers Memorial Reserve	Minor	Possible	Medium
Playgrounds paths and park furniture abutting the coastal reserve	Minor	Possible	Medium
Public Toilet adjacent to encounter shared path at Whalers Road	Minor	Likely	Medium
Carpark off Franklin Parade adjacent Fell Street	Moderate	Possible	Medium
Carpark on the Esplanade at King Street	Moderate	Likely	High
Franklin Parade in low lying areas and locations where there is currently no rock protection	Major	Almost Certain	Very High
Stormwater outlets along coastal edge	Major	Almost Certain	Very High
Aboriginal heritage site south of Caravan Park and Kent Reserve	Major	Likely	High
Victor Harbor Council Caravan Park	Catastrophic	Likely	Very High
Victor Harbor private Caravan Park west of Bay Road	Major	Possible	High
Private housing and businesses behind esplanade and Franklin Pde	Catastrophic	Possible	High
Esplande from Inman Street to Flinders Parade	Major	Likely	High
Franklin Parade from Boat Ramp to Kent Reserve	Major	Likely	High
Hooded Plover nesting area	Major	Almost Certain	Very High
Offshore reefs	Moderate	Almost Certain	High
Tidal Reefs and tidal flats	Major	Almost Certain	Very High
Bluff Boat Ramp	Minor	Almost Certain	High
Inman River Estuary	Moderate	Almost Certain	High
Causeway Jetty to Granite Island	Catastrophic	Possible	High
Council Offices	Catastrophic	Possible	High
Beach	Catastrophic	Almost Certain	Very High
Seagrass	Major	Almost Certain	Very High
Services infrastructure	Catastrophic	Likely	Very High
Seawalls	Catastrophic	Almost Certain	Very High
Swamp Paperbarks - Inman Estuary	Moderate	Likely	High
Hospital and community infrastructure	Catastrophic	Possible	High

Risk Ratings 2050 Climate

Asset	Ratings		
	Consequence	Likelihood	Risk
Foredune along the Esplanade between the Inman River and Police Point	Major	Almost Certain	Very High
Fencing along the Esplanade between the Inman River and Police Point	Minor	Almost Certain	High
Vegetation at top of foredune along the Esplanade	Moderate	Almost Certain	High
Beach pedestrian steps particularly within the foredune between Inman Street and Police Point and abutting Franklin Parade	Moderate	Almost Certain	High
Encounter shared path particularly in locations close to the coast where there is little existing rock protection and land is low lying (ie Franklin Parade & abutting Council Caravan Park)	Major	Possible	High
Norfolk Island Pines and Canary Island Palms in Soldiers Memorial Reserve	Minor	Unlikely	Low
Playgrounds paths and park furniture abutting the coastal reserve	Minor	Unlikely	Low
Public Toilet adjacent to encounter shared path at Whalers Road	Minor	Possible	Medium
Carpark off Franklin Parade adjacent Fell Street	Moderate	Unlikely	Medium
Carpark on the Esplanade at King Street	Moderate	Possible	Medium
Franklin Parade in low lying areas and locations where there is currently no rock protection	Major	Possible	High
Stormwater outlets along coastal edge	Major	Likely	High
Aboriginal heritage site south of Caravan Park and Kent Reserve	Major	Possible	High
Victor Harbor Council Caravan Park	Catastrophic	Possible	High
Victor Harbor private Caravan Park west of Bay Road	Major	Unlikely	Medium
Private housing and businesses behind esplanade and Franklin Pde	Major	Unlikely	Medium
Esplanade from Inman Street to Flinders Parade	Moderate	Possible	Medium
Franklin Parade from Boat Ramp to Kent Reserve	Moderate	Possible	Medium
Hooded Plover nesting area	Major	Almost Certain	Very High
Offshore reefs	Moderate	Possible	Medium
Tidal Reefs and tidal flats	Moderate	Possible	Medium
Bluff Boat Ramp	Minor	Possible	Medium
Inman River Estuary	Moderate	Almost Certain	High
Causeway Jetty to Granite Island	Moderate	Possible	Medium
Council Offices	Minor	Unlikely	Low
Beach	Major	Possible	High
Seagrass	Moderate	Unlikely	Medium
Services infrastructure	Moderate	Possible	Medium
Seawalls	Major	Possible	High
Swamp Paperbarks - Inman Estuary	Minor	Possible	Medium
Hospital and community infrastructure	Minor	Unlikely	Low