GOSFORD CITY COUNCIL

Open Coast and Broken Bay Beaches

Coastal Zone Management Study

301015-03417 – CS-REP-0001

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GOSFORD CITY COUNCIL
OPEN COAST AND BROKEN BAY BEACHES
COASTAL ZONE MANAGEMENT STUDY

SYNOPSIS

This report documents the Coastal Management Study as part of the development of the Coastal Management Plan for Gosford's beaches. It has been prepared in accordance with the Guidelines for Preparing Coastal Zone Management Plans as issued by the Office of Environment and Heritage (2013). This report is the Final Coastal Management Study.

Disclaimer

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PROJECT 301015-03417 - OPEN COAST AND BROKEN BAY BEACHES

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EXECUTIVE SUMMARY

Background

The Gosford City Council Local Government Area (LGA) is located on the Central Coast of New South Wales, approximately 50km north of Sydney. The LGA is bounded, to the east, by 14km of coastal beaches extending from Patonga (within Broken Bay) in the south to Forresters Beach on the open coast in the north.

Historically, coastal processes have threatened sections of the coast within the study area. Damage to public assets and recreational amenity has been experienced at the beaches in the Gosford area.

Risks have been assessed for the coastal erosion, inundation and long term beach recession hazards with consideration to current and future conditions (2050 and 2100) that include the natural processes that occur on Gosford's beaches and the impacts of projected climate changes.

Subsequently to the coastal risk assessment, Gosford City Council engaged WorleyParsons to review and update the Coastal Management Study report as part of the development of the Coastal Zone Management Plan. The outcome of this Study is a defined and prioritised set of coastal management options, supported by informed reasoning considering the uncertainties of sea level rise to address specific management issues for each beach in the Study area.

Coastline Management Process

Council undertakes coastal zone management planning in liaison with its Catchments and Coast (advisory) coastal sub-committee with beachfront property owners from all embayments included.

The basic framework for managing coastline hazards in NSW is through the *NSW Coastal Policy* and *Coastal Protection Act 1979* (OEH 2013). This is implemented through local Councils (with financial and technical support from the NSW Government) undertaking coastline hazard studies and developing coastal zone management plans that are used to inform land-use planning, development controls and coastal activities.

In accordance with the *Coastal Protection Act 1979*, a Coastal Zone Management Plan (CZMP) must make provision for:

1. protecting and preserving beach environments and beach amenity;
2. emergency actions carried out during periods of beach erosion, including the carrying out of related works, such as works for the protection of property affected or likely to be affected by beach erosion, where beach erosion occurs through storm activity or an extreme or irregular event;
3. ensuring continuing and undiminished public access to beaches, headlands and waterways, particularly where public access is threatened or affected by accretion;

4. where the plan relates to a part of the coastline, the management of risks arising from coastal hazards; and,
5. where the plan proposes the construction of coastal protection works (other than temporary coastal protection works[1]) that are to be funded by the Council or a private landowner or both, the proposed arrangements for the adequate maintenance of the works and for managing associated impacts of such works.

As noted in OEH (2013), ten Coastal Management Principles have been developed to inform strategic considerations in coastal management, including the preparation of CZMPs. These Principles are:

- **Principle 1 :** Consider the objects of the *Coastal Protection Act 1979* and the goals, objectives and principles of the *NSW Coastal Policy 1997*;
- **Principle 2 :** Optimise links between plans relating to management of the coastal zone;
- **Principle 3 :** Involve the community in decision-making and make coastal information publicly available;
- **Principle 4 :** Base decisions on the best available information and reasonable practice; acknowledge the interrelationship between catchment, estuarine and coastal processes; adopt a continuous improvement management approach;
- **Principle 5 :** The priority for public expenditure is public benefit; public expenditure should cost-effectively achieve the best practical long-term outcomes;
- **Principle 6 :** Adopt a risk management approach to managing risks to public safety and assets; adopt a risk management hierarchy involving avoiding risks where feasible and mitigation where risks cannot be reasonably avoided; adopt interim actions to manage high risks while long-term options are implemented;
- **Principle 7 :** Adopt an adaptive risk management approach if risks are expected to increase over time, or to accommodate uncertainty in risk predictions;
- **Principle 8 :** Maintain the condition of high value coastal ecosystems; rehabilitate priority degraded coastal ecosystems;
- **Principle 9 :** Maintain and improve safe public access to beaches and headlands consistent with the goals of the NSW Coastal Policy; and
- **Principle 10 :** Support recreational activities consistent with the goals of the NSW Coastal Policy.

The process for development of a Coastal Zone Management Plan for the Gosford Beaches is defined by the following phases:

- Undertake **Coastal Risk Assessment** to identify coastal hazards, management issues and their severity;

[1] "Temporary coastal protection works" has a specific meaning in relation to the *Coastal Protection Act 1979*, generally being sand or sandbags temporarily placed on a beach to reduce beach erosion impacts. To distinguish this specific meaning from the general meaning of emergency coastal protection works in coastal engineering practice (being any works implemented to limit coastal erosion in an emergency), the specific meaning is denoted as "Part 4c sand/sandbags ECPW" herein in reference to the Section in the *Coastal Protection Act 1979* in which they are described.

- Undertake a **Coastal Zone Management Study** to identify and evaluate potential management options to address current and future coastal risk, including climate change (this Study);
- Undertake a **Coastal Zone Management Plan** that proposes management actions in accordance with the management options identified during the Coastal Zone Management Study process and a set timeframe for their implementation;
- **Implementation** of the Coastal Zone Management Plan, whereby actions identified in the Coastal Zone Management Plan are implemented over a 10 – 15 year timeframe.

This report summarises the coastal processes and coastal hazard assessment, and assesses the suitability of existing management measures for the study area. The management options presented have considered the requirement to achieve a reasonable balance between any conflicting uses of the coastal zone and have considered feedback from the community obtained during the public exhibition process via formal submissions on the Draft Study.

Study Area Values

A large proportion of Gosford's population lives in the coastal areas of the Gosford LGA.

Gosford's beaches and the developments along them are of major social, environmental and economic importance to the Gosford local government area. Both natural and built coastal assets are under increasing pressure from a growing population.

The values of the study area include indigenous and non-indigenous heritage, ecological, economic and community values.

Gosford's beaches provide visual amenity, recreational opportunities that link closely with community lifestyle choices, indigenous, spiritual and cultural values and heritage, habitat and nursery ground for many coastal and estuarine plants and animals and sand dunes that have biodiversity values and protect our developments during storms.

The value of the natural environment is a paramount consideration in the sustainable management of the coastline. Beaches support a great diversity of flora and fauna and provide habitat and nursery ground for many coastal and estuarine species. Sandy beaches are an important ecosystem that links the ecology of sand dunes, the surf zone, intertidal zones, and nearby rocky reefs.

Several natural coastal and marine ecosystems are at risk from human use and coastal hazards now and into the future. They are impacted through landward migration and erosion, recreational activities (i.e. fishing, harvesting), coastal development and construction of protective works, beach cleaning and nourishment. The endangered ecological communities of Umina Sands Coastal Woodland, Coastal Sand Swamp Forest, Coastal Headland Grassland and other forest and wetland vegetation occur in a number of locations within or near the study area. Regionally significant vegetation such as coastal sand foreshore scrub, coastal sand banksia scrub, coastal headland shrubland and coastal headland low forest are found at most of the beaches.

The sand dunes along the beaches of Gosford vary in width and condition and have undergone significant erosion in many areas, especially where residential or other development occurs directly on the dune. However, there are still undeveloped areas which contain native dune vegetation which provide important coastal habitat for a diverse range of fauna including invertebrates (e.g. worms, insects and crabs), reptiles (e.g. skinks, snakes and goannas), birds (e.g. shorebirds) and mammals (DLWC 2001).

The Gosford City area is the ninth largest population centre in Australia and the third largest residential region in NSW (Regional Development Australia - Central Coast NSW, 2009). The economic value of our coastline includes the value of private dwellings, public infrastructure and the income provided through tourism, recreation and fishing.

There is widespread residential development along the Gosford coastline with beachfront properties generally highly valued within the property market. The built coastal environment is strongly linked to the risks proposed by climate change projections as infrastructure is often in close proximity to the coastline and coastal waterways. The most recent coastal risk assessment (WorleyParsons 2014) identifies a large number of properties as being at immediate risk of coastal erosion. This risk increases into the future as a result of coastal recession and climate change projections.

In addition, inundation risk currently exposes many properties along the Gosford coastline. The extent to which the buildings on these properties are at risk is a function of their design and location.

The social atmosphere is an important component of beach recreation. Gosford's coastline provides a range of social and recreational opportunities including walking or jogging on the beach, meeting with family and friends, relaxing, swimming, bonding with nature, sightseeing and people watching, surf lifesaving and nippers, sunbathing and beach games.

Planning Instruments and Legislative Framework

The legislative framework for NSW coastal management has undergone significant reform since 2009 and is covered by a range of legislation and policy as described below.

Currently, the following development controls apply to the coastal zone within Gosford City:

- Development Control Plan 2013 (Chapter 6.2 focuses upon Coastal Frontage)
- Gosford City Local Environment Plan.

Key legislation and policy applying to activities in the NSW Coastal Zone includes:

- Coastal Protection Act 1979;
- Coastal Protection Regulation 2011;
- NSW Coastal Policy 1997;
- Environmental Planning & Assessment Act 1979;
    - State Environment Planning Policy (Infrastructure) 2007
    - State Environment Planning Policy 14 Coastal Wetlands
    - State Environment Planning Policy 71 Coastal Protection
- Local Government Act 1993;

- Crown Lands Act 1989;
- Land Acquisition (Just Terms Compensation) Act 1991;
- Fisheries Management Act 1994; and
- Threatened Species Conservation Act 1995.

A series of guideline documents also apply applying to planning and management within the NSW Coastal Zone include:

- Guidelines for the development of Coastal Zone Management Plans (2013);
- NSW Coastal Planning Guideline– Adapting to Sea Level Rise (1999)
- A Guide to the Statutory Requirements for Temporary Coastal Protection Works (2010)
- A guide for authorised officers under the Coastal Protection Act (2010)
- Coastal zone management guide note - Emergency Action subplans (2011)
- Coastal Protection Service Charge Guidelines (2010)
- Code of Practice under the Coastal Protection Act 1979 (2013)

These documents and their relevance to coastal planning in Gosford are discussed in more detail within this Study report.

Coastal Processes

The coastal processes and coastal hazards are described and quantified in detail in the Coastal Process and Hazard Definition Study (WorleyParsons 2014).

The coastal processes relevant to the study area include:

- wave climate;
- elevated water levels;
- wave runup;
- coastal storms;
- sediment transport;
- climate change; and
- lagoon entrance processes.

The study area wave climate is characterised by waves generated in the southern Coral and Tasman Seas and the Southern Ocean. Although moderate waves dominate the climate, large waves (*significant* wave height Hs[2]>4 m) and/or low swell may occur in any month. Extreme events (Hs>6m) occur predominately in autumn and winter (Short and Trenaman 1992).

The majority of offshore waves and storm waves propagate from the S-SE sector. N-NE waves account for only a small percentage of the offshore wave energy and storm waves.

As waves approach the shore, they may be transformed by the processes of refraction, shoaling, diffraction, attenuation, reflection and breaking. Analysis of the nearshore wave climate indicates that

[2] Significant wave height, or Hs, refers to the average height of the highest one-third of the waves in a wave record.

offshore waves from the SSE and SE generally produce the largest inshore wave heights in the study area.

In NSW, open coast still water levels (within the wave breaking zone) can increase by up to about 2.1 m above normal levels during storms due to storm surge and wave setup, with components approximately as large as follows:

- storm surge of up to 0.7 m; and
- wave setup of up to 1.5 m.

Wave runup typically reaches a maximum level of about 7 m AHD on the open NSW coast at present.

The NSW coastline is subject to intense tropical and non-tropical storms at irregular intervals. The drop in atmospheric pressure and the winds and waves that accompany these storms can cause the ocean to rise above its normal level. If this occurs concurrently with high astronomical tides, there is the potential for:

- coastal erosion (in particular as the storm waves dissipate energy closer to the shoreline with the increased water levels); and/or
- overwash into low-lying coastal areas.

The key storms to affect the study area occurred in May-June 1974, May-June 1978, September 1985, August 1986, September 1995, May 1997, and June-July 2007. The damaging storms in the study area have generally been preceded by sequences of storms, often not particularly severe storms in isolation. The study area can be expected to again be exposed to such storms at irregular intervals in the future. These storms are most likely to occur in autumn and winter, and are least likely to occur in summer, but can generally occur at any time.

Climate change has been defined broadly by the Intergovernmental Panel on Climate Change (IPCC 2001) as any change in climate over time whether due to natural variability or as a result of human activity. The possibility of global climate change accelerated by increasing concentrations of greenhouse gases, the so-called Greenhouse Effect, is now widely accepted by the scientific and engineering communities. This is predicted to cause globally averaged surface air temperatures and sea levels to rise.

For the Open Coast and Broken Bay Beaches – Coastal Processes and Hazard Definition Study (WorleyParsons 2014), coastline hazards were estimated for the:

- immediate planning period;
- the impact of a sea level rise of 0.4 m; and
- the impact of a sea level rise of 0.9 m.

This assessment was based on Council and the NSW Government's previously adopted sea level rise benchmarks. It provides a specific assessment of projected coastal risk as which guides our understanding of potential future risk.

The coastal hazard lines represent a worst case scenario and have been developed in line with NSW Government requirements and widely accepted coastal engineering methodologies. They represent a theoretical line which assist in guiding the development of appropriate management options to deal with defined risk. However, they represent only one component in considering appropriate development going forward.

However, it should be noted that future sea level rise could be smaller or larger than predicted. It is generally expected that recession of the open coast will occur under conditions of accelerated sea level rise. Council, at is meeting of 10 March 2015, considered sea level rise and has resolved to adopt a medium sea level rise projection as its strategic position to inform Council's planning and plan making processes. Sea level rise is not the only consideration in managing coastal hazards.

Four of the beaches within the study area are backed by lagoons, namely Cockrone (behind MacMasters Beach), Avoca, Wamberal and Terrigal. All four of the lagoons are intermittently open to the oceans and are classed as Intermittently Closed and Open Lakes or Lagoons (ICOLLs).

Entrance processes for these lagoons are described further in the Coastal Processes and Hazard Definition Study (WorleyParsons 2014), and include:

- entrance migration;
- the effects of lagoon opening on surf zone processes; and
- entrance scour.

Other estuary entrances adjacent to the beaches in the study area include:

- Patonga Creek (Patonga Beach)
- Middle Creek, Green Point Creek and Pearl Beach Lagoon (Pearl Beach)
- Ettalong Creek (Umina Beach)

In general, these creeks and lagoons discharge across the beaches, breaking though the beach berms and causing scour channels during high flows.

Coastal Hazard Assessment

The potential coastline hazards that could impact on the beaches in the Gosford LGA include:

- beach erosion hazard;
- shoreline recession hazard;
- sand drift hazard;
- coastal inundation hazard;
- stormwater erosion hazard;
- climate change; and
- slope and cliff instability hazard.

The coastal processes and hazard assessment underpinning this study is detailed in the report titled Open Coast and Broken Bay Beaches – Coastal Processes and Hazard Definition Study

(WorleyParsons, 2014). That document describes the coastal hazards that apply to the beaches and makes an assessment of the risks to property posed by these hazards.

The level of risk assigned to the coastal hazard assessment is a 100 year ARI event, equivalent to the erosion that could happen under a storm event that has approximately a 1% chance of occurring (or being exceeded) in any one year. The mapped hazard lines represent the possible extent of erosion in any one location where a rip cell is present offshore from the beach location, including an allowance for slumping of the dune face. The hazard of beach erosion relates to the limit of erosion that could be expected due to a severe storm, or from the effects of a series of closely spaced storms. Storm erosion hazard was assessed for each beach in the study area based on analysis of photogrammetric data. Wave modelling was used to estimate the relative wave energy at each of the beaches to verify the values of storm erosion derived for each beach from the mapping.

The hazard of shoreline recession is the progressive landward shift in the average long term position of the coastline (NSW Government 1990). Two potential causes of shoreline recession are net sediment loss, and an increase in sea level. Long term recession due to net sediment loss is a long duration (period of decades), and continuing net loss of sand from the beach system. This occurs when more sand is leaving than entering the beach compartment. A progressive rise in sea level may result in shoreline recession through two mechanisms: first, by drowning low lying coastal land, and second, by shoreline readjustment to the new coastal water levels.

Sand drift is a result of aeolian wind movement of beach sediment. Sand drift in a coastal location is usually initiated by the degeneration or destruction of vegetation protecting the vital foredune. Common causes are foot and vehicle tracks devoid of vegetation running down the face of the dune (NSW Government 1990). Due to successful revegetation efforts since the 1950s and 1960s, the sand drift hazard in the study area is likely to be minimal.

Coastal inundation is the flooding of coastal lands by ocean waters, which is generally caused by large waves and elevated water levels associated with severe storms. During storm events, individual waves result in further temporary water level increases above the still water level due to the process of wave setup and runup or uprush. Lots affected by inundation hazard have been identified in the coastal risk assessment mapping for the present day planning period.

During major stormwater runoff events, stormwater collected from back beach areas and discharging into coastal waters can cause significant erosion to the beach berm. This in turn can allow larger waves to attack the beach and can cause migration of the stormwater discharge entrance if not structurally contained (NSW Government 1990). Flow from stormwater pipes and outlets on beaches have the potential to scour the surrounding sand, creating erosion zones. In the study area, most of the stormwater drains to creeks or lagoons, with outlets to the ocean.

Public and private infrastructure and assets as well as environmental assets have been deemed to be at risk in the present day and in the future at many of the beaches, with these assets including roads, beach accessways, public facilities, utilities, private dwellings and dune vegetation. The quantum of assets in Gosford LGA deemed to be at risk from coastal hazards are tabulated in Appendix 3.

Existing Coastal Management Measures and Issues

There are a range of coastal management measures already in place at each of the beaches within the study area. Coastal management issues at each beach have been documented within this report, as gleaned from site observations. Issues discussed include stormwater, beach access, dune vegetation, and presence of existing coastal protection works.

Some of the issues documented at the various beaches in the study area include:

- Use of ad-hoc coastal protection works which have not been designed to any engineered standard i.e. the effectiveness of these works during severe storm conditions is unknown;
- Scour along beach faces due to discharge from stormwater outlets and estuary entrances;
- Loss of regionally significant dune vegetation due to coastal erosion and inappropriate beach access arrangements;
- Impacts of beach erosion risk including social impacts (loss of beach access, impacts on beach amenity), ecological impacts (beach and dune ecology), and economic impact (damage to infrastructure).

Available Management Options

The Coastal Zone Management Plan should describe proposed actions to be implemented by Council, other public authorities and potentially by the private sector to address priority management issues in the coastal zone.

The appropriate management actions for each beach within the LGA depend on the level of risk to public safety, public and private assets and infrastructure.

The Coastal Management Principles (OEH 2013) include Principle 6 which is to “adopt a risk management approach to managing risks to public safety and assets; adopt a risk management hierarchy involving avoiding risks where feasible and mitigation where risks cannot be reasonably avoided; adopt interim actions to manage high risks while long-term options are implemented.” In accordance with this Principle, where the risks can be reasonably avoided, management options considered for the coastline are to be consistent with the key objective of finding reasonable risk avoidance strategies.

The Guidelines for Preparing Coastal Zone Management Plans (OEH 2013) discuss several categories of management options that can be adopted for each beach, within a risk management framework. These option categories include:

- Avoiding the risk (i.e. building setbacks, planning/development controls, infrastructure setbacks and building design criteria)
- Changing the *likelihood* (i.e. coastal protection works, beach nourishment, compliance action on illegal works on beaches)
- Changing the *consequence* (i.e. building and infrastructure modification or relocation, access control and public education)
- Sharing the risk with another party (i.e. insurance)

- Retaining the risk by informed decision (i.e. emergency management).

It is considered that the management actions are best defined at a scale representing each beach or locality. In this Study, potential management actions have been defined on a precinct-by-precinct basis, with precincts representing sections of beaches with unique social, physical and environmental attributes.

Certain measures can be implemented quickly, such as development and building controls, hazard education, public awareness and dune management programs. However, availability of funding will determine when certain options can be implemented (e.g. structural measures, voluntary purchase of property). Consequently, a strategy needs to be developed to implement the Plan over time. The strategy should include the staging of measures that are dependent on availability of funds, the adoption of interim measures, protection priorities, etc. Management actions can be applied in the short-term (e.g. 0 – 5 years), medium term (e.g. 5 – 20 years) or long term (e.g. greater than 20 years). The temporal scale for a particular action would depend upon how the risk is changing over time, as well how quickly they can be implemented from a regulatory and financial perspective.

Options to avoid the risk are discussed in the Guidelines for Preparing CZMPs (OEH 2013). In general, the following options are available:

- Planning/Development controls;
- Infrastructure setbacks;
- Building and infrastructure design criteria.

Options to change the risk likelihood include:

- Coastal protection works;
- Beach nourishment;
- Dune revegetation.

Examples of options to change risk consequence are to relocate critical infrastructure landward where possible, or making modifications to existing infrastructure to reduce the quantum of damage that could occur following the design storm event.

Should the risk be retained by informed decision, emergency management provisions would need to be implemented. Emergency management arrangements in the context of a Coastal Zone Management Plan are outlined in Coastal Erosion Emergency Action Subplans. A Coastal Erosion Emergency Action Subplan for Wamberal-Terrigal Beach has been developed and publicly exhibited and outlines the roles and responsibilities of the State Emergency Service, Gosford Council, Office of Environment and Heritage, Bureau of Meteorology and NSW Police in coastal emergency management. The Subplan also outlines before, during and after-storm actions to be taken by Council during a coastal erosion emergency.

Specific localised management actions could be implemented to deal with a localised issue of importance to the community or a coastal hazard which is confined to a specific location. For example a particular stormwater outlet that has caused local erosion in a particular location may need to be repaired and this stipulated as a management action in the CZMP. These localised actions may be required to improve local beach amenity, dune ecology and recreational values. Damage to local Council-managed infrastructure such as sewer or water infrastructure can occur as a result of coastal erosion and inundation, which would require repairs or relocation as a management action in the CZMP.

A combination of the above management options could be implemented to protect the vulnerable areas from erosion and improve the amenity of the beach at the same time.

Funding options for coastal management actions

The Guidelines for Preparing Coastal Zone Management Plans (OEH 2013) recognise three categories of coastal hazard responses – these are listed below:

- **Category A** - Coastal protection works are considered technically feasible and cost effective – funding is being sought for implementation
- **Category B** - Coastal protection works are considered technically feasible but not cost-effective for public funding – unlikely to be implemented by a public authority
- **Category C** - Coastal protection works are not considered technically feasible – no intended public authority works.

Funding under the NSW Coastal Management Program is limited, and funding priorities are for works that improve public safety and protecting valuable publicly-owned assets, and then to private land. Coastal protection works for the beaches within Gosford LGA would therefore fall under Category B above, due to the high cost associated with the scale of the required works for beaches such as Wamberal.

Financial mechanisms for funding large scale capital cost items and ongoing costs relating to the implementation of CZMPs throughout NSW are currently being investigated through the NSW Government's Stage 2 Coastal Reforms.

Recommended Management Options

Management options have been recommended for each beach based on the specific coastal hazard risks identified at each beach, and specific issues of importance identified by the local community and in previous studies. Options have been divided into those which address the identified coastal hazards and those which address other coastal management issues.

The major challenges for coastal management across Gosford's beaches relate to land use and development.

Coastal adaptation options have been developed for each beach within the study area. These management options align with four broad strategies for managing coastal risk into the future being:

- Defend (protect)
- Accommodate
- Retreat

- Maintain the Status Quo

A combination of these approaches may be required at each beach. Thus the final CZMP will describe the overarching management philosophy to be adopted to address landuse and development issues for each area.

An indicative capital cost has been provided for each option, based on a broad range of assumptions. Indicative benefit-cost ratios have been determined for each option to provide a first-pass assessment of the feasibility of that option. While a large range of options have been considered and discussed in the Exhibition Draft of this Study, some of these options have subsequently been excluded from further consideration based on their perceived social or environmental impacts and the submissions received from the community.

Through community consultation undertaken for this Study, which has included public exhibition of the Study and a series of targeted community presentations to discuss the proposed management options for each precinct in the study area, formal submissions have been received which have provided feedback on which options are preferred by the local community in each precinct. In addition, several management options have been suggested by the community and these have been incorporated into the final list of options to be considered for inclusion in CZMP. Further to community consultation, the options presented have been developed and discussed in several workshops held throughout the process of developing the Draft Study with Council's Catchments and Coast (advisory) coastal sub-committee.

The list of options, their descriptions, indicative costs and benefits, benefit-cost ratios and advantages and disadvantages has been developed in Section 8 of this report for each precinct at each beach within the Study area.

The outcome of this Study has been a prioritised set of coastal management options, supported by informed reasoning considering the uncertainties of sea level rise to address specific management issues for each beach in the Study area.

Each of the options to be incorporated into the final CZMP are to consider such issues as the effectiveness of each option in removing the coastal hazard risk, the compatibility of the option with the principles of ecologically sustainable development (ESD), and the likely community acceptance of each option.

1 INTRODUCTION

1.1 Background

The Gosford City Council Local Government Area (LGA) is located on the Central Coast of New South Wales, approximately 50km north of Sydney. The LGA is bounded, to the east, by 14km of coastal beaches extending from Patonga (within Broken Bay) in the south to Forresters Beach on the open coast in the north. A locality plan is shown in **Figure 1**.

Historically, coastal processes have threatened sections of the coast within the study area. In particular, Wamberal Beach on the open coast experienced severe erosion in 1974, 1978, 1986 and 1997. In May-June 1974 many houses were threatened and in June 1978 beach and dune erosion, attributed to an intense rip cell, undermined and destroyed two houses. Damage to public assets and recreational amenity has also been experienced at other beaches in the Gosford area.

In recognition of this threat and the impact on the recreational amenity, in June 1984 Council established a Coastal Committee, comprising Council's technical and professional staff and officers of the then NSW Government Public Works Department (PWD) and the Department of Environment and Planning, to consider the coastal hazards of the City's foreshores and to develop management strategies for its coastal regions. The PWD provided Coastal Engineering Advice in respect of coastal erosion at Wamberal Beach and Avoca Beach (PWD 1985). Later, in 1994, Council commissioned PWD to complete a coastal process investigation for all the open coast beaches (PWD 1994), while Patterson Britton & Partners were commissioned to complete a coastal processes study for Broken Bay beaches in 1998 (PBP 1998). Coastline hazard lines (representing the predicted extent of erosion for a severe coastal storm) were defined by these studies and adopted as planning controls for development.

The risk to assets along the Gosford LGA coast is projected to increase due to projected sea level rises. In August 2013, Gosford City Council endorsed a number of climate change scenarios relating to the Central Coast region. The climate change scenarios are intended to present a plausible future state of the climate in the region at different time periods and form the basis for risk assessment in this study. The indicative changes described in the scenarios are relative to the current period defined as the average climate experienced over the 1980 - 2007 period and are based on medium to high end of best available projections. Gosford City Council's adopted sea level rise planning benchmarks are 0.40 m by 2050 and 0.9 m by 2100. Due to the higher sea level rise planning benchmarks than those adopted for previous studies, projected shoreline recession on open coast beaches is expected to increase typically by some 7 m for the 50 years projections and, for the 100 years projections, by some 14 m. In March 2015, Gosford Council has updated their adopted sea level rise projections which are to be taken into account in finalising the management options for the CZMP.

Further, the *Guidelines for Preparing Coastal Zone Management Plans* (OEH 2013), have been adopted by the then Minister for Climate Change and the Environment as Guidelines under Section 55D of the *Coastal Protection Act 1979*, and Councils are required to prepare draft plans in accordance with these Guidelines. These Guidelines require that the beach erosion hazard is defined as a storm bite plus an allowance for reduced foundation capacity. Previously, the erosion hazard incorporated storm bite plus an allowance for slope adjustment only, so the updated Guidelines require a more conservative definition of the erosion hazard.

Council's existing development controls are based on hazard lines that do not take into account the current Gosford Council Sea Level Rise Planning Benchmarks. The existing hazard lines are based on the mid-range projections in IPCC (1990). As such, Gosford City Council engaged WorleyParsons to develop hazard lines for the immediate, 2050 and 2100 future planning periods. The coastal processes and hazard assessment underpinning this study are detailed in the report titled *Open Coast and Broken Bay Beaches – Coastal Processes and Hazard Definition Study* (WorleyParsons 2014). That document describes the coastal hazards that apply to the beaches and makes an assessment of the risks to property posed by these hazards.

Risks have been assessed for the previously mentioned hazards with consideration to current and future conditions (2050 and 2100) that include the natural processes that occur on Gosford's beaches and the impacts of projected climate changes. Subsequent to the coastal risk assessment, Gosford City Council engaged WorleyParsons to review and update the Coastal Management Study report as part of the development of the Coastal Zone Management Plan. This review is documented herein.

This Study documents the Coastal Zone Management Study for the Open Coast and Broken Bay beaches. Other areas within the Gosford LGA are subject to separate coastal zone management planning processes, these include:

- Pearl Beach Lagoon Coastal Zone Management Plan (adopted 12 August 2014)
- Coastal Zone Management Plan for Gosford's Coastal Lagoons (includes Wamberal, Terrigal, Cockrone and Avoca Lagoons), currently in Draft form
- Coastal Zone Management Plan for Brisbane Water (adopted 3 July 2012).
- Avoca Lagoon Floodplain Management Plan (2008)
- Avoca Stormwave Inundation Study (2007)
- Brisbane Water Foreshore Flood Study (2010)
- Cockrone Lagoon Floodplain Management Plan (2008)
- Lower Hawkesbury RiverFlood Study (1997)
- Middle Creek Pearl Beach Floodplain Risk Management Plan (2008)
- Green Point Creek Pearl Beach Floodplain Management Plan (1992)
- Pearl Beach Flooding & Drainage Investigation (1992)
- Pretty Beach Drainage Study – Final Report (2003)
- Turo Creek Pretty Beach Floodplain Management Plan (2007)
- Terrigal Trunk Drainage Study & Plan (1991)
- Terrigal Lagoon Floodplain Management Plan (2001)
- Kahibah Creek Floodplain Management Plan (1996)
- Wamberal Lagoon Floodplain Management Plan (2001).

It is important that the coastal management actions for specific areas are compatible with those actions identified in the existing coastal zone management plans as listed above.

Figure 1: View of the Gosford LGA Coastline

1.2 Coastline Management Process

1.2.1 Catchments and Coast Advisory Committee

Council continues to undertake coastal zone management planning in liaison with its Catchments and Coast (advisory) Committee. The committee membership includes elected councillors, Council staff, NSW Office of Environment & Heritage / NSW State Emergency Service officers and community representatives. Additionally, a coastal sub-committee has been established for the duration of the beaches planning process with beachfront property owners from all embayments included.

The principal role of the Committee is to assist council in the development and implementation of coastal and flood risk management plans for the areas under its jurisdiction. However, the committee also assists in:

- Ensuring that current community values are considered in the development of local floodplain risk and coastal zone management planning;
- Promoting linkages and co-operation between the community, Council, State and Federal Governments, and other key stakeholders in the development and implementation of floodplain and coastal zone management studies and plans;
- Monitoring and assessing effectiveness of the local floodplain and coastal risk management plan after its implementation;
- Identifying the flood, coastal and estuary health problem areas to be assessed and providing input into known hazard behaviour;
- Undertaking duties that include sustainable climate change adaptation actions based upon widely accepted competent scientific opinion and ensuring that these actions are consistent with Council's Climate Change Policy;
- Reviewing and advising Council of appropriate interim development controls for use until the management plan is completed, approved and implemented;
- Supporting and promoting public education and other community focussed programs essential to the long-term viability of the flood and coastal zone risk management plans;
- Supporting, promoting and liaising with relevant authorities in the development of emergency management and catchment management strategies; and
- Assisting Council in advocating on behalf of the community in relation to relevant government plans, strategies and legislation.

1.2.2 Basic Framework

Since late 2009, there have been several legislative changes in NSW and development of guidelines that affect how coastline hazards are managed, as outlined at DECCW (2011).

The basic framework for managing coastline hazards in NSW is through the *NSW Coastal Policy* and *Coastal Protection Act 1979* (OEH 2013). This is implemented through local Councils (with financial and technical support from the NSW Government) undertaking coastline hazard studies and developing coastal zone management plans that are used to inform land-use planning, development controls and coastal activities. These plans and related planning schemes are to contain a range of suitable management strategies indicating how coastal hazards will be dealt with in the particular LGA (or particular area within the LGA), and how individual landowners of properties at risk can and should respond.

Some of the key documents released and legislative amendments made in NSW in recent years include the following:

- *Coastal Risk Management Guide: Incorporating sea level rise benchmarks in coastal risk assessments* (DECCW 2010a), *Flood Risk Management Guide: Incorporating sea level rise benchmarks in flood risk assessments* (DECCW 2010b) and *NSW Coastal Planning Guideline: Adapting to Sea Level Rise* (Department of Planning 2010) in August 2010, *Guidelines for Preparing Coastal Zone Management Plans* (OEH 2013);
- *Coastal Protection and Other Legislation Amendment Act 2010* being passed by NSW Parliament in October 2010, and largely commencing on 1 January 2011[3];
- *Coastal Protection Regulation 2011* commencing on 3 March 2011, which includes additional requirements that support amendments to the *Coastal Protection Act 1979*;
- *Coastal Protection Amendment Act 2012* which commenced on 21 January 2013 and modified the requirements for landowners to place temporary works on their properties; and
- Several guideline documents published by the Office of Environment and Heritage, including the *Code of Practice under the Coastal Protection Act 1979, Guide to the statutory requirements for temporary coastal protection works, Guidelines for preparing coastal zone management plans, Coastal protection service charge guidelines* and *Coastal Erosion Guide*.

1.2.3 Coastal Zone Management Plans

Gosford City Council has been directed by the then NSW Minister for Climate Change and the Environment to complete a Coastal Zone Management Plan (CZMP) for Terrigal/Wamberal Beach.

[3] This Act was repealed with effect on 26 February 2011 as the Acts it amended had commenced.

At the time the Direction was given, Council had commenced the development of a CZMP for all open coast and Broken Bay beaches. The document herein will inform the subsequent CZMP.

Based on Section 55C of the *Coastal Protection Act 1979*, a CZMP must make provision for (among other matters):

1. protecting and preserving beach environments and beach amenity;
2. emergency actions carried out during periods of beach erosion, including the carrying out of related works, such as works for the protection of property affected or likely to be affected by beach erosion, where beach erosion occurs through storm activity or an extreme or irregular event;
3. ensuring continuing and undiminished public access to beaches, headlands and waterways, particularly where public access is threatened or affected by accretion;
4. where the plan relates to a part of the coastline, the management of risks arising from coastal hazards; and,
5. where the plan proposes the construction of coastal protection works (other than temporary coastal protection works[4]) that are to be funded by the Council or a private landowner or both, the proposed arrangements for the adequate maintenance of the works and for managing associated impacts of such works (such as changed or increased beach erosion elsewhere or a restriction of public access to beaches or headlands).

These items are of great importance for Coastal Zone management planning and the recently completed Coastal Process Hazard Definition Study provides the baseline risk assessment investigation to enable Council to meet the provisions as identified within Section 55C of the *Coastal Protection Act 1979*.

As noted in OEH (2013), ten Coastal Management Principles have been developed to inform strategic considerations in coastal management, including the preparation of CZMPs. These principles are:

- **Principle 1 :** Consider the objects of the Coastal Protection Act 1979 and the goals, objectives and principles of the NSW Coastal Policy 1997;
- **Principle 2 :** Optimise links between plans relating to management of the coastal zone;
- **Principle 3 :** Involve the community in decision-making and make coastal information publicly available;

[4] "Temporary coastal protection works" has a specific meaning in relation to the *Coastal Protection Act 1979*, generally being sand or sandbags temporarily placed on a beach to reduce beach erosion impacts. To distinguish this specific meaning from the general meaning of emergency coastal protection works in coastal engineering practice (being any works implemented to limit coastal erosion in an emergency), the specific meaning is denoted as "Part 4c sand/sandbags ECPW" herein in reference to the Section in the *Coastal Protection Act 1979* in which they are described.

- **Principle 4 :** Base decisions on the best available information and reasonable practice; acknowledge the interrelationship between catchment, estuarine and coastal processes; adopt a continuous improvement management approach;
- **Principle 5 :** The priority for public expenditure is public benefit; public expenditure should cost-effectively achieve the best practical long-term outcomes;
- **Principle 6 :** Adopt a risk management approach to managing risks to public safety and assets; adopt a risk management hierarchy involving avoiding risks where feasible and mitigation where risks cannot be reasonably avoided; adopt interim actions to manage high risks while long-term options are implemented;
- **Principle 7 :** Adopt an adaptive risk management approach if risks are expected to increase over time, or to accommodate uncertainty in risk predictions;
- **Principle 8 :** Maintain the condition of high value coastal ecosystems; rehabilitate priority degraded coastal ecosystems;
- **Principle 9 :** Maintain and improve safe public access to beaches and headlands consistent with the goals of the NSW Coastal Policy; and
- **Principle 10 :** Support recreational activities consistent with the goals of the NSW Coastal Policy.

1.3 Scope of this Report

This report summarises the coastal processes and coastal hazard assessment, and assesses the suitability of existing management measures for the study area.

The report describes the following, as proposed in the Guidelines for Preparing Coastal Zone Management Plans (OEH 2013):

- how the relevant Coastal Management Principles have been considered in preparing the various management options;
- how the proposed management options were identified, and the process followed to evaluate management options.
- The outcomes of the evaluation of the management options based on feedback received from the community during the public exhibition process, feedback from the Catchments and Coast Committee and other key stakeholders;
- Priorities and timeframes for potential management options, and options for funding arrangements for all actions, including any private sector funding; and
- Actions that could be implemented through other statutory plans and processes and actions that could be carried out by a public authority or relating to land or other assets it owns or manages (in accordance with section 55C(2) (b) of the *Coastal Protection Act 1979*).

The management options have considered the requirement to achieve a reasonable balance between any conflicting uses of the coastal zone.

It should be noted that the planning horizons to be adopted for the management actions need to be appropriate for different categories of decisions, based upon their economic life and the degree of flexibility. For example, different planning horizons may be appropriate for a Council land use plan, development control over a private residence, design and location of major infrastructure, and planning of recreational areas.

This report has been subject to a community and stakeholder consultation process. Key issues that have been raised during this process will be considered in producing the Coastal Zone Management Plan.

Information included in each report section is listed below:

- **Section 2** outlines the geographical and historical setting of the beaches in the study area as well as the study area values;
- **Section 3** contains a summary of the relevant planning instruments and legislative framework for the study
- **Section 4** contains a summary of the coastal processes in the study area;
- **Section 5** contains a summary of the coastal hazard assessment for the study area;
- **Section 6** outlines the existing management measures and issues in the study area;
- **Section 7** contains an overview of the range of available management options;
- **Section 8** contains a review of issues and specific options for each precinct;
- **Section 9** provides a summary of the public exhibition outcomes and presents a list of specific management actions to be included in a draft Coastal Zone Management Plan; and
- **Section 10** provides a summary of the findings of the report.

1.4 Developing the Gosford Beaches Coastal Zone Management Plan

The process for development of a Coastal Zone Management Plan for the Gosford Beaches is defined by the following phases:

- Undertake **Coastal Risk Assessment** to identify coastal hazards, management issues and their severity;

- Undertake a **Coastal Zone Management Study** to identify and evaluate potential management options to address current and future coastal risk, including climate change (this Study);

- Undertake a **Coastal Zone Management Plan** that proposes management actions in accordance with the management options identified during the Coastal Zone Management Study process and a set timeframe for their implementation;

- **Implementation** of the Coastal Zone Management Plan, whereby actions identified in the Coastal Zone Management Plan are implemented over a 10 – 15 year timeframe.

The phases in the process are described in more detail below.

1.4.1 Undertake Coastal Risk Assessment

A coastal risk assessment has been undertaken to describe the coastal processes and associated hazards that impact the Gosford coastline and provide an assessment of the risks to life and property posed by these hazards. Council endorsed the Open Coast and Broken Bay Beaches Coastal Processes and Hazard Definition Study (CPHDS) report on 25 March 2014.

The risk assessment forms the initial phase of the planning process and applies the latest information (including Council's adopted sea level rise scenarios), modelling and engineering methodologies, to provide an understanding of the coastal processes that operate within the study area. The NSW Government requires that risks need to be assessed with consideration of current and future conditions (2050 and 2100) to include the natural processes that occur on our beaches and the impacts of projected climate changes. The risk assessment examines the coastal processes and hazards that impact the coastline between Patonga and Forresters Beach.

The coastal processes considered within the CPHDS include:

- wave climate;
- elevated water levels;
- wave runup;
- coastal storms;
- sediment transport;
- climate change; and
- lagoon entrance processes.

The coastal hazards discussed, considered and evaluated as part of the risk assessment include:

- beach erosion hazard;
- shoreline recession hazard;
- sand drift hazard;
- coastal inundation hazard;
- stormwater erosion hazard;
- climate change; and
- slope and cliff instability hazard.

1.4.2 Undertake Coastal Zone Management Study (this report)

Having defined the type, nature and significance of coastline hazards, this Coastal Zone Management Study is the next step to be undertaken to identify options relevant to the environmental planning and management of the area.

The Study has considered all feasible management options to address current and future coastal risk (including climate change). It has assessed the social, economic, aesthetic, recreational and ecological issues associated with land use along the coastline.

Assessment of management options has considered the complexities of:

- implications of existing land ownership, future development and planning controls,
- the local economy, including the local employment market,
- the preservation of areas of aesthetic or ecological significance,
- the protection or enhancement of recreational amenity,
- the opportunity for and management of tourism.

A range of management options are identified including, emergency responses such as emergency warnings, evacuation, emergency protection works and barricading dangerous areas to longer term management options including, environmental planning, development control conditions, dune management, beach nourishment and the construction of protective works.

As part of the assessment of management options, the likely advantages, disadvantages, potential environmental, social and economic impacts and indicative costs are considered. Estimates of capital and maintenance costs for protection works are also prepared.

The 'do nothing' option is also considered to assist in undertaking a damages assessment. This is based on the value of coastal property and indicative costs for public infrastructure that would be lost or damaged if management strategies were not adopted.

This Coastal Zone Management Study will assist Council in developing appropriate planning provisions and in applying the criteria for proposed development through revision of the appropriate section of the Development Control Plan.

1.4.3 Prepare Coastal Zone Management Plan

The next stage in the process is to develop a Coastal Zone Management Plan. The primary purpose of coastal management planning is to describe proposed actions to be implemented by Council, other public authorities and potentially by the private sector to address priority management issues in the coastal zone over a defined implementation period. These issues include:

- equitably managing risks to public safety and built assets

- pressures on coastal ecosystems, and
- community uses of the coastal zone.

The planning process aims to ensure an appropriate long term balance in the utilisation and conservation of the coastline. This will facilitate a compatibility of uses with hazards by reducing private and public losses from hazard damage and protect the recreational amenity of beaches. Plans generally include:

- a description of the objectives of the Plan;
- a discussion of issues, problems, special features and values specific to the area of the Plan;
- a schedule of specific management measures aimed at achieving the objectives; and
- a description of the means and timing of implementation of these measures.

The development of the Coastal Zone Management Plan requires that a number of considerations be taken into account, including:

- implications of coastal planning policy and guidelines;
- the type and nature of coastline hazards, including risk and potential damage to coastal developments and amenity;
- aesthetic, recreational and ecological values of Gosford's coastline;
- social factors, including the needs and desires of the community, the social disruption and other intangible costs of potential damage, and the physical and psychological effects of damage;
- long term considerations of climate change; and
- an economic analysis of proposed or existing development, including expected costs and benefits to both the public and private based on options to develop, redevelop or leave undeveloped an area of the coast.

Upon finalisation of the CZMP Council will review and update the relevant section(s) of the Gosford LEP (2014) and Development Control Plan (2013).

1.4.4 Implement Coastal Zone Management Plan

Once a Coastal Zone Management Plan has been adopted, the next step is to implement (within a 10 – 15 year timeframe) the management measures listed within the Plan. Certain measures can be implemented quickly, such as development and building controls, hazard education, public awareness and dune management programs. However, it is unlikely that any management plan could be implemented immediately in its entirety. For example, availability of funding will determine when certain options can be implemented (e.g. structural measures, voluntary purchase of property). Consequently, a strategy needs to be developed to implement the Plan over time. The strategy should include the staging of measures that are dependent on availability of funds, the adoption of interim measures, protection priorities, etc.

Relevant time periods will include the long-term planning horizon (e.g. 50 to 100 years to set strategic directions for coastal hazard areas), the period for implementing proposed management actions (e.g. 5 to 10 years) and the period for reviewing the CZMP (e.g. towards the end of the implementation period). The timeframe to be adopted should reflect the appropriate planning horizons based upon the economic life and the degree of flexibility associated with a particular coastal management issue. For example, the Australian Tax Office allows the entire construction cost of a residential rental property to be deducted over a period of 40 years. From this, it can be inferred that the economic life of a dwelling is 40 years. Based on this, the 2050 planning horizon may be an appropriate planning horizon to adopt for new residential developments.

2 STUDY AREA

This section of the report describes the attributes of the study area, including the community profile, physical attributes, and the values of the study area including cultural heritage, ecological values, social and economic values.

Gosford's beaches and the developments along them are of major social, environmental and economic importance to the Gosford local government area. Both natural and built coastal assets are under increasing pressure from a growing population.

The values of the study area include indigenous and non-indigenous heritage, ecological, economic and community values. The values of the natural environment are a paramount consideration in the sustainable management of the coastline and need to be considered and understood when devising coastal zone management options at each beach. These values also need to be factored into the assessment of the various coastal management options.

2.1 Community Profile

Gosford City is located in the Central Coast region of NSW, around 80 km south of Newcastle and 80 km north of Sydney. The northern coastal areas of Gosford LGA are highly urbanised, whereas the southern areas are largely natural in character, including Bouddi National Park and the villages of Patonga, Pearl Beach and Killcare. A large proportion of Gosford's population lives in the coastal areas of the Gosford LGA, including over 16,000 people in Umina, 8,000 people in the area around Avoca, MacMasters and Copacabana and 21,000 people in Terrigal, Wamberal and Forresters Beach (Gosford Community Profile, http://profile.id.com.au/gosford?WebID=150).

Gosford has a higher average age than the average for NSW, and a higher proportion of older couples without children (over 65 years of age) than the NSW average. The coastal areas of Gosford LGA are projected to increase in population from between 8 – 12% between 2014 and 2036 (Gosford Community Profile, http://profile.id.com.au/gosford?WebID=150). Coastal population densities are highest in Terrigal and Umina with an average density of 20 -25 persons per hectare, with lower population densities in Pearl Beach, Patonga and Killcare with average densities of around 5 persons per hectare (Gosford Community Profile, http://profile.id.com.au/gosford?WebID=150). Median ages are over 50 in Pearl Beach, Patonga and Killcare, but under 40 in Umina, Terrigal and Wamberal. Most of the dwellings in the study area are separate houses, except in Terrigal and Umina where most housing is medium density development (Gosford Community Profile, http://profile.id.com.au/gosford?WebID=150).

2.2 Study Area Physical Description

The study area is bounded by 14km of coastal beaches extending from Patonga (within Broken Bay) in the south to Forresters Beach on the open coast in the north. The study area is shown in **Figure 1**. The study area extends in both the seaward and landward directions from the shoreline to the limit of the active coastal processes operating at present, and in the future over a planning period of up to 100 years. Each beach within the study area is described briefly below (extracts from Short 2007). Beaches are listed from south to north.

Patonga Beach *– occupies part of the 1km wide mouth of Patonga Creek at Brisk Bay. It forms a curving south to southeast-facing beach backed by a low 200-400m wide sandy barrier then the creek and mangroves of Woody Glen Swamp. The beach is 1.4km long and looks out across Broken Bay, receiving only low swell and local wind waves at the shore. These maintain a relatively steep, narrow high tide beach, fronted by deeper water in the centre. Tidal sand shoals front a smaller creek that crosses the eastern end of the beach; and there are larger shoals at the western entrance to Patonga Creek. Only during very large outside swell do ocean waves reach the beach.*

Pearl Beach *– curves for 1.1km to the south where it faces north in behind Green Point. The beach is backed by a low dune area locked in by high valley sides. The beach faces the east, however all waves must pass through Broken Bay entrance and travel 3km into the bay to reach the beach. This results in waves averaging 0.5m at the northern end, dropping in height to the southern corner. Because of the low average waves and coarse sands the beach is always steep and reflective, with deep water off the shore. High east and southeast swell which periodically reach the beach result in a strong and dangerous shorebreak.*

Umina Beach *– occupies the western 1.2km of Ocean-Umina beach. The waves, clear of the tidal delta initially increase slightly in size to average about 1m, then decrease into the western corner, where the beach turns to face east, and Ettalong creek drains across the beach. Along this section the bars remain low and wide, but rips are more common and stronger when the waves are breaking.*

Ocean Beach *– commences at Wagstaff Point, sand entrance to Brisbane Water, and trends west for 1.3km. It is sheltered by Box Head and the tidal delta with usually low waves along the shore, and a reflective beach in lee of the shallow shoals. However waves breaking over the shoals can generate rip currents together with tidal currents flowing out of Brisbane Water.*

Putty-Killcare Beach *– a slightly curving 1.6km long southeast-facing beach, located between prominent 70m high sandstone headlands, the eastern third of which is the national park, while the densely vegetated slopes behind the western end rise to 130m. The beach is well exposed to southerly waves which increase in size towards the western surf club end of the beach. The eastern end usually has an attached bar which continues to the western end at Killcare surf club. Here higher waves and rips are more common, with up to eight rips forming along the beach, including a permanent rip against the western rocks, where there is also a small rock pool.*

Copacabana-MacMasters Beach *– occupies a 1.4km wide southeast-facing embayment bordered by the prominent sandstone 110m high Tudibaring Head in the north and 90m high Second Point in the south. The beach faces the east-southeast and receives waves that average 1.5m at Copacabana, decreasing to about 1m at MacMasters. These maintain a single bar, which is usually attached along the beach, but cut by 6-8 rips, which decrease in size and intensity to the* *south, often infilling at MacMasters forming a continuous, attached bar. A strong permanent rip runs out along the northern head, and during high seas a similar rip is formed against the southern head, particularly during summer northeast waves. Cockrone Lagoon backs the centre of the beach and is mechanically opened once lagoons levels reach the identified trigger level of 2.53m AHD.*

***North Avoca & Avoca Beach** – the 1.7km long beach lies between two prominent 60m high sandstone headlands and faces the east-southeast exposing it to waves averaging 1.5m. Avoca Lake backs the centre of the beach and is mechanically opened once lagoons waters reach an identified trigger level of 2.09m AHD. The beach receives higher waves towards the north and centre where the bar is often detached and usually cut by several rips, including a permanent rip against the northern headland. At Avoca slight protection by the southern headland lowers waves in the southern corner to form a continuous, attached bar. However rips are frequent and a permanent rip runs out against the southern rocks.*

***Terrigal-Wamberal Beach** – is a 2.8km long stretch of sand that trends southwest from the rocks on the north side of Wamberal Lagoon entrance south to Terrigal Lagoon entrance where the beach begins to curve around to the southeast to terminate at the rocks on the southern end of Terrigal Beach, in lee of Broken Head. The beach blocks the entrances to two drowned valleys, now occupied by Wamberal and Terrigal lagoons, which only open during heavy rain. Terrigal and Wamberal Lagoons back the beach and are mechanically opened once lagoons waters reach an identified trigger level of 1.23m AHD. The beach berm is maintained at a height of 1.7m AHD to minimise response times in lagoon opening events (and potential foreshore flooding).*

The northern 1.5km of Wamberal Beach lies in the Wamberal Lagoon Nature Reserve. The foredune between Wamberal and Terrigal lagoons has been developed for beachfront housing. The elevation of the section of dune ranges from 8-12m AHD. Immediately south of the Terrigal Lagoon mouth, is a rocky bluff which rises to 15 m AHD elevation on the cliff face. A low dune backs the 700m long Terrigal Beach with the foreshore protected by an engineered seawall.

The northern Wamberal Beach is well exposed with waves averaging 1.5m and up to 15 rips dominating the surf zone. As wave height drops to the south the rips decrease in size, with often a continuous bar forming along Terrigal Beach.

***Forresters Beach** – a 1.5km long, southeast-facing sandy beach located along the base of vegetated bluffs rising to 100m. It is bordered by 130m high Cromarity Hill in the north and Wamberal Point to the south. The entire beach is fronted by extensive rocks and reefs, which abut the shore in the north extending 250m offshore in the south. Wave breaking occurs on the reefs, with lower waves occurring at the shore to less than 1m, maintaining a narrow, steep, reflective beach.*

2.3 Historical Setting

2.3.1 General

According to the Central Coast NSW website (2010), the first European settlement of the Gosford district began in the 1820s, with most development occurring in the eastern or coastal sector. Early industry mainly consisted of timber-getting, lime burning, shipbuilding, grazing and citrus orchards. Transport improvements, including construction of the railway network by 1887 and the Pacific Highway in 1930, resulted in a steady increase in urbanisation and transformed the region from a rural community prior to World War II, to that of a city containing some secondary and service industries related to the tourist trade.

Some relevant historical features of each beach in the study area are provided in the following sections.

2.3.2 Patonga Beach

A photograph of Patonga Beach taken in the 1920s is provided in **Figure 2**[5], which shows several properties located along the relatively flat frontal dune. Patterson Britton & Partners (1998) notes that in the late 1960s the outlet to Patonga Creek meandered to the north eroding into the caravan park. Council constructed a training wall on the northern side of the entrance in 1969/70 to direct flows further to the south, while another wall was constructed in 1971 immediately upstream of the training wall to prevent erosion in this area. Sand accreted against the northern side of the training wall until sand bypassing was re-established in the 1990s.

[5] Sourced from Gosford City Council Online Photo Archives, http://photosau.com/gosford/scripts/home.asp (accessed 27/1/12) File 002\002540.

Figure 2: Patonga Beach in the 1920s

2.3.3 Pearl Beach

Despite being first accessed by Europeans in March 1788 when Governor Phillip rowed ashore, Pearl Beach remained unsettled until 1921 when the Rock Davis Estate was bought by real estate developer Charles Staples, who subdivided it into 570 blocks and cut a road below Mt Ettalong (O'Brien 2009). Short (2007) notes that this road was replaced by the existing over the hill route when high seas destroyed part of the lower road. A photograph of Pearl Beach taken in the 1930s is provided in **Figure 3**[6], which shows several properties located along a reasonably well vegetated dune towards the northern end of the beach around Coral Crescent. Development at Pearl Beach has increased rapidly in recent times, with the number of dwellings rising from 90 in 1950 to around 600 today (O'Brien 2009).

[6] Sourced from Gosford City Council Online Photo Archives, http://photosau.com/gosford/scripts/home.asp (accessed 27/1/12) File 002\002458.

Figure 3: Pearl Beach in the 1930s or 1940s

2.3.4 Ocean-Umina Beach

The formation of Ocean-Umina Beach over the previous 9,000 years as part of the Woy Woy beach ridge barrier is discussed in Appendix D of the Coastal Processes and Hazard Definition Study (WorleyParsons 2014). A photograph of Ocean-Umina Beach taken in the 1920s is provided in **Figure 4**[7], which shows a reasonably wide sandy beach rising to a lightly vegetated foredune. The Surf Lifesaving Clubs at Ocean Beach and Umina Beach were formed in 1921 and 1958 respectively (Short 2007). The construction of a groyne at Ettalong Point following erosion in 1973 has likely enhanced the permanency of accreted sand at the northern end of Ocean Beach (Patterson Britton & Partners 1998). At the southern end of the beach between Mt Ettalong and the Ettalong Creek entrance, it is understood that rock protection has been placed on the seaward side of the road during severe storm erosion events (PBP 1998).

[7] Sourced from Gosford City Council Online Photo Archives, http://photosau.com/gosford/scripts/home.asp (accessed 27/1/12) File 002\002406.

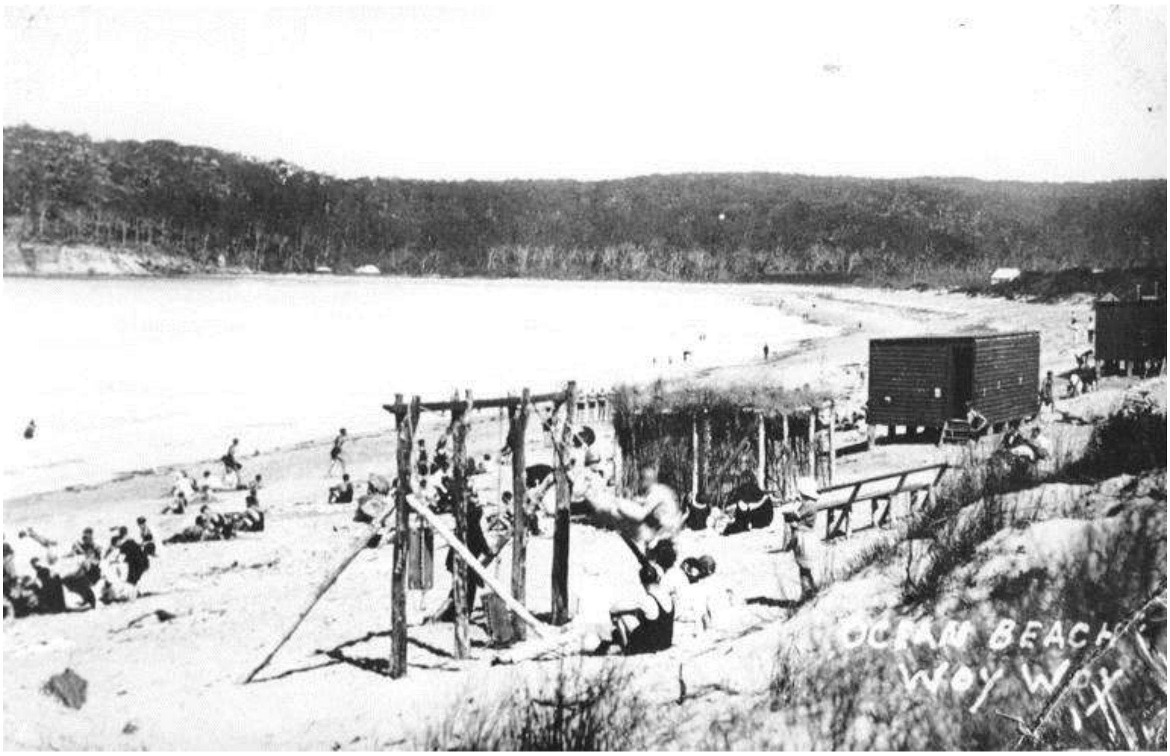

Figure 4: Ocean-Umina Beach in the 1920s

2.3.5 Putty-Killcare Beach

Killcare Surf Lifesaving Club was formed in 1932 (Short 2007). Sand mining of the frontal dune at Putty-Killcare Beach was undertaken during the late 1950s and 1960s (PBP 1998). The frontal dune was extensively lowered as a result, although subsequent revegetation efforts have succeeded in mitigating previous windblown sand losses (PBP 1998). This is discussed further in Appendix E of the Coastal Processes and Hazard Definition Study (WorleyParsons 2014).

2.3.6 MacMasters-Copacabana Beach

MacMasters Beach was occupied by the MacMaster family from the 1840s, although development progressed rapidly from 1927 onwards when Banavie Estate was subdivided, including beachfront property on Marine Parade (Gosford City Council Website 2012). Copacabana was known previously as Tudibaring (an Aboriginal word meaning "where the waves pound like a beating heart") until it was subdivided in 1954 and the northern side of Cockrone Lake was subsequently opened up (CentralCoastAustralia.com 2012). Development of MacMasters Beach and Copacabana has occurred rapidly since the 1950s. Short (2007) notes that the Surf Life Saving Clubs at MacMasters Beach and Copacabana Beach were formed in 1946 and 1963 respectively.

2.3.7 Avoca Beach

Avoca Beach became accessible to the public in 1908 when the first bridge was built across Avoca Lake and the Avoca Guest House was constructed at what was then called Moore's Beach (Short 2007). A view of Avoca Beach in around 1926 is provided in **Figure 5**, sourced from the National Library of Australia. Evident in this photograph is a wide sandy beach in front of a densely vegetated foredune which is now occupied predominantly by residential development. Further, the photograph of Avoca Beach taken in 1948 (**Figure 6**) generally indicates that development at North Avoca did not commence until the latter half of the 20th Century, while some development had occurred at Avoca at this time. The Surf Lifesaving Clubs at Avoca and North Avoca were formed in 1929 and 1957 respectively (Short 2007).

Figure 5: Avoca Beach in around 1926

Figure 6: Avoca Beach in 1948
(photo courtesy Gosford City Council)

2.3.8 Terrigal-Wamberal Beach

Photographs of Wamberal and Terrigal beaches taken in the early 1900s are presented in **Figure 7**[8] and **Figure 8**[9] respectively. The photograph of Wamberal Beach (**Figure 7**) provides evidence of a fairly prominent erosion scarp at the interface of the beach and densely vegetated foredune. Much of this area is currently occupied by residential development along Ocean View Drive and Pacific Street. The photograph of Terrigal Beach (**Figure 8**) displays a lightly vegetated incipient dune system along much of the beach, which is generally non-existent today.

Short (2007) notes that the Surf Life Saving Clubs at Terrigal and Wamberal were formed in 1924 and 1950 respectively.

[8] Sourced from State Library of NSW PICMAN database, Digital Order No a106273.
[9] Sourced from State Library of NSW PICMAN database, Digital Order No a106285.

Figure 7: Wamberal Beach in the early 1900s

Figure 8: Terrigal Beach in the early 1900s

The seawall behind Terrigal Beach protects popular recreational amenity and the local business district. Photographs of Terrigal Beach taken in the 1940s, 1988 and 2011 are provided in **Figure 9**, **Figure 10** and **Figure 11**, which show various states of the seawall over time, while it is also noted from observation of a photograph taken in 1972 that a seawall was not present at this time. It can be seen that the seawall was initially positioned further seaward at the southern end, while the photographs taken in 1988 and 1999 show the change from a timber wall to the existing sandstone block seawall.

Figure 9: Terrigal Seawall in the 1940s
(photo courtesy Gosford City Council)

Figure 10: Terrigal Beach in 1988 showing timber seawall
(Source: MHL 2003)

Figure 11: Construction of the sandstone block seawall at Terrigal Beach, December 1999
(photo courtesy Gosford City Council)

2.3.9 Forresters Beach

Beachfront property development at Forresters Beach did not commence until the 1950s (PWD 1994). Extensive subdivision of the top dune, south headland and immediately behind the dune occurred in the 1960s, which involved levelling the top of the dune and pushing a significant volume of sand seaward, completely altering the dune alignment and shape (PWD 1994). This is discussed further in Appendix I of the Coastal Processes and Hazard Definition Study (WorleyParsons 2014).

2.4 Study Area Values

Gosford's beaches and the developments along them are of major social, environmental and economic importance to the Gosford local government area. Both natural and built coastal assets are under increasing pressure from a growing population. The NSW Central Coast already experiences severe storms caused by low pressure systems such as East Coast Lows which can adversely impact the coastal areas. The impacts of these storm events will be exacerbated by climate-induced sea level rise and the projected changes to coastal processes.

There is a need to better understand how much these assets are worth to society and how they might be at risk from current and future pressures. In considering the costs associated with implementing coastal management options it is important to consider what the partial or total loss of beaches would mean for tourism and recreation, the local property market, beach users and the environment.

By better understanding the social, economic and environmental values of our coastline, we can more easily determine whether the cost of protecting our coastline outweighs the value or more particularly what management options are appropriate.

The values of the study area, including heritage, ecological, economic and community values are explored below.

2.4.1 Cultural Heritage

2.4.1.1 Indigenous Heritage

The local indigenous people in the study area are the Guringai (Kuringgai) and Darkinjung people. The Guringai country stretched from the north side of Sydney Harbour, north through Pittwater and Brisbane Water, to the southern end of Lake Macquarie.

The Aboriginal groups relevant to the study area include the Guringai Tribal Link Aboriginal Corporation and the Darkinjun Local Aboriginal Land Council (Darkinjung Local Aboriginal Land Council, 2014; Guringai Tribal Link Aboriginal Corporation, 2014).

The most common Aboriginal sites that exist in the Hunter-Central Rivers region are:

- shell middens;
- scarred and carved trees;
- surface scatters, stone artefacts, stone arrangements and open sites;
- Aboriginal burial sites;
- axe grinding grooves;
- rock art; and
- natural sacred sites.

A search of the Aboriginal Heritage Information System (AHIMS) indicated the following number of Aboriginal sites recorded in the vicinity of each beach:

- 2 Aboriginal sites recorded in or near Patonga Beach;
- 0 Aboriginal sites recorded in or near Pearl Beach;
- 2 Aboriginal sites recorded in or near Ocean-Umina Beach;
- 6 Aboriginal sites recorded in or near Putty-Killcare Beach;
- 3 Aboriginal sites recorded in or near MacMasters Beach;

- 2 Aboriginal sites recorded in or near Avoca Beach; and
- 10 Aboriginal sites recorded in or near Terrigal-Wamberal Beach and Forresters Beach.

The Aboriginal sites at Wamberal Beach include middens located at Spoon Bay and two burial sites at Wamberal Beach (NSW National Parks and Wildlife Service, 1993)

2.4.1.2 Non-Indigenous Heritage

The *Gosford Local Environment Plan (LEP) 2014* environmental heritage list (Schedule 5) lists the heritage items in **Table** 1 as being of local significance within the study area. None of the heritage conservation areas and archaeological sites listed in the LEP is located within the study area.

In addition to those items in **Table** 1, a search on the NSW Environment & Heritage's State Heritage Inventory indicated Bimbadeen (Dunromin) located on Helen Drive, Copacabana, has local significance and is recommended for inclusion on the LEP.

A search for the Maritime Heritage Sites on the NSW Environment & Heritage website indicated there are 20 records in the vicinity and offshore of the study area, as provided in **Table** 2. However, only 6 of the 20 records have been found. These sites are protected under the Historic Shipwrecks Act 1976.

Table 1 Heritage Items in the Study Area Listed in Gosford LEP 2014

Suburb	Item Name	Address	Property Description	Item Number
MacMasters Beach	Grave of Allan MacMasters	Corribeg Reserve, Tudibaring Parade	Lots 7–10, DP 12921	104
Patonga	Seven houses	Dark Corner	Lot 7307, DP 1159203	130
Patonga	Remains of Patonga Store	8 Patonga Drive	Lot 5, DP 23839	131
Patonga	War memorial	Intersection of Patonga Drive, Bay Street and Jacaranda Avenue	Road reserve	132
Pearl Beach	Roadworks, old Pearl Beach Road	Base of Mount Ettalong, off Coral Crescent	Adjacent to Lot 7039, DP 1066789	133
Pearl Beach	House, "Yamba"	13 Crystal Avenue	Lot 480, DP 14592	134
Pearl Beach	Pearl Beach Hall and memorial	9 Diamond Road	Lot 324, DP 14592	135
Terrigal	Old post office	4 Ash Street	Lot 28, DP 7914	162
Terrigal	House, "The Gunyah"	168 Terrigal Drive	Lot B, DP 347541	163

Suburb	Item Name	Address	Property Description	Item Number
Terrigal	War memorial	Terrigal Beach Foreshore, Terrigal Esplanade		165

Table 2 Maritime heritage sites

Site title	Date Lost	Type	Region	Where Lost	Found
Barangaroo	1933/01/04	Hulk	Central Coast	Off Terrigal	No
Commonwealth	1916/08/19	Steamer screw	Central Coast	Terrigal, NE of, at Foggy Reef	Yes
Fifeshire	1886/05/23	Steamer screw	Central Coast	Terrigal, Moores Beach	No
Friend	1860	Cutter	Central Coast	Terrigal Head	No
Galava	1927/02/09	Steamer screw	Central Coast	Terrigal, 3 mls east, bombora	Yes
Gitana	1857/09/05	Ketch	Central Coast	Terrigal Harbour	No
Juno	1879/04/26	Ketch	Central Coast	Terrigal, 5-6 mls east	No
Kathleen	1867/12/04	Barquentine	Central Coast	Terrigal & Norah Hd, Halfway between, ashore	No
Lord Ashley	1877/09/08	Steamer screw	Central Coast	Terrigal Reef (lies in about 8m of water)	Yes
Maud Weston	1904/11/10	Steamer screw	Central Coast	Terrigal Head, near	No
Rainbow	1857/06/17	Ketch	Central Coast	Terrigal (Fenigal), ashore	No
Rose	1852	Schooner	Central Coast	Terrigal Beach?	No (refloated)
Sir Robert Peel	1847/01/18	Ship	Central Coast	Terrigal, near, at Avoca Bay	No
Surprise	1891/01/29	Schooner	Central Coast	Terrigal, 10 miles east of	No
Tamar	1873/01/11	Steamer paddle	Central Coast	Terrigal, Norah Harbour, on nearby beach	Yes
The Pathfinder	1934/04/09	Motor Vessel	Central Coast	Terrigal, 1.5 miles east of	No
Union	1848/07	Ketch	Central Coast	Terrigal, near, at Avoca Bay	Yes
Wave	1868/02	Brig	Central Coast	Terrigal, 3 miles north of, ashore	No

Site title	Date Lost	Type	Region	Where Lost	Found
William and Alexander	1892/08/21	Ketch	Central Coast	Terrigal Beach after being abandoned	No
Yambacoona	1917/02/24	Steamer screw	Central Coast	Terrigal, off Broken Head	Yes

2.4.2 Ecological Values

The value of the natural environment is also a paramount consideration in the sustainable management of the coastline. While beaches may appear barren and largely devoid of life, they support a great diversity of flora and fauna and provide habitat and nursery ground for many coastal and estuarine species. Moreover, sandy beaches are an important ecosystem that links the ecology of sand dunes, the surf zone, intertidal zones, and nearby rocky reefs. Sand dunes also exhibit high biodiversity value and protect our developments during storms.

Several natural coastal and marine ecosystems are at risk from human use and coastal hazards now and into the future. They are impacted through landward migration and erosion, recreational activities (i.e. fishing, harvesting), coastal development and construction of protective works, beach cleaning and nourishment.

The study area is within the Sydney Basin Bioregion which is one of the most species-diverse regions in Australia due to the rock types, topography and climate (OEH, 2014).

2.4.2.1 Coastal Vegetation

The dunes of the bioregion generally support coast banksias, coast wattle, coast tea-tree, smooth-barked apple (*Angophora costata*), red bloodwood (*Corymbia gummifera*) and blackbutt (*Eucalyptus pilularis*) with a diverse scrub layer. The oldest dunes which are protected by coastal barriers such as bluff and headlands support a mature coastal forest community (OEH, 2014).

Coastal forest of the bioregion are characterised by Sydney blue gum (*Eucalyptus saligna*), blackbutt, turpentine, grey ironbark (*Eucalyptus paniculata*), spotted gum, black ash and bangalay (*Eucalyptus botryoides*) (OEH, 2014).

A search was undertaken on the Gosford City Council's Gosford Electronic Mapping System for vegetation classification, and significant and endangered vegetation within the Gosford LGA. A summary of the endangered ecological communities and regional significant vegetation within or near the study area is provided in **Table 3**. The endangered ecological communities of Umina Sands Coastal Woodland, Coastal Sand Swamp Forest, Coastal Headland Grassland and other forest and wetland vegetation occurred in a number of locations within or near the study area. Regional significant vegetation such as coastal sand foreshore scrub, coastal sand banksia scrub, coastal headland shrubland and coastal headland low forest are found at most of the beaches.

The species recorded in the Sydney Basin Bioregion includes 2 endangered and 4 vulnerable frog species, 54 vulnerable and 14 endangered bird species, 25 vulnerable, 3 endangered and one extinct mammal species, and 11 vulnerable and 2 endangered reptile species (OEH, 2014).

There are several parks and a nature reserve also within and in the vicinity of the study area and these include:

- Brisbane Water National Park;
- Bouddi National Park;
- Wamberal Lagoon Nature Reserve; and
- Wyrrabalong National Park.

Brisbane Water Estuary, Cockrone Lagoon and Avoca Lake are Nationally Important Wetlands. There are estuarine habitats such as seagrass, saltmarsh and mangroves within these wetlands. Areas within Wamberal, Terrigal, Avoca and Cockrone Lagoons are also protected under the *State Environmental Planning Policy (SEPP) 14 – Coastal Wetlands,* but these areas are outside the study area.

Bareena Lagoon near the study area is bioregionally significant and provides key habitat for the endangered green and golden bell frog (Australian Terrestrial Biodiversity Assessment, 2002).

Table 3 - Summary of endangered ecological communities and regional significant vegetation within or near the study area

Vegetation Classification		Location
Reference	**Description**	
Endangered Ecological Communities		
E4	Coastal Sand Littoral Rainforest	Avoca Beach
E15bi	Wagstaff Spotted Gum Ironbark Forest	Pearl Beach
E22ai	Narrabeen Coastal Blackbutt Forest	Avoca Beach
E25	Hawkesbury Peppermint Apple Forest	Pearl Beach
E33bi	Umina Sands Coastal Woodland	Patonga, Pearl Beach, Umina-Ocean Beach
E33bii	Umina Sands Coastal Woodland – Avoca Copacabana variant	Avoca Beach, Terrigal-Wamberal Beach
E37ei	Coastal Sand Swamp Forest	Pearl Beach, Umina-Ocean Beach, MacMasters-Copacabana, Avoca Beach, Terrigal-Wamberal Beach
E37eii	Coastal Sand Swamp Forest – Cabbage Palm variant	Umina-Ocean Beach
E40a	Phragmites Rushland	Putty-Killcare Beach, Avoca Beach
E40i	Estuarine Swamp Oak Forest	Terrigal-Wamberal Beach
E43ai	Estuarine Paperbark Scrub Forest	Terrigal-Wamberal Beach
E46a	Freshwater Typha Wetland	Umina-Ocean Beach
E51a	Coastal Headland Grassland	Putty-Killcare Beach, Forresters Beach
Regional Significant Vegetation		
E34ai	Coastal Sand Wallum – Heath	MacMasters-Copacabana Beach, Forresters Beach
E40b	Estuarine Baumea Sedgeland	Terrigal-Wamberal Beach

Vegetation Classification		Location
Reference	Description	
E50a	Coastal Sand Foreshore Scrub	Pearl Beach, Umina-Ocean Beach, MacMasters-Copacabana Beach, Avoca Beach, Terrigal-Wamberal Beach, Forresters Beach
E50b	Coastal Sand Banksia Scrub	Patonga Beach, MacMasters-Copacabana Beach, Terrigal-Wamberal Beach, Forresters Beach
E51b	Coastal Headland Shrubland	Pearl Beach, Umina-Ocean Beach, Avoca Beach, Terrigal-Wamberal Beach, Forresters Beach
E51c	Coastal Headland Low Forest	Patonga Beach, Umina-Ocean Beach, Avoca Beach, Terrigal –Wamberal Beach, Forresters Beach
E53	Coastal sand beach spinifex	Patonga Beach

Coastal vegetation at each of the beaches has been mapped by Council and is provided in Appendix 1, to help guide dune management and revegetation activities. A search for threatened flora species was undertaken within the Wyong CMA sub-region using the on-line search tool on OEH's website and the endangered flora species described below were found to occur.

The dune habitats within the study area are home to several endangered flora species, including *Chamaesyce psammogeton* (Sand Spurge), which has been recorded in the Wamberal Lagoon Nature Reserve (i.e. north of the Wamberal Lagoon entrance along Wamberal Beach). Sand Spurge is a herb that forms mats to 1 m across. It grows on dunes and sea strandlines. This species grows on fore-dunes, pebbly strandlines and exposed headlands, often with Spinifex (Spinifex sericeus) and Prickly Couch (Zoysia macrantha). Sand Spurge seeds float, so some dispersal between beaches may occur.

Other endangered flora species known to occur in the study region include *Senecio spathulatus* (Coast Groundsel) which grows on frontal dunes.

OEH (2014) recommends the following activities to assist these species:

- searches should be conducted in suitable habitat for proposed developments and activities affecting dunes.
- Prohibit vehicle access in known or suspected habitat.
- Position beach access tracks away from sites and fence off populations if required.
- Undertake Bitou Bush control in known or suspected habitat.
- Monitor known populations to investigate population fluctuations and reasons for decline.

An endangered ecological community, the *Umina Coastal Sandplain Woodland,* is largely restricted to coastal sands on the Umina, Woy Woy and Ettalong Sandplain within the study area. It is estimated that less than 10% (being less than 10 hectares) of the community's estimated original cover of about 80 hectares remains. This comprises four main remnants at Umina, while a few smaller remnant patches and scattered trees around Pearl Beach and Patonga and elsewhere on the 'Peninsula' indicate its former distribution (OEH 2014).

The sand dunes along the beaches of Gosford vary in width and condition and have undergone significant erosion in many areas, especially where residential or other development occurs directly on the dune. However, there are still undeveloped areas which contain native dune vegetation which will provide important coastal habitat for a diverse range of fauna including invertebrates (e.g. worms, insects and crabs), reptiles (e.g. skinks, snakes and goannas), birds (e.g. shorebirds) and mammals (DLWC 2001). Dune vegetation is recognised widely as an “integrated botanical system exhibiting interdependence in both community structure and floristics and providing food and shelter for a variety of fauna” (DLWC 2001).

Native coastal dune vegetation is highly adapted to withstand the harsh salt laden winds and sand drift which are typical of coastal beach environments. For example, growth of some plants such as Spinifex (*Spinifex sericeus*) and Beach Fescue (*Austrofestuca littoralis*) is stimulated by sand accretion, while others such as Coastal Wattle (*Acacia sophorae*) can withstand slow, partial burial by developing roots on buried branches (DLWC 2001). The low nutrient levels of dune soils have also led to other adaptations. For example, plant leaves are very efficient collectors of salt spray. Coastal Banksia (*Banksia integrifolia*) has masses of fine proteoid roots that are efficient in collecting phosphorus, while Coastal Beard Heath (*Leucopogon parviflorus*) has bacteria growing in its root area that serve the same purpose.

Where significant human disturbance is absent, distinctive zonation of plants in the dune system may be observed, reflecting the increasingly protected / sheltered environment which is created with increasing distance from the shoreline. Three plant zones are usually recognised, extending landward from the backbeach: primary, secondary and tertiary. Primary zone species (grasses and creepers) colonise lower parts of the beach and trap abrasive sand particles forming a “foundation’’. Transient beach vegetation is generally dominated by grasses (e.g. Spinifex sericus and Festuca littoralis) which aid in the creation of incipient foredunes. The foredune represents an elevated “wall” that can be colonised by secondary zone species (semi-permanent populations of herbs, shrubs and trees) to provide a wind deflecting “shutter” near the shoreline. These stabilise the foredune sand mass. Finally a “roof” forms from the growth of tertiary species (taller shrubs and trees), further elevating the wind and providing increased shelter to vegetation further inland. When exposed to persistently strong, salt-laden winds, remarkably streamlined canopy surfaces often develop (DLWC 2001) (Figure 12).

It is essential to consider the surf zone, intertidal beach, dunefield and land behind the dunes as a single system (Brown and McLachlan 2002). As normal exchanges of sand between beaches and dunes and also along shore need to be maintained, only structures that are deemed to be economically essential should be considered for construction on beach and dune systems (Brown and McLachlan 2002).

Several exotic weed species are present also along Gosford’s beaches. These include bitou bush at Forresters Beach, the Sea Holly, Asparagus Fern and Small Matweed at Wamberal and Yellow Bignonia at MacMasters Beach.

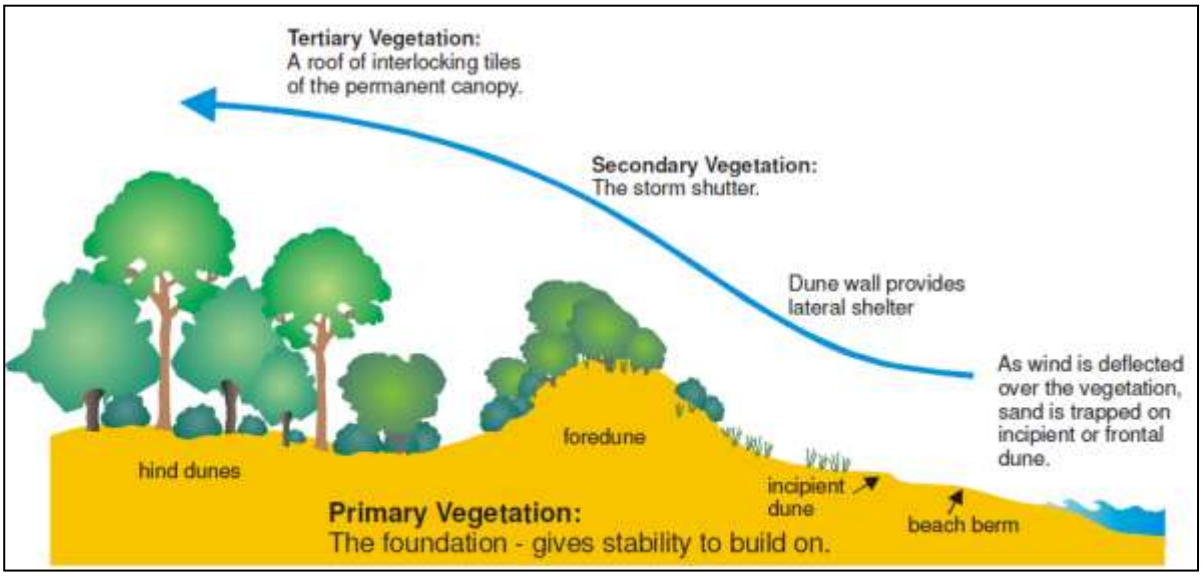

Figure 12 – Typical zonation of dune vegetation (DLWC 2001).

2.4.2.2 Sandy Beach Habitats

Sandy shores cover approximately 55 - 60% of the NSW coastline and there around 700 individual beaches in the State (Short 1993). Sandy beach ecosystems have unique physical and ecological attributes. They are found where the rate of sediment supply exceeds the rates of removal. Sandy beaches are closely linked to surf zones and coastal dune systems through the storage, transport and exchange of sand. Therefore, impacts on beaches have consequences for these adjacent habitats (Komar 1998). In addition to sediments, beaches and dunes exchange a variety of organic materials, and animals from both habitats may move across the dune / beach interface to feed (Defeo *et al.* 2009).

Sandy beach habitats do not generally support floral communities due to a lack of attachment surfaces for plants. Sandy beach flora is therefore limited to microscopic diatoms which live attached to the surface of sand grains. Terrestrial dune vegetation often fringes sandy beach ecosystems as is present in the study area.

Intertidal areas of sandy beaches provide a unique habitat for a wide diversity of meiofauna and macrofauna. Bacteria, protozoans, microalgae and meiofauna inhabit the small areas between sand grains, forming a distinct food web. Larger macroinvertebrate fauna (i.e. infauna), dominated by crustaceans (e.g. sand bubbler crabs, soldier crabs, ghost crabs), bivalve and gastropod molluscs (e.g. pippis, moon snails) and polychaete worms burrow actively in this zone, and can reach high abundances and biomass, particularly in dissipative to intermediate beach types in temperate zones (Defeo *et al.* 2009). Evidence of burrowing macrofauna can often be seen along the beach berms within the study area (Figure 13). The distribution and abundance of fauna in intertidal zones of Australian beach ecosystems may be strongly influenced by position (i.e. across shore or along shore) and is strongly influenced by tidal level and exposure to wave action. In a study of macrofaunal community structure of beaches in northern NSW, Hacking (1998) found that the community composition of ten exposed sandy beaches in this region appeared to correlate with beach morphodynamic state. Seaward of the high tide mark and into the surf zone zooplankton, shrimps and prawns may be abundant (Defeo *et al.* 2009). Surf zones are also important nursery and foraging areas for fishes (Defeo *et al.* 2009).

Figure 13 - Evidence of burrowing macrofauna on a sandy beach

Areas of accumulated wrack are often present along Gosford's beaches (Figure 14). Wrack has been defined as "*organic material such as kelp and sea grass that is cast up onto the beach by surf, tides, and wind*" (California Coastal Commission). In coastal beach areas wrack consists primarily of large macroalgae (e.g. kelp) that has come loose from where it grows offshore and has washed up along the beach. The wrack line usually marks the high tide line. The organic portions of wrack provide an important food source and / or a microhabitat refuge (providing protection against desiccation) to many species that inhabit the shoreline, including marine invertebrates, insects and shorebirds. As such, the structure of sandy beach macroinvertebrate communities has been closely linked to wrack deposits (e.g. McLachlan 1985, Colombini and Chelazzi 2003; Dugan *et al.* 2003). Beaches that receive significant inputs of algae / seagrass wrack are known to support a rich supralittoral fauna of crustaceans and insects which are found in no other environment. These species are uniquely adapted to life in these dynamic systems and exhibit features such as mobility, burrowing ability, protective exoskeletons, rhythmic behaviours, orientation mechanisms and behavioural plasticity (Chelazzi and Vannini 1988; Skapini *et al.* 1995; Brown 1996). The common practice of cleaning or grooming of wrack on heavily visited tourist beaches can thus have significant ecological consequences for sandy beach ecosystems (Defeo *et al.* 2009).

Figure 14 – Accumulated seagrass wrack at Terrigal Beach. Wrack provides an important food source and refuge to many species, including marine invertebrates, insects and shorebirds

Supralittoral areas of sandy beaches (i.e. above the high tide mark) may provide important nesting areas for shorebirds and marine turtles. Occasional sightings of sea turtles, including green turtles, have been recorded on Gosford's beaches, including at Wamberal, Terrigal, MacMasters and Umina beaches. Loggerhead turtles are known to occur along the NSW coast between Sydney and the Queensland border. A number of shorebirds (many of which are threatened / protected species) have the potential to occur along the sandy beach stretches in Gosford.

A large range of local and migratory shorebirds are known to occur in Gosford. Local shorebirds include the beach stone-curlew, pied oystercatcher and sooty oystercatcher. A larger number of migratory / visiting shorebirds which breed in areas such as New Zealand, Siberia, Alaska and the Arctic are also known to use these sandy beach habitats. These species include the black-necked stork, lesser sand plover, curlew sandpiper, sharp-tailed sandpiper, greater sand plover, great knot and eastern curlew.

Shorebird numbers are known to be positively correlated with wrack cover, and the biomass of their invertebrate prey which feed on this wrack (Tarr and Tarr 1987; Dugan *et al.* 2003; Hubbard and Duggan 2003). Therefore, any processes or activities which lead to a removal of wrack from the system will also have effects on shorebird numbers. In addition, beach grooming or other construction activities on sand beaches can cause direct mortality of eggs and young of beach nesting shorebirds, turtles and fish (Martin *et al.* 2006).

2.4.3 Intertidal Rocky Reef Habitat

There are a variety of intertidal rocky reef habitats separating the sandy beaches within the study area. Rocky intertidal habitats are reported to cover around 40% of the NSW coastline. Rocky intertidal areas are present where rates of sediment removal exceed rates of sediment supply. Such areas include the rock platforms at the base of the headlands on the northern and southern ends of all the open coast beaches, rocky coastline between MacMasters and Avoca Beaches as well as artificial rocky habitats such as the training wall at Patonga Creek and sandstone rock seawall at Patonga. The types of organisms that can inhabit such areas are described below.

2.4.3.1 Sessile Marine Organisms

Intertidal rocky areas provide a hard substrate for attachment of a variety of sessile marine invertebrates including barnacles, limpets, siphon shells, gastropods, tube worms and marine algae.

As is observed along intertidal rocky shores worldwide, there is a typical zonation of the marine flora and fauna attached to these hard structures. This zonation is created as each individual organisms / species has a preferred habitat range with an upper and lower limit determined by different environmental and biological factors. Typical zonation of Australian rocky shores follows the pattern of habitation as summarised below (as per Davey 1998):

Splash Fringe Level: This is the level immediately above the highest tide level. This level may be wetted or sprayed by mist. Littorinids (e.g. periwinkles) are often present here.

High-tide Level: The upper part of the high-tide level is covered by the tide for just a few hours each day. High-shore barnacles dominate this area. Below these are semi-mobile molluscs e.g. acmaeid limpets, patelloid limpets, siphon shells, chitons, top shells, periwinkles, conniwinks and nerites.

Mid-tide Level: The mid-tide level is covered and uncovered for equal time periods each tidal cycle. Typically, Galeolaria tube worms form dense aggregations here. An example of an organism that would be present in these habitats within the Gosford study area is the tube worm *Galeolaria caespitosa* (Sydney coral). These worms build white to grey calcareous tubes which are up to 30 mm long. This species range extends from southern Queensland around to Western Australia. In some cases the colonies can be so thick that they form microhabitat for other marine organisms.

Low-tide Level: This area is uncovered for only a few hours each tidal cycle. This is the favoured habitat for many intertidal species. Anemones, sea stars, urchins, chitons, tritons, whelks, limpets, barnacles, crabs and ascidians (e.g. cunjevoi) may all be present in this tidal region. Some algae species may occur in the moist crevices, gutters and rock pools. The low-tide level is often referred to as the "cunjevoi region" as the solitary ascidian species *Pyura stolonifera* (cunjevoi) often forms extensive and dense mats here.

Low-fringe Level: Low tide level oscillates during a lunar month and this level is wetted and exposed during each wave. Most species living here are fully marine and most algae species occur here (Davey 1998). The diversity of organisms that can be found in this zone including solitary and compound ascidians, multiple red, brown and green algae species, hydroids, zoanthids, anemones, flat worms, marine snails, periwinkles, cowries, whelk, sea hares, nudibranchs, starfish, brittle starts, feather stars, sea urchins, sea cucumber, oysters, mussels, octopus, tube worms, errant worms, shrimp, hermit crabs and crabs (Wilson 1988; Bent 1990; Lee 1996).

2.4.4 Subtidal Zone

Within the subtidal zone, a range of marine fishes and other species including sharks, dolphins, whales and turtles use these areas.

There are over 1000 species of fin-fish in NSW and tens of thousands of species of crustaceans, aquatic molluscs, beachworms, aquatic insects and other aquatic invertebrates – all of which are classified as 'fish' under the *Fisheries Management Act 1994*. (NSW DPI, 2013). More species of fin-fish are found in marine environments than in freshwater environments. The recent Census of Marine Life recorded almost 33,000 marine species in Australian waters and estimated that up to 250,000 marine species may be present.

Several marine fish species, including the Grey Nurse Shark, White Shark and Black Rockcod have declined in abundance and are now listed as 'threatened' in NSW (NSW DPI, 2013). In addition, many marine and estuarine species have been listed as 'protected' including the Ballina Angelfish, Eastern Blue Devil, Elegant Wrasse, Goldspotted Rockcod (Estuary Cod), Queensland Groper, Sandtiger Shark (Herbsts Nurse Shark) and all Syngnathids (i.e. sea dragons, pipefish, etc.).

Within the study area, the waters immediately adjacent to Bouddi National Park are closed to all recreational fishing. Spearfishing, and some forms of netting and trapping are not permitted in parts of Broken Bay adjacent to Umina and Pearl Beach. Some types of netting and trapping are not permitted in Wamberal and Terrigal Lagoons and in Avoca and Cockrane Lake.

The waters of the central coast are influenced by the East Australian Current (EAC). As such, a mix of tropical, subtropical and temperate species co-exist in the area, resulting in the area supporting a high diversity of marine species (NSW Marine Parks 2010).

A number of subtidal reefs exist within the study area, including offshore from Bouddi National Park, off the southern and northern ends of MacMasters Beach and Avoca Beach, offshore from the Skillion and Terrigal/Wamberal, and adjacent to Forresters Beach. These reefs were mapped by NSW Public Works in the early 1980's and by DECCW in 2010. Most of the reef is shallow and continuous to the shore from 200 metres up to about 1.8 kilometres offshore (DECCW 2011a). Rocky reef refers to all areas of rocky outcrops or boulders occurring within marine and estuarine waters below the highest astronomical tide level. Macroalgae and invertebrates contribute to the physical structure of rocky reef habitats and are therefore considered part of these habitats (NSW DPI 2013).

Rocky reefs support hundreds of species of invertebrates including sponges, sea squirts and corals. Some groups of species such as barnacles, sponges and kelps are attached to the reef and are commonly distributed in particular areas, while other species such as fish can move between many marine habitats (NSW DPI 2013).

The reefs provide refuge and feeding opportunities for a wide variety of fish. Small fish can escape predators among caves and crevices, while carnivorous species, such as black cod and bream, can use the rocky habitat as cover to ambush their prey (NSW DPI 2013).

Rocky and coral reefs in NSW are susceptible to sedimentation from dredging which may smother near shore reefs. Recreational and commercial activities such as fishing and SCUBA diving can also harm these sensitive habitats (NSW DPI 2013).

The HMAS Adelaide was scuttled off the coast of Terrigal and Avoca Beach in April 2011 to act as an artificial reef. Reef community baseline surveys (WorleyParsons 2011) have since identified that the reef has attracted marine growth has begun to colonise the reef (green foliose algae and serpulid tube worm casings on the hull of the vessel). Marine fauna observed during the Reef Community Baseline Survey included juvenile fish species including brown sabretooth blennies, blackspot goatfish, and bannerfish.

2.4.5 Economic Values

The Gosford City area has an estimated resident population of 170,752 as of 30 June 2013 (Australian Bureau of Statistics). It is the ninth largest population centre in Australia and the third largest residential region in NSW (Regional Development Australia - Central Coast NSW, 2009). The population growth is at a rate of just over 1% per annum (Regional Development Australia - Central Coast NSW, 2011).

The Central Coast has a growing number of older people and families moving to the region. The older people are attracted to the retirement living and the families are attracted to the affordable housing, coastal lifestyle and the accessibility to the Sydney metropolitan area (EC3 Global, 2010).

Gosford City is well known for its environmental qualities and its attributes and strengths as noted by Central Coast Tourism (2010) include:

- one of the top surf beaches in the world;

- over 625 km of water frontage, which is more than two times that of Sydney Harbour;
- land use is 80% natural;
- proximity to Sydney and Newcastle;
- natural beauty including national parks, lakes, waterways, headlands, beaches and hinterland;
- moderate and pleasant weather; and
- festivals and events.

The recent Ex-HMAS Adelaide Artificial Reef Project located approximately 1.8km from Avoca Beach would also attract additional tourism to the area.

The economic value of our coastline includes the value of private dwellings, public infrastructure and the income provided through tourism, recreation and fishing.

There is widespread residential development along the Gosford coastline with beachfront properties generally highly valued within the property market. The built coastal environment is strongly linked to the risks proposed by climate change projections as infrastructure is often in close proximity to the coastline and coastal waterways. The most recent coastal risk assessment (WorleyParsons 2014) identifies a large number of properties as being at immediate risk of coastal erosion. This risk increases into the future as a result of coastal recession and climate change projections.

In addition, inundation risk currently exposes many properties along the Gosford coastline. The extent to which the buildings on these properties are at risk is a function of their design and location.

Gosford City's Gross Regional Product is estimated at $5.88 billion (NIEIR, 2012). In 2011/12, the total tourism and hospitality sales were $504 million with a total value added of $217 million.

Tourism directly employed 2,500 people in Gosford City and indirectly employed 1,150 people in 2011/12 (NIEIR, 2012). Tourism has a significant contribution to the regional economy including the retail, manufacturing, property and business services, and health and community services sectors. The tourism industry also assists in the local retail businesses (EC3 Global, 2010).

One quantifiable measure of the value of the beaches is the value associated with use of the beach. This value incorporates the use of the beach by residents and the use of the beach by tourists. A guide as to this value can be based on the number of users of the beach and the value per use.

The beaches of Gosford are extremely popular – in the 2014-15 season between September 2014 and April 2015, over 2.1 million visits to the Gosford beaches recorded (refer Table 4). The most popular beaches in terms of visitor numbers in 2014-15 were Umina, Terrigal and Avoca. Detailed beach usage information has been provided by Council for all the beaches and is presented in Appendix 2.

Table 4 – Beach usage and rescue statistics for all beaches in Gosford (Gosford City Council, 2015)

Month	Beach Attendance				
	In Flags	**Out Flags**	**On Beach**	**Special (on water)**	**Total**
September 2014	47,810	36,025	87,350	0	171,185
October 2015	41,534	41,777	114,319	4,210	201,840
November 2014	51,929	40,715	112,911	4,040	209,587
December 2014	107,278	91,435	193,540	4,480	396,733
January 2015	161,002	125,329	300,185	486	587,002
February 2015	50,150	40,446	115,531	2,230	208,357
March 2015	60,233	68,512	160,891	6,730	296,366
April 2015	19,597	18,059	45,400	250	83,294
Whole Season	**539,533**	**462,298**	**1,130,127**	**22,426**	**2,154,364**

During peak season (December and January), there may be in excess of 2,000 people using the beach each day at Terrigal, Umina or Avoca for swimming, surfing and walking.

The value per beach use is not known. However, the value of each beach visit set out in *Adelaide's Living Beaches* for which annual value of beaches were estimated at $46 million (in 2005 dollars) for around 9 million visits, is approximately $5 per visit per beach.[10] Applying this value to Gosford's beaches would equate to beach users directly contributing over $10.5 million per annum to the local economy, not including their contribution to the hospitality industry.

Coastal management options that improve or maintain beach amenity will have positive impacts on tourism. Potentially, there will be flow-on tourism benefits to the local community associated with higher tourism from a better quality beach – e.g. expenditures at local businesses for example. If management options result in a loss in beach amenity, there will be an economic impact measured in terms of a reduction in beach visitor numbers, which would be felt in terms of a reduction in their contribution to the local economy and a reduction in the value of the tourism industry. It is therefore important from an economic perspective that coastal management options are selected which improve upon or maintain the current level of beach amenity.

[10] South Australia Department of Environment and Heritage 2005, *Adelaide's Living Beaches: A strategy for 2005-2025*, Technical Report, p. 133.

An understanding of economic factors within the coastal zone is essential in determining costs and benefits of various coastal management options now and into the future. Such economic considerations include:

- impact on Council revenues (including contribution of coastal property owners to proportion of rates with the Gosford area and potential transfer of costs onto rate base)
- Impact on State revenues
- Impact on Federal revenues (including land taxes, stamp duty, etc.)
- Impact on property values and confidence in economic investment
- Flow on impacts to the wider community
- Socio-financial impacts – impact of development restrictions on local employment, local services contractors and ancillary services.

Additionally, accurate information on rates and land valuations (based on 2014 figures) of affected properties has assisted in the assessment of costs and benefits for various management options in this study.

Gosford's coastline provides a sense of liveability to the community. Given the popularity of the coastline, there are a vast number of coastal assets managed by local government, including beach pathways and fencing, existing protective works and drainage infrastructure, amenities, car parks and surf clubs. They also require a financial commitment for both construction and maintenance. The impacts of climate change are likely to exacerbate these maintenance costs. This is likely to place immense pressure financially on Council to continue to provide such assets.

Depending on the location, there may be opportunity to retreat or relocate such infrastructure, however in many cases the infrastructure hinges on the location of private property and there may be no room to move.

2.4.6 Community Values

Gosford's beaches provide visual amenity, recreational opportunities that link closely with community lifestyle choices, indigenous, spiritual and cultural values and heritage, habitat and nursery ground for many coastal and estuarine plants and animals and sand dunes that have biodiversity values and protect our developments during storms.

The social atmosphere is an important component of beach recreation and provides many social values to our community. Gosford's coastline provides a range of social and recreational opportunities including, walking or jogging on the beach, meeting with family and friends, relaxing, swimming, bonding with nature, sightseeing and people watching, surf lifesaving and nippers, sunbathing and beach games. The high visitation rate at Gosford's beaches demonstrates the importance that both local residents and tourists put on the social value of our coastline.

The Gosford community is diverse and community values and aspirations vary between the various precincts within the study area, as well as between different individuals. Some of the precincts within the study area have retained their natural character and do not have a large quantum of property and infrastructure at risk from coastal hazards (e.g. Putty Beach), where others have a much more urban character and contain many properties at risk from coastal hazards (e.g. Wamberal). The community within these areas will have different aspirations and visions for their area, influenced by the character of the area and the severity of the local coastal risk.

The beaches within the study area are used by the local communities in the following ways:

- Informal uses or “leisure and recreation” activities – such as walking, sunbathing, fishing, swimming/surfing, jogging, cycling, family picnics, informal games, or relaxing – these uses typically involve little organisation and maximum personal choice or self-selection, they may be unplanned or spontaneous, and most often do not involve larger groups;
- Organised or structured recreational activities – such as nippers, surf training, volleyball games/ competitions – these uses are typically more structured or organised sporting or competitive uses with a more specific purpose and are generally more planned and controlled – they may range from training session or informal competitions to major surf carnivals; and
- Commercial recreational uses or events – these uses are characterised by their commercial nature, and can range from small “boot camps” and surf schools to major organised profit-driven or corporate events.

It is estimated that over 2 million people use the beaches in Gosford each year for swimming, walking and surfing. During the 2014-15 season over 1,000 rescues and 35,000 preventative actions were carried out by Council’s lifeguard services, highlighting the importance of these services to the wellbeing of the community (beach rescue data for each beach for the 2014-15 is provided in Appendix 2). It is important, therefore, that these services continue to be supported and are adequately resourced into the future.

The health benefits derived from living near beaches are well known, with local communities in these areas often living a healthy, outdoor lifestyle. There are also health implications potentially posed by coastal hazards, such the risk of financial loss due to storm damages, and physical risks including catastrophic damage to property due to erosion from wave impact.

Community values have been further gauged during the public exhibition of the Management Study, where written submissions were sought from the community regarding their values and aspirations for the various beaches in the Study area. These community values and aspirations have been considered in development of management actions to be included in the Coastal Zone Management Plan for Gosford’s beaches.

3 PLANNING INSTRUMENTS AND LEGISLATIVE FRAMEWORK

This section of the report provides an overview of the relevant statutory planning controls, policies and procedures relating to the coastal zone and the policy framework applying to the development of a Coastal Zone Management Plan. The legislation sets out various coastal planning and management approaches, such as land zoning, development control, strategic planning and requirements for coastal protection works, generally enacted through actions of local government.

The legislative framework for NSW coastal management has undergone significant reform since 2009 and is covered by a range of legislation and policy as described below. The implications of the ongoing reforms are that there is considerable uncertainty for Council in the future application of the planning system.

Currently, the following development controls apply to the coastal zone within Gosford City:

- Development Control Plan 2013 (Chapter 6.2 focuses upon Coastal Frontage)
- Gosford City Local Environment Plan.

Key legislation and policy applying to activities in the NSW Coastal Zone includes:

- Coastal Protection Act 1979;
- Coastal Protection Regulation 2011;
- NSW Coastal Policy 1997;
- Environmental Planning & Assessment Act 1979;
    - State Environment Planning Policy (Infrastructure) 2007
    - State Environment Planning Policy 14 Coastal Wetlands
    - State Environment Planning Policy 71 Coastal Protection
- Local Government Act 1993;
- Crown Lands Act 1989;
- Land Acquisition (Just Terms Compensation) Act 1991;
- Fisheries Management Act 1994; and
- Threatened Species Conservation Act 1995.

A series of guideline documents also apply applying to planning and management within the NSW Coastal Zone include:

- Guidelines for the development of Coastal Zone Management Plans (2013);
- NSW Coastal Planning Guideline– Adapting to Sea Level Rise (1999)
- A Guide to the Statutory Requirements for Temporary Coastal Protection Works (2010)
- A guide for authorised officers under the Coastal Protection Act (2010)

- Coastal zone management guide note - Emergency Action subplans (2011)
- Coastal Protection Service Charge Guidelines (2010)
- Code of Practice under the Coastal Protection Act 1979 (2013)

Each of the statutory planning controls, legislation, policies and procedures applicable to the Gosford LGA and the development of specific management options for the coastline are discussed in more detail below.

3.1 Gosford Development Control Plan 2013

Gosford Development Control Plan 2013 came into force in February 2014 and replaces the previous Development Control Plans in Gosford LGA (including DCP 125). Chapter 6.2 "Coastal Frontage" applies to all coastal frontage land within Gosford LGA, namely all land between Forresters Beach and Patonga. The current DCP has largely adopted the contents of the previous DCP 125 in relation to coastal frontage land within the Gosford LGA.

The objectives of this section of the DCP are to:

(a) Minimise the risk to life and property associated with development and building on land which has a coastal beach and/or cliff frontage; and

(b) Provide guidelines for the development of land within the coastal frontage area.

For the Broken Bay beaches (between and including Patonga and Putty-Killcare Beach), the designated coastal hazard areas are seaward of the 2098 erosion line, except at Pearl Beach where Council has determined a building/hazard line adjacent to Coral Crescent. For the open coast beaches (MacMasters, Avoca, Terrigal/Wamberal and Forresters Beach) the designated coastal hazard areas are seaward of the 2045 erosion line (as determined by the previous coastal hazard assessments carried out in 1995).

The following text summarises the existing DCP Chapter 6.2 and provides the detail relevant to development on Gosford's open coast and Broken Bay beaches (based upon previous risk information).

3.1.1 Terminology used in the DCP

The DCP defines various intensities of development that are used to define what type of development is permitted in a particular coastal hazard zone. The categories are:

- '<u>Major investment</u>' - defined in the DCP as the expenditure on improvements, changes, additions or renovations of more than 20% of the cost (or current value) of the building.
- '<u>Minor Investment</u>' – defined as the expenditure on improvements, changes, additions or renovations of less than 20% of the cost (or current value) of the building.
- '<u>Maintenance</u>' is defined as replacing defective, worn-out, rotten and/or damaged materials within the building, that have had development consent, with similar new

materials. Maintenance does not include any increase in floor area or the movement of walls, replacement of one type of wall with another (such as replace a timber frame wall with brickwork), building/extending decks, moving kitchens to other areas or changing the roof profile, pitch or height.

3.1.2 Provisions of the DCP

The DCP covers all the beaches within the Gosford Local Government area and defines what development is allowable at the Broken Bay and Open Coast beaches. The level of risk had been defined separately for the Broken Bay and Open Coast beaches with two separate Coastal Management Plans - *Broken Bay Beaches Management Plan* and *Open Coast Beaches Management Plan.*

At the Open Coast beaches, the DCP stipulates the following:

Development Exceptions

Council will not permit buildings or building structures to be constructed on, over or below the land which has been identified by the Coastal Management Plan for Gosford City Open Coast Beaches as subject to designated coastal hazards except where permitted below:

a. *Existing buildings which have been identified as being within the designated coastal hazard areas will not be permitted to be renovated as major investments except as permitted in the subclauses below. Planned retreat of the buildings is recommended.*

b. *The designated coastal hazard areas are areas seaward of the year 2045 erosion line and the high risk cliff stability line. The lines are shown within the Council's Coastal Management Plans.*

c. *All structures constructed in the coastal frontage zones shall:*

   i. *be compatible with the coastal hazards identified;*

   ii. *be set back as far landward as practicable;*

   iii. *not give rise to any increased hazard;*

   iv. *be designed to not be damaged by the designated hazard;*

   v. *give consideration to the effects of larger events than the designated hazard;*

   vi. *be constructed in a manner or to a level which overcomes any problem from the coastal hazards of run-up and inundation.*

d. *On Wamberal Beach building will be permitted seaward of the 2045 erosion line but landward of the proposed revetment subject to the following:*

   i. *adequate foundation treatment designed to withstand the stormwave erosion;*

   ii. *that the building shall be set back from the alignment of the proposed revetment as required by Council;*

iii. *the owner executing a positive covenant as detailed in subclause 6.2.5.1(f).*

iv. *The development will not give rise to any increased hazard.*

v. *Council will not permit any buildings or building structures to be constructed on, over or below the land identified as being within 3 metres landward of the proposed revetment.*

e. *Minor Investment will be considered in the designated coastal hazard areas provided that it does not increase the risk of loss or increase the level of coastal hazard. Minor Investment in the designated coastal hazard areas will be considered as a once-off development subject to Council approval. A report prepared by a suitably qualified Quantity Surveyor is to accompany any development application. Such minor investment will not be approved until a positive covenant has been provided as detailed below.*

Maintenance of buildings is permitted, provided that the maintenance work carried out does not change the nature of the structural element maintained. Certification by a suitably qualified person in relation to the current condition of the existing structural elements of the building is to be submitted with the development application.

f. *Prior to the issue of a Construction Certificate the registered proprietor must execute a positive covenant in favour of Council (pursuant to Section 88E(3) of the Conveyancing Act 1919) requiring the registered proprietor to carry out and maintain works to minimise any threat to the dwelling by the effects of the sea. The positive covenant will be prepared by Council's solicitor at the cost of the registered proprietor.*

g. *Major investment in redevelopment of existing buildings within the designated hazard areas recommended for planned retreat will not be permitted.*

h. *Major investment in redevelopment of existing buildings in areas to be protected by the revetment wall will not be permitted unless the existing structure has adequate foundations or adequate foundations are provided so that loss will not occur in the event of a major storm event occurring prior to the provision of the revetment structure. Any major investment in this area must also provide evidence that the proposed development will not give rise to any increased hazard.*

i. *Matters for consideration and existing building policies will apply in conjunction with the provisions of this chapter.*

j. *Building design and structural design shall take into account that storms greater than the storms causing the predicted hazards can occur and that erosion and run-up could occur to a greater extent than the predictions.*

k. *The coastal, geotechnical and structural considerations shall not cease because the building is just landward of the hazard line. Any Major Investment or Minor Investment and their foundations shall be designed to withstand the effects of larger storm events than the predicted storm event.*

l. *Where structural consideration of coastal forces is required the engineer shall take into account the forces generated by coastal attack, possible dune slumping, loss of support, slope readjustment, changing water table as well as the normal structural and foundation considerations, including reduced foundation capacities. Foundation design shall extend beyond the reduced foundation capacity zone of influence.*

m. *In the coastal frontage area with a moderate coastal cliff stability risk, the site will need to be examined by a competent and experienced geotechnical engineer to determine the most suitable location for building and development. The building shall be designed taking into account any expected foundation difficulties and adequate provisions be made to overcome any identified difficulties (reference Cliff Hazard Management Plan for Tudibaring Headland, Copacabana).*

n. *Removable buildings may be considered within the designated hazard areas provided that it can be shown that they are readily removable and an indemnity is provided. In the event of severe erosion threatening a removable building, Council may condition such development and/or instruct the owner at short notice to relocate the building. Removable buildings will not be permitted within the high risk cliff stability zone.*

o. *Any suitable sand excavated during the course of building and redevelopment work shall have all deleterious material removed and shall be placed on the adjacent beach at a location approved by the Council.*

<u>Information to be supplied with a Development Application</u>

a. *For areas seaward of the 2045 erosion line:*
   i. *a specialist coastal engineering report;*
   ii. *geotechnical report indicating the sub-strata and the type of foundations required;*
   iii. *a structural engineering report addressing the coastal hazards up to the 2045 event and considering coastal events of greater magnitude, a structural engineering report shall show the materials of construction;*
   iv. *principal dimensions of the main structural elements;*
   v. *floor levels;*
   vi. *top and bottom levels of foundations, footings or piles;*
   vii. *an indemnity in the form required by Council.*

b. *In areas of moderate or high risk cliff stability:*
   i. *a geotechnical report detailing the nature of the risks and how they can be mitigated.*

c. *For areas landward of the 2045 erosion line:*

i. *plans showing the location of the erosion line on the site;*

ii. *a coastal and a structural engineering report giving consideration to storm events larger than the predicted storm events.*

Development at Wamberal Beach is subject to special provisions in the DCP. The current setback from the proposed revetment for properties along the Wamberal beachfront is defined in the *Design Study for Wamberal Beach Terminal Protection Structure Final Design Report* (WRL 1998) and, generally, is 3 m, but varies depending on the location of the property in relation to the chainage distance along the proposed revetment (Table 5).

Table 5 – Allowable Setback of properties along Wamberal beachfront in relation to proposed Terminal Protection Structure (WRL 1998)

Table 14 Wamberal Beach TPS Final Design Summary

Chainage (m)	Description	Crest Level (m AHD)	Minimum Development Setback (m)
0.0-16.8	Sheet pile return (Figure 37)	4.0-6.0	Note (1)
16.8-391.0	Seabee TPS gabion/reno toe (Figure 38)	7.0	3.0 – 8.0
391.0-398.5	Seabee TPS gabion/reno toe (Figure 39)	7.0 – 8.0	8.0 – 4.0
398.5-1307.4	Seabee TPS gabion/reno toe (Figure 40)	8.0	4.0 – 3.0
1307.4-1319.4	Seabee TPS gabion/reno toe	8.0 – 6.0	3.0 – 13.0
1319.4-1350.2	Seabee TPS gabion/reno toe	6.0	Note (2)
1350.2-1358.5	Basalt armoured rock round-head (Figure 41)	6.0	Note (2)

1. This area is prone to flooding from Terrigal Lagoon and subject to storm wave overtopping. Development restrictions requiring a Coastal Engineering Report apply.

2. This area is subject to storm wave overtopping. Development restrictions requiring a Coastal Engineering Report apply.

At the Broken Bay beaches (Little Beach to Patonga inclusive), the DCP stipulates similar conditions to development as per the Open Coast Beaches, except that the basis for defining areas subject to coastal hazards is the 2098 erosion line (rather than the 2045 erosion line). It is noted that there is no technical basis for adopting a different planning horizon (i.e. 2045 or 2098) for the Broken Bay and Open Coast beaches. The 2098 erosion line is the planning horizon for development adopted at all the Broken Bay beaches, except at Pearl Beach where Council has determined a foreshore building/hazard line for lots fronting Coral Crescent. In addition to Section 6.2 of the DCP, residential development at Pearl Beach is subject to the specific provisions of the DCP, which identifies development controls more specifically for Pearl Beach.

A specialist coastal engineering report is required for areas seaward of the 2098 erosion line where development is permitted under the DCP. Maps within the DCP identify individual properties that are subject to the DCP.

At Pearl Beach, the DCP stipulates that:

"*building will be permitted seaward of the 2098 erosion line but landward of the building/hazard line for Coral Crescent, subject to the following:*

- *i. The building shall be founded on deep pile foundations which extend below the locally unstable foundation zone which relates to the 2098 erosion prediction;*
- *ii. the owner executing a positive covenant as detailed in clause 6.2.6.1(f).*
- *iii. Not give rise to any increased hazard.*

Major investment in redevelopment of existing buildings within areas seaward of the adopted building or 50 year hazard line, whichever is most landward (Broken Bay Beaches Coastal Management, August 1999), at Pearl Beach will not be permitted."

A one-off major investment in redevelopment of existing buildings in areas between the 2098 hazard line and the building/hazard line at Pearl Beach will not be permitted unless the structure has adequate foundations or adequate foundations are provided so that loss will not occur in the event that the predictions of erosion between the building/hazard line and the year 2098 line do occur.

3.1.3 Link between the DCP and the coastal hazard definition

The provisions of the existing DCP are strongly linked to the definition of the coastal hazards at each of the beaches as part of the 1995/1998 planning process. For the sandy beach areas, the hazard definition is based on Nielsen et al (1992), with a number of coastline hazard zones delineated as shown in Figure 15, below.

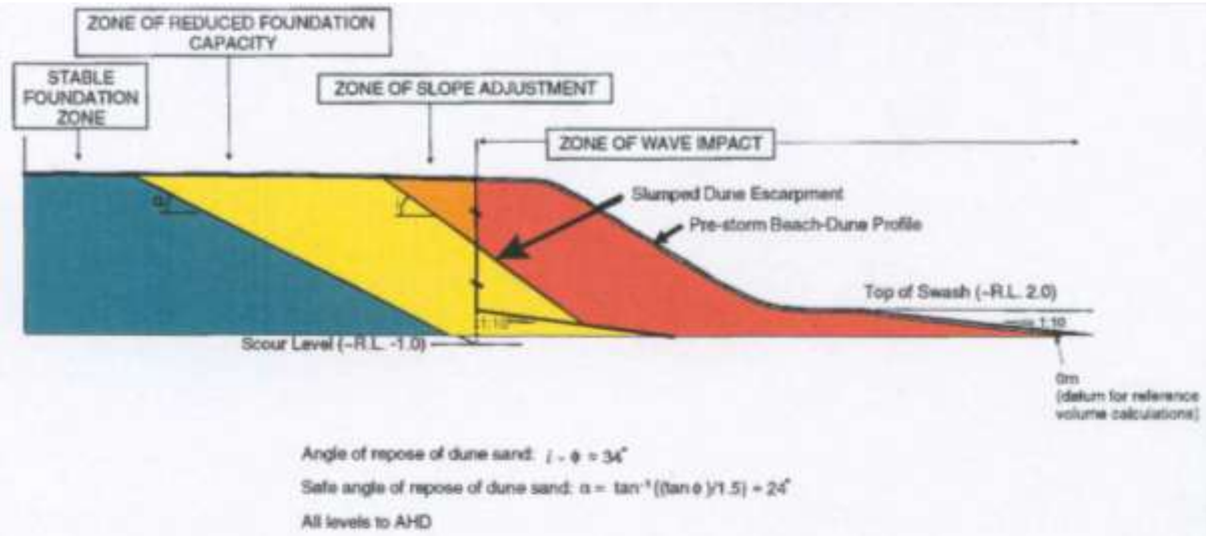

Figure 15: Schematic representation of coastline hazard zones (after Nielsen et al 1992)

The *Zone of Wave Impact* delineates an area where any structure or its foundations would suffer direct wave attack during a severe coastal storm. It is that part of the beach that is seaward of the beach erosion escarpment (as defined by the beach erosion hazard, see **Section 5.2**).

A *Zone of Slope Adjustment* is delineated to encompass that portion of the seaward face of the beach that would slump to a natural angle of repose following removal by wave erosion of the design storm demand. It represents the steepest stable beach profile under the conditions specified.

A *Zone of Reduced Foundation Capacity* for building foundations is delineated to take account of the reduced bearing capacity of the sand adjacent to the storm erosion escarpment. Nielsen et al (1992) recommended that structural loads should only be transmitted to soil foundations outside of this zone (i.e. landward or below), as the factor of safety within the zone is less than 1.5 during extreme scour conditions at the face of the escarpment. In general (without the protection of a terminal structure such as a seawall), dwellings/structures not piled and located within the Zone of Reduced Foundation Capacity would be considered to have an inadequate factor of safety.

The 1995/1998 coastline hazard zones for the study area are determined with the position of the Zone of Slope Adjustment defined for the immediate planning period, and the Zone of Slope Adjustment defined by the previous coastal risk assessments for the 2045 and 2098 planning periods.

It is noted that DCP stipulates that development in the coastal hazard areas, where allowable, should be founded on deep pile foundations. Within the Zone of Reduced Foundation Capacity, the soil mass has a reduced capacity to support building foundations, unless they constructed on piles deep enough to resist the lateral forces induced on them by movement within the soil mass. Light structures within this zone (e.g. fences, utilities, roads, paths etc.) are not at risk of damage. However, heavy structures (buildings) not supported on piled foundations could be at risk of some structural damage due to an increased risk of slumping in this area if they are located within this zone and the dune in front of them collapses back to the Zone of Slope Adjustment line.

3.1.4 Comments on the existing DCP

The development of a revised Coastal Zone Management Plan provides the foundation for the development of appropriate planning controls in the coastal zone. The planning process will provide the basis upon which a full review of DCP Chapter 6.2 can occur.

In light of the findings of the Coastal Process and Hazard Definition Study (WorleyParsons 2014), the following observations are made about the applicability of the existing DCP:

- A different planning horizon has been adopted for the Open Coast and Broken Bay beaches, as they are each based on the previous and location specific coastal risk assessment information. Special provisions have been made for Pearl Beach and Wamberal Beach as these areas are subject to a greater quantum of existing development at risk. There is no practical reason why the planning horizon should be different between the Open Coast and Broken Bay beaches. The planning horizon should ideally be adopted based on the level of risk determined at each beach, which is a function of the intensity of existing development in each area, the quantum of development at risk within the coastal hazard zones and community acceptance.

- There is a link between the provisions of the DCP and the way that the hazards are defined. The DCP stipulates deep pile foundations be used as a risk mitigation measure, which would mitigate the risk of structural damage to coastal development. The provision for deep pile foundations is key to mitigating coastal erosion hazard risk in each area. There are also provisions in the DCP to ensure that risk to new development due to coastal inundation hazards is minimised.

- The updated risk information in the latest Coastal Process and Hazard Definition Study (WorleyParsons 2014) will require the planning horizon adopted in the DCP to be revised. As each beach has a different quantum of development at risk and the local communities in each area have different views and aspirations, the planning horizon may need to be tailored to suit the level of risk defined at each particular location, to ensure that allowable development in each area takes into account factors such as the existing intensity of development in each area (i.e. adopt an adaptive risk management approach at each precinct in accordance with Principle 7 of the Coastal Management Principles, Guidelines for Preparing Coastal Zone Management Plans, OEH 2013). Asset classes and life are also important and require further consideration in development control. The DCP needs to ensure that allowable development in each precinct is dealt with equitably throughout the LGA but at the same time takes into account the social fabric of each precinct.

- The Gosford LEP 2014 identifies that development consent must not be granted to development on land that is wholly or partly within the coastal zone unless the consent authority is satisfied that the proposed development will not be significantly affected by coastal hazards, or increase the risk of coastal hazards in relation to any other land. The DCP does not consider the loss of land at present.

- The current DCP differentiates between major and minor development which creates some confusion in development assessment. The definitions may need to be better defined to ensure clarity going forward. The DCP currently requires property owners execute a positive covenant in favour of Council in order to issue a construction certificate for a minor and often unrelated building development. Requirements in regard to supporting information to be provided for minor development (and requirement for the execution of a covenant) should be reviewed.
- The DCP provisions apply to all land parcels irrespective of whether they lie landward of major road, sewer and water infrastructure (which will be protected). The application of all DCP provisions to all properties identified in 'coastal hazard definition' may need to be reviewed.
- Review of the CZMP creates an opportunity to think creatively in determining future DCP provisions to retain development potential. The full review of the DCP will involve Council revisiting concepts and established rules relating to development footprints, engineered design, cantilevering and setbacks from the street-side property boundary to improve development potential and enable ongoing development in the short to medium-term. In doing so, Council must be confident it does not create further legacy implications for future generations.

3.2 Gosford Local Environment Plan 2014

The Gosford Local Environment Plan came into effect in February 2014. Through zoning and development controls LEPs allow councils to manage the ways in which land is used to shape communities. A LEP provides a way of reflecting strategic land use planning undertaken by councils, for example providing an adequate supply of land for housing and employment.

The Gosford Local Environment Plan (LEP) aims to make local environmental planning provisions for land in Gosford in accordance with the relevant standard environmental planning instrument under section 33A of the *Environmental Planning and Assessment Act 1979*.

The particular aims of the Plan are as follows:

(a) to encourage a range of housing, employment, recreation and services to meet the needs of existing and future residents of Gosford,

(b) to foster economic, environmental and social well being so that Gosford continues to develop as a sustainable and prosperous place to live, work and visit,

(c) to provide community and recreation facilities, maintain suitable amenities and offer a variety of quality lifestyle opportunities to a diverse population,

(d) to strengthen the regional position of Gosford City Centre as the service and employment centre for the Central Coast,

(e) to concentrate intensive land uses and trip-generating activities in locations that are most accessible to transport and centres,

(f) to promote the efficient and equitable provision of public services, infrastructure and amenities,

(g) to conserve, protect and enhance the environmental and cultural heritage of Gosford,

(h) to protect and enhance the natural environment in Gosford, incorporating ecologically sustainable development,

(i) to minimise risk to the community in areas subject to environmental hazards, particularly flooding and bush fires,

(j) to promote a high standard of urban design that responds appropriately to the existing or desired future character of areas,

(k) to promote design principles in all development to improve the safety, accessibility, health and well being of residents and visitors,

(l) to encourage the development of sustainable tourism that is compatible with the surrounding environment

At present the LEP does not include maps of coastal hazard areas and generally provides maps of land zonings, and development controls which are specific to a particular zoning.

Clause 5.5 of the LEP details Council's particular provisions for development within the coastal zone. This clause enshrines the need for the protection of the coastal environment for the benefit of both present and future generations through promoting the principles of ecologically sustainable development, and implements the principles of the NSW Coastal Policy.

The objectives of Clause 5.5 of the LEP are as follows:

(a) to provide for the protection of the coastal environment of the State for the benefit of both present and future generations through promoting the principles of ecologically sustainable development,

(b) to implement the principles in the NSW Coastal Policy, and in particular to:

(i) protect, enhance, maintain and restore the coastal environment, its associated ecosystems, ecological processes and biological diversity and its water quality, and

(ii) protect and preserve the natural, cultural, recreational and economic attributes of the NSW coast, and

(iii) provide opportunities for pedestrian public access to and along the coastal foreshore, and

(iv) recognise and accommodate coastal processes and climate change, and

(v) protect amenity and scenic quality, and

(vi) protect and preserve rock platforms, beach environments and beach amenity, and

(vii) protect and preserve native coastal vegetation, and

(viii) protect and preserve the marine environment, and

(ix) ensure that the type, bulk, scale and size of development is appropriate for the location and protects and improves the natural scenic quality of the surrounding area, and

(x) ensure that decisions in relation to new development consider the broader and cumulative impacts on the catchment, and

(xi) protect Aboriginal cultural places, values and customs, and

(xii) protect and preserve items of heritage, archaeological or historical significance.

Clause 5.5 of the LEP also stipulates conditions under which development consent can or cannot be granted to development in the coastal zone as well as matters that need to be considered in dertermining development applications. According to the LEP:

Development consent must not be granted to development on land that is wholly or partly within the coastal zone unless the consent authority has considered:

(a) existing public access to and along the coastal foreshore for pedestrians (including persons with a disability) with a view to:

(i) maintaining existing public access and, where possible, improving that access, and

(ii) identifying opportunities for new public access, and

(b) the suitability of the proposed development, its relationship with the surrounding area and its impact on the natural scenic quality, taking into account:

(i) the type of the proposed development and any associated land uses or activities (including compatibility of any land-based and water-based coastal activities), and

(ii) the location, and

(iii) the bulk, scale, size and overall built form design of any building or work involved, and

(c) the impact of the proposed development on the amenity of the coastal foreshore including:

(i) any significant overshadowing of the coastal foreshore, and

(ii) any loss of views from a public place to the coastal foreshore, and

(d) how the visual amenity and scenic qualities of the coast, including coastal headlands, can be protected, and

(e) how biodiversity and ecosystems, including:

(i) native coastal vegetation and existing wildlife corridors, and

(ii) rock platforms, and

(iii) water quality of coastal waterbodies, and

(iv) native fauna and native flora, and their habitats, can be conserved, and

(f) the cumulative impacts of the proposed development and other development on the coastal catchment.

(3) Development consent must not be granted to development on land that is wholly or partly within the coastal zone unless the consent authority is satisfied that:

(a) the proposed development will not impede or diminish, where practicable, the physical, land-based right of access of the public to or along the coastal foreshore, and

(b) if effluent from the development is disposed of by a non-reticulated system, it will not have a negative effect on the water quality of the sea, or any beach, estuary, coastal lake, coastal creek or other similar body of water, or a rock platform, and

(c) the proposed development will not discharge untreated stormwater into the sea, or any beach, estuary, coastal lake, coastal creek or other similar body of water, or a rock platform, and

(d) the proposed development will not:

(i) be significantly affected by coastal hazards, or

(ii) have a significant impact on coastal hazards, or

(iii) increase the risk of coastal hazards in relation to any other land.

Table 6 provides details on the land zoning located within or near the designated coastal hazard areas, including the objectives of the zones and uses within each zone permissible with consent.

Table 6 – Gosford LEP Zones relevant to the study area

LEP Zone and location	Zone Objectives (as relevant to the Study area)	Permissible uses (with consent)
RE1 Public Recreation (Patonga, Pearl, Ocean/Umina, Putty-Killcare, McMasters, Copacabana, Avoca, North Avoca, Terrigal,	• To enable land to be used for public open space or recreational purposes. • To provide a range of recreational settings and activities and compatible land uses. • To protect and enhance the natural environment for recreational purposes. • To identify areas suitable for development for recreation, leisure and cultural purposes. • To ensure that development is compatible with the desired future character of the zone.	Camping grounds; Car parks; Caravan parks; Child care centres; Community facilities; Kiosks; Recreation areas; Recreation facilities (indoor); Recreation facilities (major); Recreation facilities (outdoor); Respite day care centres; Restaurants or cafes; Roads; Water recreation structures

LEP Zone and location	Zone Objectives (as relevant to the Study area)	Permissible uses (with consent)
Wamberal, Forresters Beach)		
R1 General Residential (Ocean/Umina, Avoca, Terrigal)	• To provide for the housing needs of the community. • To provide for a variety of housing types and densities. • To enable other land uses that provide facilities or services to meet the day to day needs of residents. • To ensure that development is compatible with the desired future character of the zone. • To promote best practice in the design of multi dwelling housing and other similar types of development. • To ensure that non-residential uses do not adversely affect residential amenity or place demands on services beyond the level reasonably required for multi dwelling housing or other similar types of development.	Home occupations; Recreation areas Attached dwellings; Bed and breakfast accommodation; Boarding houses; Car parks; Child care centres; Community facilities; Dual occupancies; Dwelling houses; Group homes; Home-based child care; Hostels; Hotel or motel accommodation; Multi dwelling housing; Neighbourhood shops; Places of public worship; Residential flat buildings; Respite day care centres; Roads; Semi-detached dwellings; Seniors housing; Shop top housing
R2 Low Density Residential (Patonga, Pearl, Ocean/Umina, McMasters, Copacabana, Wamberal, Forresters Beach)	• To provide for the housing needs of the community within a low density residential environment. • To enable other land uses that provide facilities or services to meet the day to day needs of residents. • To ensure that development is compatible with the desired future character of the zone. • To encourage best practice in the design of low-density residential development. • To promote ecologically, socially and economically sustainable development and the need for, and value of, biodiversity in Gosford. • To ensure that non-residential land uses do not adversely affect residential amenity or place demands on services beyond the level reasonably required for low-density housing.	Home occupations; Recreation areas Bed and breakfast accommodation; Boarding houses; Boat sheds; Child care centres; Community facilities; Dwelling houses; Group homes; Home-based child care; Home industries; Hospitals; Neighbourhood shops; Places of public worship; Respite day care centres; Roads; Secondary dwellings; Seniors housing
E1 National Parks and Nature Reserves (Bouddi National Park at Putty-Killcare Beach, Wamberal Lagoon Nature Reserve at Wamberal and	• To enable the management and appropriate use of land that is reserved under the National Parks and Wildlife Act 1974 or that is acquired under Part 11 of that Act. • To enable uses authorised under the National Parks and Wildlife Act 1974. • To identify land that is to be reserved under the National Parks and Wildlife Act 1974 and to protect the environmental significance of that land.	Uses authorised under the National Parks and Wildlife Act 1974

LEP Zone and location	Zone Objectives (as relevant to the Study area)	Permissible uses (with consent)
Forresters Beach)		
B1 Neighbourhood Centre (Patonga, Ocean/Umina, McMasters, Copacabana, Wamberal)	• To provide a range of small-scale retail, business and community uses that serve the needs of people who live or work in the surrounding neighbourhood. • To allow for an increased residential population in neighbourhood centres where land is not required to serve local needs. • To ensure that development is compatible with the desired future character of the zone. • To promote ecologically, socially and economically sustainable development. • To ensure that local nodes and neighbourhood centres are recognised as small-scale centres that provide a range of services and facilities commensurate with their local population catchments and that development is of a scale that is appropriate to meet local needs. • To encourage residential development as either stand alone development or as part of mixed use development in local nodes and neighbourhood centres, while retaining opportunities for retail and service activities to serve the population in the immediate locality.	Recreation areas; Roads Boarding houses; Business premises; Child care centres; Community facilities; Dwelling houses; Medical centres; Neighbourhood shops; Residential flat buildings; Respite day care centres; Shop top housing.
B2 Local Centre (Avoca, Terrigal)	• To provide a range of retail, business, entertainment and community uses that serve the needs of people who live in, work in and visit the local area. • To encourage employment opportunities in accessible locations. • To maximise public transport patronage and encourage walking and cycling. • To provide for residential uses, but only as part of a mixed use development. • To ensure that development is compatible with the desired future character of the zone. • To promote ecologically, socially and economically sustainable development. • To ensure that village centres such as Avoca, East Gosford, Ettalong Beach, Kincumber, Lisarow, Niagara Park, Terrigal, Umina Beach, West Gosford and Wyoming are recognised as providing a broad range of services and facilities to serve the population of the locality. • To ensure that villages are recognised as providing local level services and facilities and are developed	Recreation areas Boarding houses; Child care centres; Commercial premises; Community facilities; Educational establishments; Entertainment facilities; Function centres; Information and education facilities; Medical centres; Passenger transport facilities; Recreation facilities (indoor); Registered clubs; Respite day care centres; Restricted premises; Roads; Service stations; Shop top housing; Tourist and visitor accommodation

LEP Zone and location	Zone Objectives (as relevant to the Study area)	Permissible uses (with consent)
	at a scale that reflects their population catchment and as a focus for public transport routes. • To ensure that the different roles of villages are recognised with some villages being key tourist destinations with boutique activities in addition to serving the needs of local residents, while other villages are purpose-built centres to serve the needs of the local population. • To encourage the residential population of villages and town centres to contribute to the vitality of those locations.	

3.3 Coastal Protection Act 1979

The *Coastal Protection Act 1979* (CP Act) provides a statutory mechanism to protect, maintain, enhance and restore the environment of the coastal region, associated ecosystems, ecological processes, biological diversity and its water quality.

The objects of this Act are to provide for the protection of the coastal environment of NSW for the benefit of both present and future generations and, in particular:

a. *to protect, enhance, maintain and restore the environment of the coastal region, its associated ecosystems, ecological processes and biological diversity, and its water quality, and*

b. *to encourage, promote and secure the orderly and balanced utilisation and conservation of the coastal region and its natural and man-made resources, having regard to the principles of ecologically sustainable development, and*

c. *to recognise and foster the significant social and economic benefits to the State that result from a sustainable coastal environment, including:*

    i. *benefits to the environment, and*

    ii. *benefits to urban communities, fisheries, industry and recreation, and*

    iii. *benefits to culture and heritage, and*

    iv. *benefits to the Aboriginal people in relation to their spiritual, social, customary and economic use of land and water, and*

d. *to promote public pedestrian access to the coastal region and recognise the public's right to access, and*

e. *to provide for the acquisition of land in the coastal region to promote the protection, enhancement, maintenance and restoration of the environment of the coastal region, and*

f. *to recognise the role of the community, as a partner with government, in resolving issues relating to the protection of the coastal environment, and*

g. *to ensure co-ordination of the policies and activities of the Government and public authorities relating to the coastal region and to facilitate the proper integration of their management activities, and*

h. *to encourage and promote plans and strategies for adaptation in response to coastal climate change impacts, including projected sea level rise, and*

i. *to promote beach amenity.*

Under Section 55B, all councils that have land within the "coastal zone" are required to prepare a coastal zone management plan (CZMP) in accordance with the CP Act. Under Section 55C, a CZMP must make provision for:

- protecting and preserving beach environments and beach amenity; and
- emergency actions carried out during periods of beach erosion, including the carrying out of related works, such as works for the protection of property affected or likely to be affected by beach erosion, where beach erosion occurs through storm activity or an extreme or irregular event; and
- ensuring continuing and undiminished public access to beaches, headlands and waterways, particularly where public access is threatened or affected by accretion; and
- where the plan relates to a part of the coastline, the management of risks arising from coastal hazards; and
- where the plan relates to an estuary, the management of estuary health and any risks to the estuary arising from coastal hazards; and
- the impacts from climate change on risks arising from coastal hazards and on estuary health, as appropriate; and
- where the plan proposes the construction of coastal protection works (other than emergency coastal protection works) that are to be funded by the council or a private landowner or both, the proposed arrangements for the adequate maintenance of the works and for managing associated impacts of such works (such as changed or increased beach erosion elsewhere or a restriction of public access to beaches or headlands).

"Coastal protection works" are defined under Section 4 of the CP Act and include "activities or works to reduce the impact of coastal hazards on land adjacent to tidal waters and includes seawalls, revetments, groynes and beach nourishment".

Section 55K of the Act states that a person must not carry out work in relation to remediating beach erosion unless the work is in accordance with the coastal zone management plan, or development consent has been granted.

3.4 Coastal Protection Regulation 2011

This Regulation applies to the "unzoned" coastal zone that is below the mean high water mark (excluding estuaries and lakes).

Clause 5 prohibits the carrying out of development in any part of the coastal zone (including by a public authority), without the concurrence of the Minister. However, concurrence of the Minister is not required if the development is carried out in accordance with a CZMP. Certain dredging, sediment placement, placement of solid objects and temporary disturbance of the seabed are excluded from this Clause.

The Regulation also details requirements relating to temporary protection works and links to the Code of Practice under the Coastal Protection Act 1979.

3.5 NSW Coastal Policy 1997

The NSW Coastal Policy is based on the four principles of Ecologically Sustainable Development (ESD) contained in the Intergovernmental Agreement on the Environment in 1992. The principles are:

- **Conservation of biological diversity and ecological integrity**. This refers to the need to conserve the variety of all life forms, especially the variety of species, and to ensure that the productivity, stability and resilience of ecosystems is maintained.
- **Inter-generational equity**. This requires that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations. Social equity considerations, in terms of equal access opportunities to resources, is inherent in the concept of inter-generational equity.
- **Improved valuation, pricing and incentive mechanisms**. This requires environmental factors, such as the value of ecosystems, polluter pays principles etc., to be incorporated into the valuation of assets and services and considered in decision making processes.
- **The precautionary principle**. Requires a risk averse approach to decision making. Where there are threats of serious or irreversible environmental damage, lack of full scientific certainty is not to be used as a reason for postponing measures to prevent environmental degradation.

The Policy has adopted nine goals within this framework which include:

- Protecting, rehabilitating and improving the natural environment of the coastal zone.
- Recognising and accommodating the natural processes of the coastal zone.
- Protecting and enhancing the aesthetic qualities of the coastal zone.
- Protecting and conserving the cultural heritage of the coastal zone.
- Providing for ecologically sustainable development and use of resources.

- Providing for ecologically sustainable human settlement in the coastal zone.
- Providing for appropriate public access and use.
- Providing information to enable effective management of the coastal zone.
- Providing for integrated planning and management of the coastal zone.

3.6 Environmental Planning and Assessment Act 1979

The Environmental Planning and Assessment Act 1979 (EP&A Act) provides the legal mechanism for land use planning and development control in NSW. The objectives of the EP&A Act are intended to regulate land in a manner that promotes orderly economic and social development while minimising any potential environmental impacts.

Clause 92 of the Environmental Planning and Assessment Regulation 2000 (EP&A Regulation) requires a consent authority to consider the NSW Coastal Policy in determining a development application for the purposes of section 79C (1)(a)(iv) of the Environmental Planning and Assessment Act 1979 (EP&A Act).

The section 117 Direction No. 6 – Coastal Protection (reissued by the Minister on 30 September 2005) also lists matters that council must do in drafting their LEPs. This includes having provisions to give effect to the NSW Coastal Policy, NSW Coastline Management Manual and the Coastal Design Guidelines.

Part 3 of the EP&A Act establishes the framework for environmental planning instruments (EPIs) such as State environmental planning policies (SEPPs) and local environmental plans (LEPs) that apply to all local government areas in NSW.

According to Section 111 of the Act, a determining authority (which in this case is Gosford Council), has a duty to consider the environmental impact of any proposed works. Section 112 prescribes that a determining authority shall not carry out an activity, or grant an approval in relation to an activity, that is likely to significantly affect the environment (including critical habitat) or threatened species, populations or ecological communities, or their habitats, unless they have considered an environmental impact statement in respect of the activity.

Clause 228 of the Environmental Planning and Assessment Regulation 2000 (EP&A Regulation) sets out the factors which must be taken into account when consideration is being given to the likely impact of an activity on the environment where an EIS is required. The factors specifically include an assessment of ‘any impact on coastal processes and coastal hazards, including those under projected climate change conditions’.

Environmental impacts of potential management options for dealing with the coastal hazards within the study area could be adequately assessed through a Review of Environmental Factors (REF) and could be self determined by Council. The level of detail and extent of assessment provided in the REF will depend on the complexity of the environmental impacts of the proposed activity.

If the activity is likely to significantly affect critical habitat, or threatened species, populations or ecological communities or their habitats, a Species Impact Statement (SIS) and/or an Environmental Impact Statement (EIS) must be considered.

If an EIS is necessary, it must be prepared in accordance with Schedule 2 to the Regulations and the Director-General of Planning for their requirements. The EIS must be placed on public exhibition for at least 30 days and forwarded to the Director-General. If a SIS is required, the determining authority must obtain the concurrence of the Director-General of the Department of Planning.

3.6.1 State Environmental Planning Policy (Infrastructure) 2007

The State Environmental Planning Policy (Infrastructure) 2007 (known as the Infrastructure SEPP) assists in providing new infrastructure by introducing updated planning provisions to improve efficiency and service delivery.

The Infrastructure SEPP assists local government, the NSW Government and the communities they support, by simplifying the process for providing essential infrastructure including:

- electricity transmission and distribution
- emergency services facilities
- flood mitigation works
- gas transmission and distribution
- health services facilities
- housing and group homes
- parks and other public reserves
- port, wharf and boating facilities
- public administration buildings and buildings of the Crown
- road and traffic facilities
- sewerage systems
- soil conservation works
- stormwater management systems
- telecommunications networks
- waste or resource management facilities
- water supply systems
- waterway or foreshore management activities

'Waterway or foreshore management activities' are regulated under Division 25 of the Infrastructure SEPP. This definition includes 'Coastal Protection Works' as defined under the CP Act (Clause 128(d)). Clause 129(1) of the Infrastructure SEPP states that 'development for the purpose of waterway or foreshore management activities may be carried out by, or on behalf of a public authority without consent on any land'.

Clause 129(2A) states that prior to any development taking place, the provisions of a CZMP must be considered. If a plan is not in force, then the public authority must notify the Coastal Panel before carrying out the development, and take into consideration any response received from the Panel.

Note that new coastal protection works excludes beach nourishment works. Therefore if any erosion remediation works are required to be carried out prior to the CZMP being put in place, Council would need to notify the Coastal Panel.

It is important to note that the provisions of the Infrastructure SEPP, a state environmental planning policy, would prevail over any inconsistency with a local environmental plan.

3.6.2 State Environmental Planning Policy 14 Coastal Wetlands

SEPP 14 was introduced in 1985 to protect coastal wetlands in the environmental and economic interested of the State. The Policy requires the preparation of an EIS, the consent of local council and the concurrence of the NSW Director General for development in affected wetlands. Development Applications may be refused when the proposal involves the irrevocable destruction of large areas of wetland. In cases where development proceeds, concurrence is generally granted subject to a number of conditions specific to the site. Proposals are more likely to succeed if they include offsetting damage to wetlands by restoration or other mitigation measures. In this way, SEPP 14 has attempted to ensure that developments in wetlands have little impact on wetland values.

Any development within the mapped SEPP 14 areas would need the requirements of Clause 7 of the SEPP.

3.6.3 State Environmental Planning Policy 71 Coastal Protection

This policy has been made under the Environmental Planning and Assessment Act 1979 to ensure:

- development in the NSW coastal zone is appropriate and suitably located
- there is a consistent and strategic approach to coastal planning and management
- there is a clear development assessment framework for the Coastal Zone.

SEPP 71 aims to:

- foster a strategic and consistent approach to coastal planning and management

- ensure that the coastal zone is managed and protected in accordance with ecologically sustainable development principles
- facilitate the assessment of development proposals, and assess each proposal on its individual merits
- set out matters for consideration by councils and consent authorities
- develop a review process for significant coastal development proposals, which includes development proposed in sensitive locations
- create a DCP process to ensure developments involving particular types of subdivisions in the coastal zone are consistent with the SEPP's provisions.

Key provisions of SEPP 71 include:

- the need for councils to consider certain matters in preparing a draft LEP and in determining a development application (clause 8)
- referral of significant coastal development proposals, (as detailed in clause 9) to the Director General of the Department of Planning (clause 11). This includes development in ‘sensitive coastal locations, or within 100m below mean high water mark
- the need for DCPs, adopted by the Minister for Planning, where there is subdivision of residential or rural residential land (as detailed in clause 18).

3.7 Local Government Act 1993

The purposes of this Act are as follows:

a. *to provide the legal framework for an effective, efficient, environmentally responsible and open system of local government in New South Wales,*

b. *to regulate the relationships between the people and bodies comprising the system of local government in New South Wales,*

c. *to encourage and assist the effective participation of local communities in the affairs of local government,*

d. *to give councils:*

   i. *the ability to provide goods, services and facilities, and to carry out activities, appropriate to the current and future needs of local communities and of the wider public*

   ii. *the responsibility for administering some regulatory systems under this Act*

   iii. *a role in the management, improvement and development of the resources of their areas,* *e. to require councils, councillors and council employees to have regard to the principles of ecologically sustainable development in carrying out their responsibilities.*

Powers of compulsory acquisitions are given to Council pursuant to Section 186 of the *Local Government Act 1993* (LG Act) to 'acquire land … for the purpose of exercising any of its functions'. Its function is defined as the following in Section 24, 'A council may provide goods, services and facilities, and carry out activities, appropriate to the current and future needs within its local community and of the wider public, subject to this Act, the regulations and any other law'.

The process associated with acquisition of land, either compulsory or by agreement is set out in the *Land Acquisition (Just Terms Compensation) Act 1991* (JTCA). Section 7B of this Act allows councils to acquire land, even if the land is vested in the authority itself. Combined with Section 188(2)(a) of the LG Act, which states that a council may acquire land without the approval of the owner, if the land adjoins or lies in the vicinity of other land acquired at the same time (other than the purpose of resale).

Pursuant to Section 59A, the council is the owner of all works of water supply, sewerage and stormwater drainage installed in or on land by the council (whether or not the land is owned by the council). The council has the power to 'repair, replace, remove or do any other things that are necessary or appropriate to any of its works to ensure that, in the opinion of the council, the works are used in an efficient manner for the purposes for which the works were installed'.

Council can therefore carry out essential repairs and works to the water supply and sewer in areas subject to immediate coastal hazards pursuant to Section 59A of the LG Act.

In addition, section 733 of the *Local Government Act 1993* provides an exemption from liability for certain management actions by councils and the State Government relating to coastal management, provided these actions were made in good faith. Under this section, councils and the State Government are considered to have acted in good faith if the actions were undertaken substantially in accordance with the principles contained in the specified manual (the Guidelines referred to in Section 3.12).

3.8 Crown Lands Act

Much of the land comprising the actual beaches and foreshores of Gosford LGA is Crown land.

The *Crown Lands Act 1989* sets out how Crown land is to be managed. In particular:

- all actions are to be consistent with the 'principles of Crown land management'
- an assessment must be carried out prior to any dealings in Crown land (such as a lease)
- specific use of Crown land generally needs to be authorised by a lease, licence or other permit.

In summary, the principles of Crown land management are that, as appropriate:

- environmental protection principles be observed

- natural resources be conserved wherever possible
- public use and enjoyment, and multiple use be encouraged
- the land and its resources be sustained in perpetuity, and
- it be occupied, sold, or otherwise dealt with consistent with these principles.

Development on private land within the coastal zone should cater for the coastal hazards within the development site without reliance on adjoining or nearby Crown land. This is particularly so where that Crown land may also be constrained by the impacts of such coastal processes.

Section 55N of the *Coastal Protection Act* describes the modification of the doctrine of erosion and accretion, for the case where a land boundary is defined with reference to the high water mark. However, there are no such ambulatory boundaries for properties bounding the beaches within the study area and the doctrine of erosion and accretion would not apply. All boundaries for private development within the beaches of the study area are defined by cadastral lots with a set seaward boundary (i.e. not ambulatory), with separate Crown Land lots defined seaward of these. However, Corkill (2013) notes that should the seaward boundary of these lots eventually be below HWM as a result of "gradual erosion or diluvion" the land below the HWM would revert to the Crown. This has not occurred at the present time within the study area.

According to the *Coastal Protection Act 1979,* a Coastal Authority that is a designated authority for land on which a person has placed temporary coastal protection works may order the person to remove, alter or repair the works and restore the land if the Coastal Authority is of the opinion that the works "*unreasonably limit public access to a beach or headland"*. This could conceivably occur if the temporary protection works are constructed on the seaward boundary of a beachfront property and the Crown Land in front of the property is subject to long term recession, if the recession is gradual and imperceptible.

Where the MHWM has eroded suddenly (e.g. as occurred in the storms of 1974 and 1978) and the processes causing the change did not satisfy the doctrine or erosion or accretion (i.e. natural, gradual and imperceptible erosion), then the former position of the natural feature boundary will not change.

3.9 Land Acquisition (Just Terms Compensation) Act 1991

The JTCA outlines the formal process where land is to be purchased by either agreement or compulsory acquisition. It does not apply to any such acquisition if the land is available for public sale and the land is acquired by agreement. Pursuant to Section 30, Council and the owners of the land may agree that the land may be compulsorily purchased by Council and therefore the procedures are minimised if the owners have agreed on all relevant matters concerning the acquisition and the compensation to be paid.

3.10 Fisheries Management Act 1994

The *Fisheries Management Act 1994* is administered by NSW Department of Primary Industries and includes the need for permits under Part 7 of the Act for the following activities:

- dredging and reclamation;
- temporarily or permanently obstructing fish passage; and
- harming marine vegetation.

Should any of the proposed management options under the Coastal Zone Management Plan include these activities, a permit would be required from the NSW Department of Primary Industries under the *Fisheries Management Act 1994*.

3.11 Threatened Species Conservation Act 1995

The *Threatened Species Conservation Act* (*TSC Act*) 1995 outlines the protection of threatened species, communities and critical habitat in NSW. Schedules 1, 1A and 2 of the *TSC Act* 1995 list endangered, critically endangered and vulnerable species and ecological communities. Schedule 3 of the *TSC Act* 1995 lists key threatening processes (defined as processes that could adversely affect threatened species, populations or ecological communities or that cause a species, population or ecological community to become threatened). Part 3 of the *TSC Act* 1995 allows for declaration of critical habitat for endangered species, populations and ecological communities and critically endangered species and ecological communities.

The *TSC Act* 1995 also provides information on Species Impact Statements (SIS). The *EP&A Act* 1979 requires a SIS be prepared in the event that an activity is being undertaken within a declared critical habitat or is likely to significantly affect threatened species, populations or ecological communities, or their habitats. In order to determine whether an activity is likely to significantly affect threatened species, populations or ecological communities, a seven part test under Section 5A of the *EP&A Act* 1979 is required for threatened species, populations or ecological communities that have the potential to be impacted by a proposal.

Following environmental assessment, should the adopted coastal management measures be deemed to have a detrimental impact on threatened species, a Species Impact Statement may be required under the *Threatened Species Conservation Act 1995* (TSC Act).

3.12 Guidelines for Preparing Coastal Zone Management Plans (OEH 2013)

The Guidelines for Preparing Coastal Zone Management Plans (OEH 2013) provide the framework for preparation of a Coastal Zone Management Plan. The Guidelines replace the Coastline Management Manual (1990) and Estuary Management Manual (1992). The Coastal Zone Management Plan (CZMP) should describe proposed actions to be implemented by Council, other public authorities and potentially by the private sector to address priority management issues in the coastal zone. The CZMP should support the goals and objectives of the Coastal Policy (1997).

In addition, section 733 of the *Local Government Act 1993* provides an exemption from liability for certain management actions by councils and the State Government relating to coastal management, provided these actions were made in good faith. Under this section, councils and the State Government are considered to have acted in good faith if the actions were undertaken substantially in accordance with the principles contained in the specified manual (the Guidelines).

The Guidelines specify several Coastal Management Principles, which have been developed to inform strategic considerations in coastal management, including the preparation of CZMPs. The Coastal Management Principles are illustrated in Figure 16, below.

The Guidelines also stipulate minimum requirements for CZMPs. CZMPs are to include:

- a description of how the relevant Coastal Management Principles have been considered in developing the Plan
- a description of the community and stakeholder consultation process
- a description of how the proposed management options were identified, the process followed to evaluate management options and the outcomes of the process
- proposed management actions over the CZMP's implementation in a prioritized implementation schedule

The Guidelines also stipulate minimum requirements with respect to addressing coastal risks, including a description of coastal processes within the study area, the nature and extent of the risk to public safety and built assets, proposed actions to manage current and projected risks from coastal hazards, and an emergency action subplan.

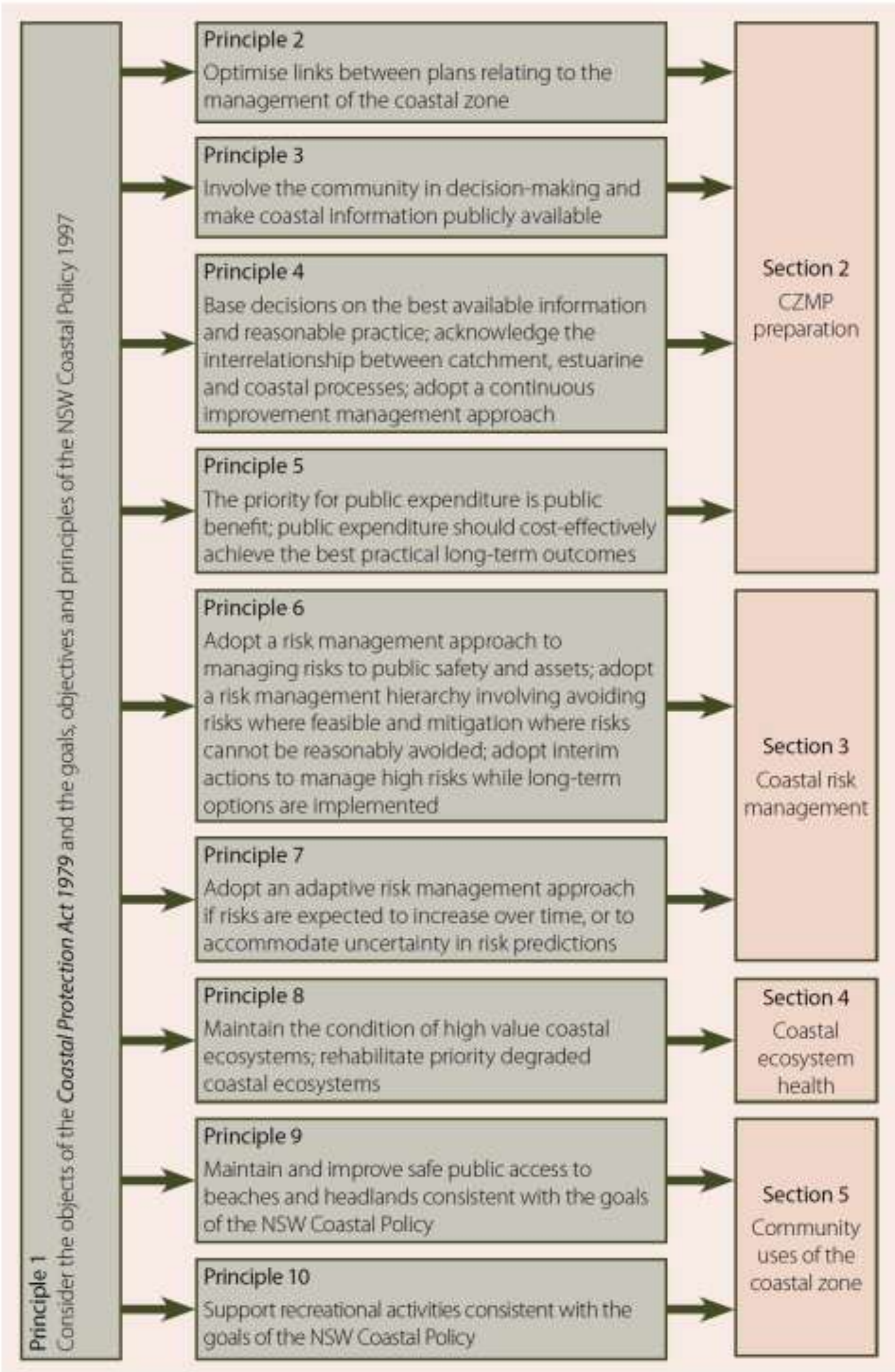

Figure 16 – Coastal Management Principles, Guidelines for Preparing Coastal Zone Management Plans (OEH 2013)

3.13 NSW Coastal Planning Guideline

The *NSW Coastal Planning Guideline: Adapting to Sea Level Rise* (Department of Planning, 2010), was released in August 2010. This is designed to support NSW Government policy and, as such, Councils are to have regard to it when addressing sea level rise matters in land use planning and development assessment in coastal areas.

The Guideline adopts the following six coastal planning principles for sea level rise adaptation:

1. Assess and evaluate coastal risks taking into account the NSW sea level rise planning benchmarks
2. Advise the public of coastal risks to ensure that informed land use planning and development decision-making can occur
3. Avoid intensifying land use in coastal risk areas through appropriate strategic and land-use planning
4. Consider options to reduce land use intensity in coastal risk areas where feasible
5. Minimise the exposure to coastal risks from proposed development in coastal areas
6. Implement appropriate management responses and adaptation strategies, with consideration for the environmental, social and economic impacts of each option.

Also, based on Department of Planning (2010), consent authorities should take into consideration the:

- location of the development site in relation to coastal risk areas (see Figure 17 and Figure 18[11]);
- *NSW Sea Level Rise Policy Statement* including the sea level rise planning benchmarks (as these are no longer Government Policy, Gosford City Council's Sea Level Rise benchmarks apply);
- level of risk associated with the type and extent of development proposed;
- whether the development can achieve the planning criteria, including for a defined period of time;
- whether the development incorporates appropriate management responses and adaptation strategies, commensurate with the level of risk associated with the site location and the type of development being proposed;
- issues raised in public submissions; and,
- advice/general terms of approval from State agencies.

[11] Note that it is assumed that "creek/river" in Figure 18 also applies to the ocean.

In addition to Department of Planning (2010), it is stated in the same that consent authorities should also have regard to other relevant policies and development controls that apply to the development and the subject site. For Gosford LGA, this would be Gosford 2013 DCP Chapter 6.2 “Coastal Frontage” in relation to coastal engineering matters.

It is evident from Figure 17 and Figure 18 that development seaward of the Immediate Hazard Line is considered to be typically unsuitable, while for development seaward of the 2100 Hazard Line (and landward of the Immediate Hazard Line) a Development Application requires merit assessment against the coastal erosion clause in the Council LEP (and Chapter 6.2 of the Gosford Development Control Plan 2013) and planning criteria in Department of Planning (2010).

It is noted that the Department of Planning (2010) defines the Immediate Hazard Line as a “*mapped line representing the estimated extent of beach erosion from an extreme oceanic storm event plus any allowance for reduced foundation capacity.*” This differs from the way that coastal hazard lines have been defined in the previous coastal risk assessments for the Gosford LGA, where the erosion lines for the purpose of defining the existing Gosford DCP was defined as the landward limit of the *Zone of Slope Adjustment*. Development in areas seaward of the *Zone of Slope Adjustment* would be typically unsuitable, but an option to mitigate the risk to development in areas that are seaward of the *Zone of Reduced Foundation Capacity* is the use of deep pile foundations for new development, as adopted in the existing DCP.

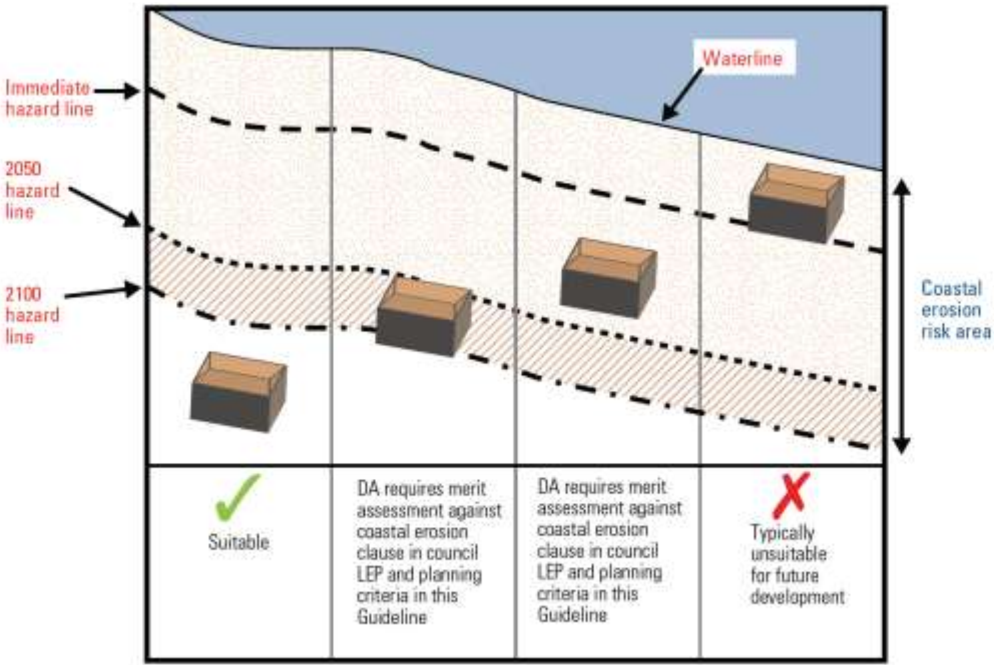

Figure 17 – Suitability of development positions in relation to erosion/recession hazard lines as described by Department of Planning (2010)

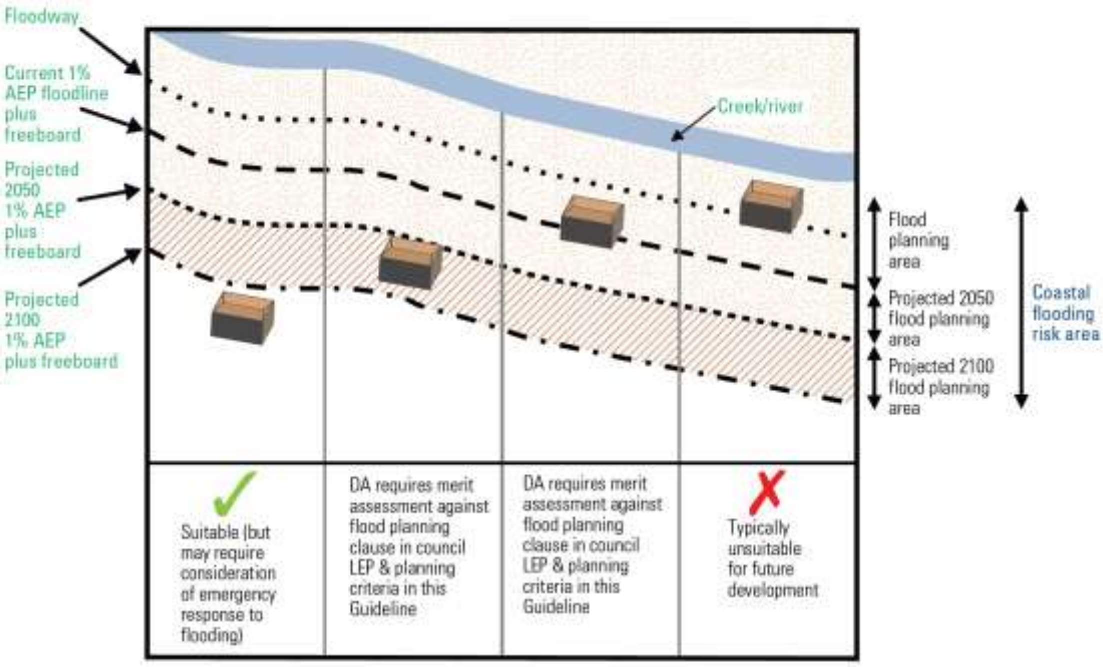

Figure 18 – Suitability of development positions in relation to oceanic inundation levels as described by Department of Planning (2010)

The planning criteria in Department of Planning (2010) are as follows:

1. development avoids or minimises exposure to immediate coastal risks (within the immediate hazard area or floodway);
2. development provides for the safety of residents, workers or other occupants on-site from risks associated with coastal processes;
3. development does not adversely affect the safety of the public off-site from a change in coastal risks as a result of the development;
4. development does not increase coastal risks to properties adjoining or within the locality of the site;
5. infrastructure, services and utilities on-site maintain their function and achieve their intended design performance;
6. development accommodates natural coastal processes including those associated with projected sea level rise;
7. coastal ecosystems are protected from development impacts; and,
8. existing public beach, foreshore or waterfront access and amenity is maintained.

3.14 Guide to the Statutory Requirements for Temporary Coastal Protection Works (2013)

The Guide published by OEH (2013) is designed to help landowners understand the statutory requirements for installing, maintaining and removing temporary coastal protection works, and how following these rules helps protect the NSW coastal environment.

Temporary coastal protection works are defined as sand, or geotextile fabric bags filled with sand, placed on a beach or a sand dune adjacent to a beach. They can be placed by landowners who wish to undertake temporary action to reduce erosion impacts on their property.

Temporary coastal protection works can be placed:

(i) only at authorised locations along the NSW coastline

(ii) at any time on private land

(iii) on other (adjacent) private land, with the permission of the owner of the adjacent land

(iv) on public land, with the written authority of the public land owner and a certificate issued from the relevant local council, public authority or OEH.

The Guide outlines that landholders should ensure the works do not:

- cause increased erosion of a beach or land adjacent to a beach
- unreasonably limit public access to a beach at times of both high and low tide
- pose a threat to public safety
- use sand taken from a beach or a sand dune adjacent to a beach
- use rocks, concrete, construction waste or other debris.

According to the Guide, landowners may also apply to construct other types of coastal protection works of a larger scale than temporary coastal protection works and which include long-term protection works or alternate temporary or short-term protection works. These works will need approvals under various Acts, including the *Environmental Planning and Assessment Act 1979*. The landowners will need to demonstrate that they (and their successors in title) commit to maintaining the works and managing any off-site erosion impacts.

Temporary coastal protection works are only permitted to be placed at selected authorised locations. Authorised locations for placing works and associated beach access locations are named in the Guide to the Statutory Requirements for Temporary Coastal Protection Works (OEH 2013) and the Code of Practice under the Coastal Protection Act 1979. In the study area, authorised locations where works can be placed and beach access points include:

- Avoca Beach (south), South Avoca (South Avoca Surf Life Saving Club carpark)

- North Avoca Beach, North Avoca (View Street)
- Forresters Beach (Kalakua Avenue, opposite Henrys Road)
- Copacabana – MacMasters Beach, MacMasters Beach (Gerda Road and Del Monte Place)
- Patonga Beach, Patonga (Brisk Street)
- Pearl Beach (Coral Crescent, Pearl Parade, Gem Road); and
- Wamberal Beach (adjacent to Wamberal Surf Life Saving Club, Dover Road).

3.15 Guide for authorised officers under the Coastal Protection Act (2010)

Councils can appoint *authorised officers* to exercise certain compliance functions under the *Coastal Protection Act 1979.* This guideline describes the role of these officers and their powers in relation to placement and removal of temporary coastal protection works and to regulate activities under the *Coastal Protection Act 1979.*

Practical requirements in relation to the issuing of orders and notices under the *Coastal Protection Act* are outlined in this document, which is still in Draft form and has not yet been formally adopted (as of April 2015).

3.16 Coastal Zone Management guide note - Emergency Action subplans (2011)

The Guide Note provides the minimum requirements that must be addressed when preparing a CZMP and an emergency action subplan. These include:

- describing intended emergency actions to be carried out during periods of beach erosion, such as coastal protection works for property or asset protection, other than matters dealt with in any plan made under the *State Emergency and Rescue Management Act 1989* relating to emergency response (sections 55C(1)(b) and (g) of the Coastal Protection Act 1979)
- describing any site-specific requirements for landowner emergency coastal protection works
- describing the consultation carried out with the owners of land affected by a subplan.

An “emergency” is defined in the *State Emergency and Rescue Management Act 1989* and the NSW State Disaster Plan as:

> “an emergency due to an actual or imminent occurrence (such as fire, flood, storm, earthquake, explosion, terrorist act, accident, epidemic or warlike action) which:

(a) endangers, or threatens to endanger, the safety or health of persons or animals in the State; or

(b) destroys or damages, or threatens to destroy or damage, any property in the State, being an emergency which requires a significant and co-ordinated response.

For the purposes of the definition of emergency, property in the State includes any part of the environment of the State. Accordingly, a reference in the Act to:

(a) threats or danger to property includes a reference to threats or danger to the environment, and

(b) the protection of property includes a reference to the protection of the environment."

A "beach erosion emergency" in the context of an emergency action subplan can therefore be defined as an actual or imminent occurrence of a beach erosion event which "endangers, or threatens to endanger, the safety or health of persons or animals" or "destroys or damages, or threatens to destroy or damage, any property, being an emergency which requires a significant and co-ordinated response."

Section 55C(1)(b) of the *Coastal Protection Act 1979* states a CZMP must provide for 'emergency actions carried out during periods of beach erosion, including the carrying out of related works, such as works for the protection of property affected or likely to be affected by beach erosion, where beach erosion occurs through storm activity or an extreme or irregular event'. Section 4 of the Act states that the part of a CZMP that deals with the matters specified in Section 55C(1)(b) is an emergency action subplan. The *Coastal Protection Act 1979* (sections 55B and 55C) allow the Minister administering the Act to issue a direction to a council to prepare an emergency action subplan, i.e. a CZMP that only includes the requirements under Section 55C(i)(b).

While an emergency action subplan of a CZMP is required under these provisions, Section 55C(2)(a) of the *Coastal Protection Act 1979* requires that CZMPs **must not** include matters dealt with in any plan made under the *State Emergency and Rescue Management Act 1989* (SERMA) in relation to emergency responses.

An Emergency Action Subplan (EAS) has been developed for Wamberal Beach and has been publicly exhibited as per requirements of the *Coastal Protection Act 1979.* The EAS will be included as an Appendix to the CZMP once it is finalised.

3.17 Coastal Protection Service Charge Guidelines (2010)

These statutory Minister's guidelines describe how a council should calculate the coastal protection service charge to be levied on land under the *Local Government Act* (OEH 2013).

The coastal protection service charge (CPSC) is a charge that councils can levy on a parcel of rateable land where either the current or previous owner has voluntarily:

- constructed or contributed to the cost of constructing long-term coastal protection works, such as seawalls, that benefit the land, or
- agreed to pay the charge relating to works that existed prior to the commencement of the *Local Government Act 1993* amendments that introduced this charge.

It describes how councils should calculate the reasonable costs of providing a coastal protection service and how these costs should be apportioned between the various parcels of land subject to the charge. The Guide states that these works voluntarily constructed by landowners need to be properly maintained and impacts mitigated for the life of the works, to protect against transferring erosion problems.

The Guide describes the legal avenues and legislative framework for Councils to obtain funding from ratepayers directly benefiting from coastal protection works. It describes an alternative to a CPSC for funding coastal protection activities, which is for a council to levy a 'special rate' (provided for in section 495 of the *Local Government Act 1993*) on those rate payers benefiting from the work. Section 495 of the *Local Government Act 1993* provides that a council may make a 'special rate' for or towards meeting the cost of any works, services, facilities or activities provided or undertaken, or proposed to be provided or undertaken, by the council within the whole or any part of the council's area, other than domestic waste management services. A special rate could be differential, where a higher rate applies to land directly benefiting from works funded by the special rate and a lower or no rate applied to land that does not benefit from the works. The Guide also notes that landowners can apply for development consent if they want to construct works to protect their property from coastal erosion.

"Coastal protection services" are defined by these guidelines as including:

- maintenance and repair of coastal protection works and managing the impacts of coastal protection works.
- works voluntarily constructed by a benefiting landowner (or landowners)
- works constructed jointly by a public authority (e.g. council) with voluntary contributions from benefiting landowners
- works that existed before section 496B of the Local Government Act 1993 commenced, where the landowner or a previous landowner voluntarily agreed to pay the CPSC
- works that existed before section 496B of the Local Government Act 1993 commenced, where the landowner has voluntarily agreed to upgrade the works. A pro-rata CPSC then applies, based on the incremental additional costs of maintaining the works and managing their off-site impacts.

The Guidelines also outline the circumstances under which local councils <u>cannot</u> levy a CPSC. Councils <u>cannot</u> levy a CPSC:

- to maintain emergency coastal protection works placed by or on behalf of landowners,

- under the provisions of Part 4C of the Coastal Protection Act 1979. All costs associated with these works are the responsibility of the landowner
- to construct coastal protection works. Councils could fund construction from ordinary rate income, a special rate or from external grant funding
- to maintain works constructed by or on behalf of a public authority, with no landowner financial contribution. These costs could be recovered through ordinary or special rate revenue
- on land that may physically benefit from coastal protection works funded by landowners, but where the owner of the land (current or past) did not contribute to the cost of constructing the works. This may apply, for example, to a parcel of land behind beachfront.

3.18 Code of Practice under the Coastal Protection Act 1979 (2013)

The Code of Practice document details requirements for placement of temporary coastal protection works as described in the following sections of the *Coastal Protection Act 1979*:

- placement of material that forms part of temporary coastal protection works under the provisions of section 55P(2)(f)
- maintenance of temporary coastal protection works under the provisions of section 55R(1)(d)
- removal of temporary coastal protection works on public land under the provisions of section 55VC(1)(b)
- removal of certain material and structures unlawfully placed on beaches under the provisions of section 55ZA(3)(b)
- restoration of land, including public land, under certain circumstances under the provisions of section 55ZC(5)(b).

Sand, sandbag and geotextile requirements for these works are defined as are safety requirements and other general requirements.

Temporary coastal protection works are only permitted to be placed at selected authorised locations as named in the Guide to the Statutory Requirements for Temporary Coastal Protection Works (OEH 2013). According to the Code of Practice, vehicular access to a beach at an authorised location must only be via authorised access points. Note that the property owner does not have permission to access the beach with a vehicle directly from their property for placement of the works, and access must be via the authorised access point. As Council does not have any "authorised officers" under the *Coastal Protection Act 1979*, regulating the placement of emergency coastal protection works is the role of OEH.

4 SUMMARY OF COASTAL PROCESSES

This section of the report summarises the relevant coastal processes prevalent along the study area coastline. Coastal management options developed for the beaches in the study area need to be developed based on a detailed understanding of the local coastal processes operating within each precinct at each beach, to ensure that they are compatible with the coastal processes.

The coastal processes and coastal hazards are described and quantified in detail in the Coastal Process and Hazard Definition Study (WorleyParsons 2014). That assessment led to the development of Coastline Hazard Lines for the immediate, 2050 and 2100 planning periods (representing the predicted extent of erosion for a severe coastal storm) for the study area that take into account the sea level rise planning benchmarks adopted recently by Gosford City Council at its Ordinary Meeting of 20 August 2013 and make allowance for reduced foundation capacity as required now by the *Guidelines for Preparing Coastal Zone Management Plans* (OEH 2013).

Historically, coastal processes have threatened sections of the coast within the study area. In particular, Wamberal Beach on the open coast experienced severe erosion in 1974, 1978, 1986 and 1997. In May-June 1974 many houses were threatened and in June 1978 beach and dune erosion, attributed to an intense rip cell, undermined and destroyed two houses. Damage to public assets and recreational amenity has also been experienced at other beaches in the Gosford area.

In this Section, the coastal processes prevalent along the study area coastline are summarised. In particular, details are provided on:

- wave climate (**Section 4.1**);
- elevated water levels (**Section 4.2**);
- wave runup (**Section 4.3**);
- coastal storms (**Section 4.4**);
- sediment transport (**Section 4.5**);
- climate change (**Section 4.6**); and
- lagoon entrance processes (**Section 4.7**).

4.1 Wave Climate

The study site is located in the south-west Pacific at around 33.5°S and receives waves generated in the southern Coral and Tasman Seas and the Southern Ocean. Although moderate waves dominate the climate, large waves (*significant* wave height Hs[12]>4 m) and/or low swell may occur

[12] Significant wave height, or Hs, refers to the average height of the highest one-third of the waves in a wave record.

in any month. Extreme events (Hs>6m) occur predominately in autumn and winter (Short and Trenaman 1992).

The majority of offshore waves and storm waves propagate from the S-SE sector. N-NE waves account for only a small percentage of the offshore wave energy and storm waves. The largest period waves typically occur from the S-SE sector in the winter months.

The wave height likely to occur or be exceeded, on average, every 100 years was estimated to be 9.3 m. This value compares well with previously reported values for the 100 year return significant wave height for the Sydney region.

As waves approach the shore, they may be transformed by the processes of refraction, shoaling, diffraction, attenuation, reflection and breaking. Typically, waves break in a water depth about equal to the wave height.

Analysis of the nearshore wave climate indicates that offshore waves from the SSE and SE generally produce the largest inshore wave heights in the study area. The highest wave heights in the study area were determined offshore at Forresters Beach, which is likely related to wave focussing on the rocky reef.

Wave climate within the study area is described in detail in the Coastal Processes and Hazard Definition Study (WorleyParsons 2014).

4.2 Elevated Water Levels

In NSW, open coast still water levels (within the wave breaking zone) can increase by up to about 2.1 m above normal levels during storms due to storm surge and wave setup, with components approximately as large as follows:

- storm surge of up to 0.7 m (barometric setup of up to 0.3 m to 0.4 m and wind setup of up to 0.2 m to 0.3 m); and
- wave setup of up to 1.5 m (caused by breaking waves, typically about 10-15% of the deepwater significant wave height).

This increase in water level is superimposed on the astronomical tide, which typically varies between about –1m AHD and 1m AHD along the NSW coast, with 0m AHD close to mean sea level. On the NSW coast, Mean High Water Springs is about 0.6m AHD, Mean High Water is about 0.5m AHD, and Mean High Water Neaps is about 0.4m AHD.

Assuming extreme water levels in Sydney were representative of conditions between Patonga (within Broken Bay) in the south to Forresters Beach in the north, a 100 year ARI water level (including astronomical tide and storm surge) of 1.5m AHD can be adopted.

Wave setup can be expected to vary along the study area depending on wave exposure. Assuming wave setup as being equal to 15% of the maximum 100 year ARI significant wave height, the estimated wave setup values ranged from 0.3 to 1.2 m and the estimated 100 year ARI total design still water levels ranged from 1.8 to 2.7 m.

The derivation of elevated water levels in the study area is described in detail in the Coastal Processes and Hazard Definition Study (WorleyParsons 2014).

4.3 Wave Runup

Wave runup is site specific, but typically reaches a maximum level of about 7 m AHD on the open NSW coast at present. The height of wave runup on beaches depends on many factors, including:

- wave height and period;
- the slope, shape and permeability of the beach;
- the roughness of the foreshore area; and
- wave regularity.

Wave runup can be difficult to predict accurately due to the many factors involved. Anecdotal evidence and the surveying of debris lines following a storm event usually provide the best information on wave runup levels.

A comprehensive assessment of wave runup was undertaken in detail in the Coastal Processes and Hazard Definition Study (WorleyParsons 2014), for each beach in the Gosford LGA, while an assessment of potential inundation levels near the entrances to Cockrone Lagoon, Avoca Lake, Terrigal Lagoon and Wamberal Lagoon was also completed. The calculated design wave runup levels (exceeded by 2% of waves) ranged from 2.0 to 8.0 m AHD.

The runup levels calculated would only be realised if the foreshore was at this runup height or higher. In reality, any waves that overtopped dunes or creek banks in the study area would fold over the foreshore crest and travel as a sheet flow at shallow depth, spreading out and infiltrating over landward areas. Accordingly a significant reduction in the velocity and depth of runup would be expected within about 10 m from the foreshore crest.

4.4 Coastal Storms

The NSW coastline is subject to intense tropical and non-tropical storms at irregular intervals. The drop in atmospheric pressure and the winds and waves that accompany these storms can cause the ocean to rise above its normal level (see **Section 4.2**). If this occurs concurrently with high astronomical tides, there is the potential for:

- coastal erosion (in particular as the storm waves dissipate energy closer to the shoreline with the increased water levels); and/or
- overwash into low-lying coastal areas (PWD 1985).

PWD (1985a) recognised six different major storm types which impacted on the NSW coast, namely:

- tropical cyclones;
- easterly trough lows;
- inland trough lows;
- continental lows;
- southern secondary lows; and
- anti-cyclonic intensification.

The spatial variation in occurrence of these six storm types along the NSW coast (PWD, 1985; PWD 1986) indicates that, on average:

- the Central Coast (incorporating the study area) and South Coast have more storms than areas further north in NSW;
- southern secondary lows and easterly trough lows are the dominant storm types on the Central Coast; and,
- most storms on the Central Coast occur in Autumn and Winter, in particular due to the prevalence of southern secondary lows and easterly trough lows during these seasons.

The key storms to affect the study area occurred in May-June 1974, May-June 1978, September 1985, August 1986, September 1995, May 1997, and June-July 2007.

The damaging storms in the study area have generally been or been preceded by sequences of storms, often not particularly severe storms in isolation. A key factor in the erosiveness of a storm, besides the storm energy, is also the water level occurring during the storm.

The study area has been subject to damaging coastal storms in the past, and can thus be expected to again be exposed to such storms at irregular intervals in the future. These storms are most likely to occur in Autumn and Winter, and are least likely to occur in Summer, but can generally occur at any time.

The occurrence and impact of coastal storms in the study area has been described in detail in the Coastal Processes and Hazard Definition Study (WorleyParsons 2014).

4.5 Sediment Transport

In the region between where waves break and the shoreline, two processes can result in net sediment transport, namely longshore sediment movement and onshore / offshore (termed cross-shore) sediment movement.

Longshore currents essentially move parallel to the shoreline. These currents cause movement of sediment along the shoreline, commonly referred to as littoral drift. Based on analysis of historical beach profile data, it is unlikely that there has been extensive net longshore sediment transport at the open coast beaches along the Gosford LGA coastline in the last 60 or so years. The extensive offshore reef systems for Avoca, Terrigal-Wamberal, Forresters and MacMasters Beach would limit the drift supply further offshore and limit longshore transport of sand.

Sediment transport processes within Broken Bay are dominated by estuarine circulations, particularly in the vicinity of major creek and lagoon entrances. In particular, the wide ranging sand shoals fringing the entrance to Brisbane Water has a large influence on sand volume fluctuations at Ocean Beach.

Onshore/offshore sand movement is caused by natural variations in wave climate and water level. The offshore movement of sand is usually referred to as storm erosion. This onshore/offshore movement of sand results in short term fluctuations in the width of the beach profile.

Net sediment transport can also occur due to movement of windblown sand. Along the Gosford open coast beaches there is generally coverage of some dune vegetation or an elevated seawall landward of the beach, although vegetation coverage is limited in some areas due to the proximity of development to the beach. Therefore, from an overall sediment budget perspective, there is likely to be minimal sand loss from beaches in the study area due to aeolian sand movement.

The various stormwater systems and lagoon entrances may also contribute sediment to or capture sediment from the beach system.

Sediment transport processes within the study area are described in the Coastal Processes and Hazard Definition Study (WorleyParsons 2014).

4.6 Climate Change

Climate change has been defined broadly by the Intergovernmental Panel on Climate Change (IPCC 2001) as any change in climate over time whether due to natural variability or as a result of human activity.

The possibility of global climate change accelerated by increasing concentrations of greenhouse gases, the so-called Greenhouse Effect, is now widely accepted by the scientific and engineering communities. This is predicted to cause globally averaged surface air temperatures and sea levels to rise.

The State Government, through its Stage 1 Coastal Reforms which came into effect in January 2013, stipulated that “Councils should consider information on historical and projected future sea level rise which is widely accepted by competent scientific opinion.” To this end, Gosford Council, at its Ordinary Meeting of 20 August 2013, endorsed a number of climate change scenarios relating to the Central Coast region. The climate change scenarios are intended to present a plausible future state of the climate in the region at different time periods and form the basis for risk assessment in this study. The indicative changes described in the scenarios are relative to the current period defined as the average climate experienced over the 1980 - 2007 period and are based on medium to high end of best available projections.

The scenarios were first published in 2010, in a report commissioned by the Hunter and Central Coast Regional Environmental Strategy (HCCREMS) called, Potential Impacts of Climate Change on the Hunter, Central and Lower North Coast of NSW (HCCREMS, 2010). That report was informed by a range of different sources, the most significant of which was a detailed analysis of historical climate variability in the Hunter, Central and Lower North Coast region of NSW (Blackmore & Goodwin, 2010). The methodology adopted by Blackmore and Goodwin in their analysis determined projected changes in key climate parameters using a weather typing approach to statistical downscaling from the CSIRO Mk3.5 Global Climate Model.

The scenarios (Table 7) include consideration of future climate as it relates to:

- Sea Level rise and storm surge
- Extreme rainfall, flooding and storms
- Fire weather
- Average and extreme temperatures
- Average rainfall and water availability.

Gosford Council's sea level rise planning benchmarks are being used for purposes such as incorporating the projected impacts of sea level rise on predicted flood risks and coastline hazards.

The sea level rise scenario is to be used in all relevant strategic processes whereby all relevant strategic documents are to incorporate the adopted sea level rise planning level.

Table 7: Climate Change Scenarios for Gosford (Sources: Blackmore & Goodwin, 2009, 2010; CSIRO, 2007; Macadam, McInnes and O'Grady, 2007; CSIRO, 2007b)

Climate Variable	Current[1] (indicative)	Indicative change[2] (relative to current)		Comments
		2050	2100	
1. Sea level rise and storm surge				
Sea level		↑ 0.4m	↑ 0.9m	Latest projections indicate SLR of up to 1.4m by 2100
Storm tide – max height, 1:100 ARI (average recurrence interval)	1.4m	1.8m	2.3m	Based on NSW design still water levels - excludes wave setup
Storm tide – ARI (1.4 m)	1:100	1:1	na	Limited regional modelling of recurrence intervals has been undertaken to date

Key

↑ increase; ↑↑ greater increase

↓ decrease, ↓↓ greater decrease

1. Current - average 1977-2007, 2. Indicative change - based on 'most likely' projections

For the investigation reported herein, coastline hazards are estimated for the:

- immediate planning period;
- 2050 planning period with sea level rise of 0.4m (as per Table 7);
- 2100 planning period with sea level rise of 0.9m (as per Table 7).

However, it should be noted that there is considerable uncertainty regarding these values, and future sea level rise could be smaller or larger than predicted. On 10 March 2015 Council considered a report in reviewing its sea level rise benchmarks. Council resolved to adopt a Sea Level Rise Planning Level based on RCP8.5 and the medium sea level rise projection as defined in an Independent Report, as a strategic position to inform Council's planning and plan making processes. The rates are as follows:

Local sea level rise projection (rates projected from current/2015 levels)

**Note: To obtain the absolute projected sea level elevation relative to AHD, a further 0.08m would need to be added to these values*

Year	Medium local sea level rise projection based on RCP8.5 measured in metres (m)
2015	**0.00**
2030	**0.07**
2050	**0.20**
2070	**0.39**
2100	**0.74**

Council also resolved that, every Council term or within two years of a new IPCC report, a review of the Sea Level Rise Planning level occurs.

It is generally expected that recession of the open coast will occur under conditions of accelerated sea level rise.

Further information on the projected impacts of climate change at the beaches in the study area can be sourced from the Gosford City Council Open Coast & Broken Bay Beaches Coastal Processes & Hazard Definition Study (WorleyParsons 2014).

4.7 Lagoon Entrance Processes

Four of the beaches within the study area are backed by lagoons, namely Cockrone (behind MacMasters Beach), Avoca, Wamberal and Terrigal (refer **Figure 1**). All four of the lagoons are intermittently open to the oceans and are classed as Intermittently Closed and Open Lakes or Lagoons (ICOLLs).

When closed, the lagoons are separated from the ocean by the beach berm. Breakout of the lagoon entrances occurs as flood levels in the lower estuary increase and overtop the berm, or

Council mechanically open the lagoon to alleviate flooding or to allow flushing of the lagoon for water quality purposes. Full breakout channel development typically takes 6 hours, although this is dependent on the magnitude and duration of the flood and prevailing ocean water level. A breakout may be of short duration if the floodwater discharge is not sufficient to significantly scour the entrance channel and/or coincides with high wave conditions, which can rapidly transport sediment back into the lagoon.

At times, waves can overtop the beach berm causing filling of the lagoons. Water levels in the lagoons are typically managed by Council for flood mitigation purposes, which in some cases has had a significant impact on estuarine hydraulics, water quality, sediment transport and ecological processes. The breakout levels in the entrance management policy are determined by the levels at which property inundation starts to occur. Oceanic conditions can sometimes interfere with the ability of Council to initiate mechanical openings at the estuary entrances.

Entrance processes for these lagoons are described further in the Coastal Processes and Hazard Definition Study (WorleyParsons 2014), and include:

- entrance migration;
- the effects of lagoon opening on surf zone processes;
- entrance scour; and
- an assessment of breakout modelling undertaken by Cardno Lawson Treloar (2010);

Other estuary entrances adjacent to the beaches in the study area include:

- Patonga Creek (Patonga Beach)
- Middle Creek, Green Point Creek and Pearl Beach Lagoon (Pearl Beach)
- Ettalong Creek (Umina Beach)

In general, these creeks and lagoons discharge across the beaches, breaking though the beach berms and causing scour channels during high flows. Movements of sand at lagoon and creek entrances are generally manifested by localised depressions in the beach surface and are unlikely to be significant in terms of the overall sediment budget. Further, these systems would not be expected to supply any significant quantities of sand to the beach system.

The Brisbane Water estuary, however, being a much larger system, does have an influence on the sediment budget for Umina Beach.

Lagoon and estuary entrance processes are described in more detail in the Coastal Processes and Hazard Definition Study (WorleyParsons 2014). They are described also in the Gosford Coastal Lagoons Processes Study (Cardno Lawson and Treloar 2010), Coastal Zone Management Study for Gosford Lagoons (BMT WBM 2014) and Coastal Zone Management Plan for Gosford Lagoons (BMT WBM 2014) which proposes a full review of lagoon entrance management procedures consistent this study.

5 SUMMARY OF COASTAL HAZARD ASSESSMENT

This section of the report summarises the relevant coastal hazards impacting each precinct at each beach within the study area. Coastal management options developed for the beaches in the study area need to be developed based on a detailed understanding of the present day and future risks to both natural and built assets from coastal hazards. Specific natural and built assets deemed to be at risk from coastal hazards in the present day and for the 2100 planning horizon have been summarised below and tabulated in Appendix 3, for all beaches within the study area.

5.1 Overview

The potential coastline hazards that could impact on the beaches in the Gosford LGA are defined in subsequent sections, namely:

- beach erosion hazard (**Section 5.2**);
- shoreline recession hazard (**Section 5.3**);
- sand drift hazard (Section **5.4**);
- coastal inundation hazard (**Section 5.5**);
- stormwater erosion hazard (**Section 5.6**); and
- climate change (**Section 5.7**); and
- slope and cliff instability hazard (**Section 5.8**).

The coastal processes and hazard assessment underpinning this study are detailed in the report titled Open Coast and Broken Bay Beaches – Coastal Processes and Hazard Definition Study (WorleyParsons, 2014). That document describes the coastal hazards that apply to the beaches and makes an assessment of the risks to property posed by these hazards.

Risks have been assessed for the previously mentioned hazards with consideration to current and future conditions (2050 and 2100) that include the natural processes that occur on Gosford's beaches and the impacts of projected climate changes. The coastal hazard lines represent a worst case scenario and developed in line with NSW Government requirements at the time and widely accepted coastal engineering methodologies. They represent a theoretical line which assists in guiding the development of appropriate management options to deal with defined risk. It must also be understood that they represent only one component in considering appropriate development going forward.

The risks to infrastructure at each beach in the study area for the immediate, 2050 and 2100 planning periods are summarised in Appendix 3.

The level of risk assigned to the coastal hazard assessment is a 100 year ARI event, equivalent to the erosion that could happen under a storm event that has approximately a 1% chance of occurring in any one year. The hazard lines represent the possible extent of erosion in any one location, including an allowance for slumping of the dune face. However, the line does not mean that the dune would erode back this far along the entire length of beach in the next large storm event. The line represents the possible extent of erosion, given that large rips can form in a storm and increase the volume of sand taken from the beach in the location directly landward of where the rip forms. The lines do not take into account geotechnical conditions at any particular location and assume the absence of bedrock or buried protective material.

The magnitude of storm event that could lead to the erosion predicted by the "*Zone of Slope Adjustment*" line in the hazard mapping is approximately equivalent to the storm event that occurred in May-June 1974. While other storms have occurred since that time, generally, (but not in all areas), they have been of lesser magnitude and caused less erosion damage than the 1974 storm.

5.2 Beach Erosion Hazard

During storms, large waves, elevated water levels and strong winds can cause severe erosion to sandy beaches (NSW Government 1990). The hazard of beach erosion relates to the limit of erosion that could be expected due to a severe storm, or from the effects of a series of closely spaced storms.

The erosion can be measured in terms of the volume of sand transported offshore or in terms of the landward movement of a significant beach feature.

The beach erosion hazard is analogous to the "storm demand". There are several methods to estimate storm erosion demand in the study area, including:

- analysing measurements of beach erosion that have been collected for the Broken Bay and open coast beaches;
- comparing measurements of beach erosion that have been collected at other similar beaches;
- storm cut numerical modelling;
- recently developed statistical joint probability type distribution approaches (i.e. estimating the joint occurrence of high water levels, high waves and high winds through data analysis or by statistical simulation of a multitude of synthetic storm events and assigning an annual recurrence interval to these); and
- correlating storm demand to relative wave energy along the beaches in the study area.

Storm demand was assessed for each beach in the study area based on analysis of photogrammetric data. The storm demand at a particular beach can be estimated by comparing "pre-storm" and "post-storm" beach volumes obtained from analysis of photogrammetry data. Volume change (above 0 m AHD and landward of the 0 m AHD contour) between the pre and post-storm photography was assessed to estimate the storm demand attributable to a major storm event, such as that which occurred in June 1974. It should be noted that the photography used to generate this data is often separated by several years and, therefore, does not necessarily reflect precise volume changes during the storm event. There are also limitations to the accuracy of the data, with vertical accuracy generally between 0.3 and 0.5 m, especially with the older photography.

Storm erosion demand measured in this way was applied to each particular precinct at each beach, based on the envelope of maximum storm erosion demand measured in each particular precinct. This is a conservative assessment as the erosion would not occur uniformly along the beach in practice but would be worst at locations adjacent to where rips form along the beach during storms. The storm erosion demand also considers the influence of localised effects such as stormwater outlets and estuary entrance instability.

Wave modelling has been used to estimate the relative wave energy at each of the beaches to verify the values of storm erosion derived for each beach from the mapping.

Coastline hazard lines for the immediate, 2050 and 2100 future planning periods were developed as part of this risk assessment.

Coastline Hazard Lines for the study area were last defined in 1994 for open coast beaches and in 1998 for Broken Bay beaches, and adopted as planning controls for development. However, these lines did not make any allowance for reduced foundation capacity as required now by the Guidelines for Preparing Coastal Zone Management Plans (Office of Environment and Heritage 2013). The updated Hazard Line is the predicted position of the back beach erosion escarpment after a 100 year ARI coastal storm in 2011, 2050 and 2100 respectively, including subsequent slumping to a stable angle of repose and an allowance for reduced foundation capacity as required by the Guidelines for Preparing Coastal Zone Management Plans (Office of Environment and Heritage 2013) and the NSW Coastal Planning Guide (Department of Planning 2010).

Beach erosion hazard determination is described in more detail in the Coastal Processes and Hazard Definition Study (WorleyParsons 2014).

5.3 Shoreline Recession Hazard

The hazard of shoreline recession is the progressive landward shift in the average long term position of the coastline (NSW Government 1990). Two potential causes of shoreline recession are net sediment loss, and an increase in sea level.

Long term recession due to net sediment loss is a long duration (period of decades), and continuing net loss of sand from the beach system. According to the sediment budget concept, this occurs when more sand is leaving than entering the beach compartment. This recession tends to occur when:

- the outgoing longshore transport from a beach compartment is greater than the incoming longshore transport;

- offshore transport processes move sand to offshore "sinks", from which it does not return to the beach; and/or,
- there is a landward loss of sediment by windborne transport (NSW Government 1990).

A progressive rise in sea level may result in shoreline recession through two mechanisms: first, by drowning low lying coastal land, and second, by shoreline readjustment to the new coastal water levels. The second mechanism is probably the more important since deeper offshore waters expose the coast to attack by larger waves, the nearshore refraction and diffraction behaviour of waves may change, and a significant volume of sediment may move offshore as the beach seeks a new equilibrium profile (NSW Government 1990).

It is also appropriate to discount the historical recession due to net sediment loss, due to actual sea level rise that occurred during the measurement period from 1941 to 2006.

Note that the previous coastline Hazard Lines for the study area did not make any allowance for reduced foundation capacity as required now by the Guidelines for Preparing Coastal Zone Management Plans (Office of Environment and Heritage 2013).

Shoreline recession hazard determination is described in more detail in the Coastal Processes and Hazard Definition Study (WorleyParsons 2014).

5.4 Sand Drift Hazard

As noted in **Section 4.5,** sand drift is a result of aeolian wind movement of beach sediment. Sand drift in a coastal location is usually initiated by the degeneration or destruction of vegetation protecting the vital foredune. Common causes are foot and vehicle tracks devoid of vegetation running down the face of the dune (NSW Government 1990). Beach drift can be limited by the coverage of dune vegetation or elevated seawall landward of the beach along the Gosford open coast. Further, dune stabilisation works (including log and wire fencing and access control) are present along most of the open coast. In particular, dune revegetation undertaken at Putty-Killcare Beach following the completion of sand mining activities in the 1950s and 1960s were noted to be successful in mitigating previous windblown sand losses (PBP 1998). The sand drift hazard in the study area is likely to be minimal.

5.5 Coastal Inundation Hazard

Coastal inundation is the flooding of coastal lands by ocean waters, which is generally caused by large waves and elevated water levels associated with severe storms. Severe inundation is an infrequent event and is normally of short duration, but it can result in significant damage to both public and private property (NSW Government 1990).

The components which give rise to elevated still water levels are storm surge (including wind setup and barometric setup) and wave setup (see **Section 4.2**). This increased water level may persist for several hours to days and can inundate low lying beach areas and coastal creeks. For long term planning purposes, sea level rise would also be included.

During storm events, individual waves result in further temporary water level increases above the still water level due to the process of wave setup and runup or uprush (see **Section 4.3**).

The inundation hazard near lake and lagoon entrances can occur as a result of ocean stormwave (coastal) inundation and/or catchment derived flooding. As such, the assessment of potential inundation levels at the lagoon entrances involved comparison of inundation levels caused by wave runup with the 1% flood level determined near the entrance at each lagoon, and adopting the higher value as the potential inundation level.

Inundation hazard has been identified for the present day, but not for 2050 or 2100. It is difficult to assess inundation extents under future planning periods, given that the position of the shoreline is likely to change in the future as a result of ongoing coastal processes and climate change.

Inundation hazard determination is described in more detail in the Coastal Processes and Hazard Definition Study (WorleyParsons 2014).

5.6 Stormwater Erosion Hazard

During major stormwater runoff events, stormwater collected from back beach areas and discharging into coastal waters can cause significant erosion to the beach berm. This in turn can allow larger waves to attack the beach and can cause migration of the stormwater discharge entrance if not structurally contained (NSW Government 1990). Flow from stormwater pipes and outlets on beaches have the potential to scour the surrounding sand, creating erosion zones.

In the study area, most of the stormwater drains to creeks or lagoons, with outlets to the ocean. While scour can occur around stormwater outlets, due account of this hazard has been made in the selection of the storm demand value, where appropriate. Within the limitation of the spacing of photogrammetric profiles for hazard definition, natural long-term lowering of beach berms surrounding stormwater outlets is explicitly accounted for in the volumetric analysis defining hazard line positions.

Potential beach management issues associated with the stormwater outlets include:

- Localised erosion resulting from stormwater scour;
- Loss of vegetation associated with stormwater flows;
- Localised lowering of beach level as a result of stormwater erosion/scour allowing larger waves to access the back beach area;
- Potential reduction in amenity as result of strong flows and reduced water quality;
- Aesthetic impact of structures on the beach;
- Impact on longshore sediment transport of structures extending across the beach;

- Accumulation of fines and organic matter around outlet.

5.7 Climate Change

A discussion on sea level rise and the possibility of other effects associated with climate change was provided in **Section 4.6**.

Under the projected accelerated sea level rise, it is expected that shoreline recession will occur at most beaches in the study area, excluding Ocean-Umina beach.

5.8 Slope Instability

Beach slope and cliff instability hazards relate to the possible structural incompetence of these features, and associated potential problems with the foundations of buildings, seawalls and other coastal works (NSW Government 1990).

The study area is composed largely of sandy beach and dune areas within the active coastal zone. For such areas, based on Nielsen et al (1992), a number of coastline hazard zones can be delineated as shown in **Figure 19**.

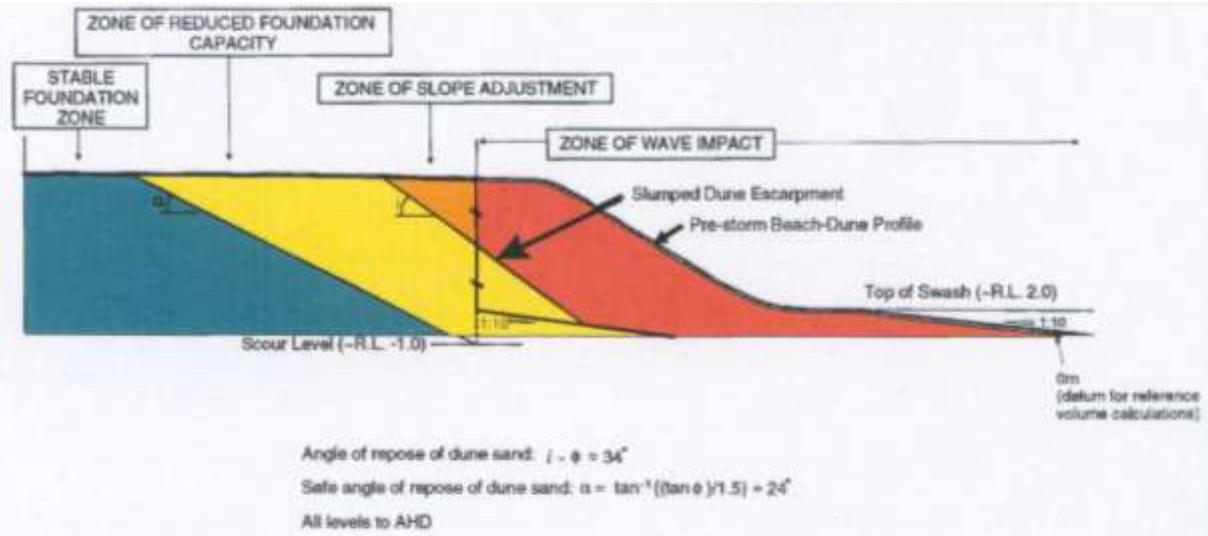

Figure 19: Schematic representation of coastline hazard zones (after Nielsen et al 1992)

The *Zone of Wave Impact* delineates an area where any structure or its foundations would suffer direct wave attack during a severe coastal storm. It is that part of the beach that is seaward of the beach erosion escarpment (as defined by the beach erosion hazard, see **Section 5.2**).

A *Zone of Slope Adjustment* is delineated to encompass that portion of the seaward face of the beach that would slump to a natural angle of repose following removal by wave erosion of the design storm demand. It represents the steepest stable beach profile under the conditions specified.

A *Zone of Reduced Foundation Capacity* for building foundations is delineated to take account of the reduced bearing capacity of the sand adjacent to the storm erosion escarpment. Nielsen et al (1992) recommended that structural loads should only be transmitted to soil foundations outside of this zone (i.e. landward or below), as the factor of safety within the zone is less than 1.5 during extreme scour conditions at the face of the escarpment. In general (without the protection of a terminal structure such as a seawall), dwellings/structures not piled and located within the Zone of Reduced Foundation Capacity would be considered to have an inadequate factor of safety.

It is noted that where development is founded on deep pile foundations, deep enough to resist the lateral forces induced on them by movement within the soil mass, the risk to the development is mitigated and the buildings are not subject to reduced foundation capacity. Light structures within the *Zone of Reduced Foundation Capacity* (e.g. fences, utilities, roads, paths etc.) are not at risk of damage. However, heavy structures (buildings) not supported on piled foundations could be at risk of some structural damage due to an increased risk of slumping in this area if they are located within this zone and the dune in front of them collapses back to the *Zone of Slope Adjustment* line.

The coastline hazard zones for the study area are determined using the position of the *Zone of Slope Adjustment* and *Zone of Reduced Foundation Capacity* defined for the immediate, 2050 and 2100 planning periods.

Cliff instability has previously been assessed for Tudibaring Headland but not for the other coastal headlands adjoining the beaches in the study area. The cliff instability assessment information is to be taken into account when developing the Coastal Zone Management Plan for Gosford's beaches.

5.9 Coastal Hazard Risk Assessment at each beach

The coastal hazards have been mapped for a risk likelihood equivalent to approximately a 1% Annual Exceedance Probability (AEP) event (i.e. the event that could lead to the erosion would have approximately a 1% chance of being exceeded in any one year – i.e. a "1 in 100 year" storm event). This was based on the storm erosion measured during past storm events of known magnitude. Wave modelling was also undertaken to consider the impact of a 1% AEP storm event (i.e. 100 year wave height and water levels) on the amount of wave energy reaching each beach, which was found to correlate well with the measured storm erosion as determined by analysis of photogrammetry data derived from historical aerial photography (WorleyParsons 2014).

Below is a summary of how the coastal hazard risk has been defined for the key hazards of coastal erosion, inundation and slope instability, together with a summary of the coastal hazard risk as identified for each beach in the study area. Hazard mapping for each beach has been undertaken as part of the Coastal Process and Hazard Definition Study and is provided for reference in **Appendix 4**. A table outlining the quantum of assets and properties at coastal hazard risk for each beach is provided in **Appendix 3**.

The economic value of the assets at risk from coastal hazards ranges from a few hundred thousand dollars at the beaches where only minor assets are at risk of damage (e.g. Killcare-Putty Beach), to many tens of millions of dollars where there are large numbers of dwellings seaward of the Immediate Zone of Slope Adjustment (e.g. Wamberal, although many of these dwellings will have been constructed on deep-piled foundations). In the future, depending on the planning period adopted and depending on what action is taken to address the coastal hazard, there may only be a minor increase in the economic value of assets at risk at some beaches (e.g. Patonga), while other beaches may experience a large increase in the value of assets at risk (e.g. Pearl, North Avoca). In total, the economic value of the natural and built assets currently at risk from coastal hazards within the Gosford LGA would run into the hundreds of millions of dollars. This does not include the damage costs from coastal-related hazards identified in areas not within the immediate study area, such as the identified 6,111 properties projected to be impacted in Brisbane Water by inundation under future sea level rise (Brisbane Water Foreshore – Floodplain Risk Management Study, Cardno 2014).

5.9.1 Coastal Erosion Risk

The present day *Zone of Slope Adjustment* lines represent where the beach escarpment could erode to if a 1% storm event occurred tomorrow. The 2050 Zone of Slope Adjustment lines represent where the beach escarpment could get to if a 1% AEP storm event occurred in 2050, and the 2100 Zone of Slope Adjustment lines represent where the beach escarpment could erode to if a 1% storm event occurred in 2100. However, the line does not mean that the dune would erode back this far along the entire length of beach in the next large storm event. The line represents the possible extent of erosion, given that large rips can form in a storm and increase the volume of sand taken from the beach in the location directly landward of where the rip forms. Expressed in another way, in the 1% AEP storm the Hazard line presented is the assessed extent of resultant erosion where the property is directly landward of where rips form. Erosion where rips do not form would likely be less extensive. Any structures seaward of this line are therefore at risk of being damaged in a severe storm (with approximately a 1% probability of occurrence in any one year).

The previous Coastline Hazard Lines for the study area were based on this *Zone of Slope Adjustment*.

5.9.2 Slope Instability Risk

Within the *Zone of Reduced Foundation Capacity*, the soil mass has a reduced capacity to support building foundations, unless they constructed on piles deep enough to resist the lateral forces induced on them by movement within the soil mass. This is because there is insufficient mass of soil in front of the dune to resist the forces acting on it due to the mass of heavy structures not supported on piled foundations. The NSW Government Office of Environment and Heritage defines the landward extent of this zone as being the Coastal Hazard area. Light structures within this zone (e.g. fences, utilities, roads, paths etc.) are not at risk of damage. However, heavy structures (buildings) not supported on piled foundations could be at risk of some structural damage due to an increased risk of slumping in this area if they are located within this zone and the dune in front of them collapses back to the *Zone of Slope Adjustment* line.

The mapped *Zone of Reduced Foundation Capacity* line indicates the landward limit of this hazard associated with the 1% AEP storm event, in the present day, 2050 and 2100.

5.9.3 Coastal Inundation risk

Coastal inundation risk has been identified in this Study in the context of wave runup at the beaches within the study area. Not included in this assessment is the coastal inundation of properties within Brisbane Water or within the coastal lagoons, which have been assessed in other studies such as Cardno (2014).

Elevated still water levels at times of storms comprise storm surge, including wind setup (the piling up of water against the coastline caused by onshore wind), barometric setup (elevated water levels caused by low atmospheric pressure) and wave setup (elevated water levels caused by breaking waves). Combined with high tides this increased water level may persist for several hours to days and can inundate low lying beach areas and coastal creeks.

On a beach dune, waves can typically run up the dune and reach a maximum level which is much higher than the water level due to storm surge and tide alone. The wave runup is a function of the height of the waves and the slope of the beach face. As per the coastal erosion and slope stability hazards, the maximum extent of the wave runup on each beach was assessed for a storm having approximately a 1% probability of occurrence in any one year. Future sea level rise would be expected to increase the risk of inundation due to wave runup.

At lagoon entrances, the inundation hazard at these areas can occur as a result of ocean stormwave inundation and/or catchment derived flooding.

Individual lots which have been identified as being affected by maximum wave runup have been marked on the maps in blue. Marking of an individual lot does not necessarily mean that there would be overfloor flooding of dwellings within the lot, but only that part of the land within the lot is within a zone which could be affected by wave runup or coastal inundation.

Inundation hazard has been identified for the present day, but not for 2050 or 2100. It is difficult to assess inundation extents under future planning periods, given that the position of the shoreline is likely to change in the future as a result of ongoing coastal processes and climate change.

5.9.4 Patonga Beach

At Patonga, there are no buildings affected by coastal erosion, in the present day, by 2050 or 2100. The coastal erosion risk is substantially reduced from the previous assessment undertaken in 1999.

However, the following assets are considered to be subject to coastal erosion or inundation risk:

Present Day:

- In the present day, 75 m length of carpark on the seaward side of Patonga Drive is at risk from coastal erosion;
- 130 m length of the unnamed road to the boat ramp is at risk of erosion;
- jetty and footpath, boat ramp and boat ramp carpark, dune fencing adjacent to boatramp access road (all within Council Managed Crown Reserve).
- 67 m length of drainage pipe underlying carpark at eastern end, two kerb inlets and one headwall, including a box culvert under road with bank stabilising rock work and pipe discharging onto back of beach parallel to shoreline.
- 49 lots affected by coastal inundation, with 42 dwellings and 5 commercial premises located within these lots.
- Dune vegetation (coastal sand beach spinifex and coastal sand banksia scrub) within the Council Managed Crown Reserve.

2050:

All the assets at risk of coastal erosion in the present day are also at risk in 2050, plus the following additional assets:

- 60 m length of Patonga Drive
- 150 m length of the unnamed road to the boat ramp.
- Power supply to the wharf.

2100:

All the assets at risk of coastal erosion in the present day are also at risk in 2100, plus the following additional assets:

- 75 m length Patonga Drive,
- 160 m unnamed road to boat ramp
- Three power poles adjacent to the boat ramp.

Table 8 provides a general description of the stormwater outlets at Patonga Beach and potential impacts they may have on coastal processes.

Table 8 – Stormwater outlets at Patonga

Location	Description	Impact on coastal processes
Bay Street	Box culvert under road with bank stabilising rock work	Minimal
Between jetty and boat ramp	Pipe discharging onto back of beach parallel to shoreline	Local scour and lowering of beach levels from depression caused by stormwater channel. Limited impact on processes.

5.9.5 Pearl Beach

At Pearl Beach, there are two buildings affected by coastal erosion in the present day (one commercial building and one residential building). However, coastal erosion impacts the seaward side of 37 beachfront properties at Coral Crescent, and up to 28 buildings at Coral Crescent are impacted by reduced foundation capacity. Note that some unknown number of the buildings partly or wholly within the *Zone of Reduced Foundation Capacity* will be constructed on piled foundations and therefore would not be subject to reduced foundation capacity. By 2050, the number of properties affected by reduced foundation capacity would increase to 37, and up to 85 m length of Pearl Parade becomes under threat. By 2100, up to 16 buildings would be under threat from coastal erosion and 42 are impacted by reduced foundation capacity (either partially or completely), as well as a length of 135 m of Pearl Parade, and associated services come under erosion threat. Following reassessment, the coastal erosion risk has reduced slightly when compared with the previous assessment undertaken in 1999.

Inundation from wave runup may affect 36 dwellings and one commercial building on 38 lots.

The following assets are considered to be subject to coastal erosion or inundation risk:

Present Day:

- In the present day, 37 lots are at risk of coastal erosion, including 1 private dwelling and 1 commercial building located partially within the Zone of Slope Adjustment;
- 28 buildings are potentially at risk of reduced foundation capacity, being partially located within the *Zone of Reduced Foundation Capacity*;
- The amenities block at the southern end of the beach lies partially within the Zone of Slope Adjustment;
- Approximately 20 m of stormwater pipe near the carpark and 75 m length of sewer pipe adjacent to Gem Road is under threat of erosion. This includes a culvert under the road with three openings, and rock protection on bank adjacent to property near the entrance to Pearl Beach Lagoon;
- Power pole at Gem Road, public reserve and playground, dune fencing are at risk of erosion, being located within the Present Day Zone of Slope Adjustment;
- 38 lots are affected by coastal inundation, with 36 dwellings and 1 commercial building located within these lots;
- Dune vegetation including coastal sand foredune scrub, and a stand of Umina Coastal Sands Woodland near Pearl Beach Lagoon, which is listed as an Endangered Ecological Community.

2050:

All the assets at risk of coastal erosion in the present day are also at risk in 2050, plus the following additional assets:

- By 2050, 38 lots are affected by coastal erosion, including 1 private dwelling and 1 commercial building located partially within the *2050 Zone of Slope Adjustment*;

- 37 buildings are located partially within the *2050 Zone of Reduced Foundation Capacity;*
- 85 m length of Pearl Parade at risk of coastal erosion by 2050;
- Headwall and 375mm stormwater pipe near amenities block; 25 m length stormwater discharge pipe and headwall from carpark, stormwater pipe near 11 Pearl Parade at risk from erosion by 2050;
- Approximately 20 m of stormwater pipe near the carpark and 75 m length of sewer pipe adjacent to Gem Road will be under threat of erosion by 2050;
- Power pole at Gem Road, public reserve and playground, carpark, dune fencing, power pole and public telephone near amenities block located in the *2050 Zone of Slope Adjustment*.

2100:

All the assets at risk of coastal erosion in by 2050 are also at risk in 2100, plus the following additional assets:

- By 2100, 41 lots are at risk of coastal erosion, including 16 private dwellings and 1 commercial building located partially within the *2100 Zone of Slope Adjustment*;
- Up to 42 private dwellings and 2 commercial buildings are located partially within the *2100 Zone of Reduced Foundation Capacity;*
- 135 m length of Pearl Parade at risk of coastal erosion by 2100;
- Headwall and 375mm diameter stormwater pipe near amenities block; 35 m length stormwater discharge pipe and headwall along Pearl Parade shops and down through carpark, stormwater pipe near 11 Pearl Parade at risk from coastal erosion;
- Approximately 105 m length of watermain along Pearl Parade, 10 m length of water main at Gem Road at risk from coastal erosion by 2100;
- Approximately 100 m length of sewer pipe and sewer maintenance pit at end of Gem Road at risk from coastal erosion by 2100.

Table 9 provides a general description of the stormwater outlets at Pearl Beach and potential impacts they may have on coastal processes.

Table 9 – Stormwater outlets at Pearl Beach

Location	Description	Impact on coastal processes
Entrance to Pearl Beach Lagoon	Culvert under road with three openings, and rock protection on bank adjacent to property	Minimal

5.9.6 Ocean Umina Beach

At Ocean/Umina Beach, there is one residential building at Berrima Crescent affected by coastal erosion in the present day. The *Zone of Slope Adjustment* affects portions of two lots, and the

Zone of Reduced Foundation Capacity affects portions of three lots, all at Berrima Crescent. Portions of two lots are affected by coastal inundation due to wave runup. Erosion due to estuary instability affects the seaward portion of the lots at Berrima Crescent at the southern end of the beach.

Coastal erosion may impact on a significant stormwater discharge structure in front of the Ocean Beach Surf Club and parts of the carpark, which are protected by a vertical concrete seawall. Coastal erosion may impact on power infrastructure at Berrima Crescent, a stormwater pipe discharging onto the beach near the toilet block at the southern corner of the beach as well as dune fencing and vegetation along the entire beachfront.

Coastal inundation risk may increase in the future due to sea level rise. However, at Ocean/Umina Beach, sea level rise is not expected to cause significant beach recession, for reasons outlined in the Coastal Process and Hazard Definition Study (WorleyParsons 2014). In addition, the beach has been assessed as stable or accreting over the historical data record.

Dune vegetation (coastal sand foredune scrub) has been damaged due to erosion in previous storms, and the seawall at the carpark at Ocean Beach Surf Club has come under direct wave attack in previous storm events.

The coastal hazard assessed at Ocean/Umina should be reassessed in the future as more data becomes available.

Table 10 provides a general description of the stormwater outlets at Ocean-Umina Beach and potential impacts they may have on coastal processes.

Table 10 – Stormwater outlets at Ocean-Umina Beach

Location	Description	Impact on coastal processes
Southern corner of Umina Beach	Pipe discharging onto vegetation at back of beach near toilet block	Minimal

5.9.7 Putty-Killcare Beach

At Putty-Killcare Beach, the Surf Club and carpark is located partially within the *Immediate Zone of Slope Adjustment*, and the lot on which the Surf Club is located is subject to coastal inundation due to wave runup. A stormwater discharge structure at the Surf Club, as well as dune fencing and accessways are also subject to immediate erosion hazard. Dune vegetation, including coastal sand banksia scrub and coastal sand foredune scrub is also at risk from erosion.

By 2050, in addition to the Surf Club building, a portion of the water supply main under the Surf Club carpark is expected to come under erosion risk. Part of the carpark servicing the camping area at the northern end of the beach also comes under erosion hazard.

By 2100, in addition to the Surf Club and carpark, a portion of the road servicing the camping area at the northern end of the beach comes under erosion risk as does the amenities block servicing the campground. Part of the main carpark servicing the southern end of the beach comes under erosion risk, as does sewer infrastructure servicing the Surf Club. One building at the southern end of the beach adjacent to the Surf Club is expected to be affected by reduced foundation capacity by 2100.

Table 11 provides a general description of the stormwater outlets at Putty-Killcare Beach and potential impacts they may have on coastal processes.

Table 11 – Stormwater outlets at Putty-Killcare Beach

Location	Description	Impact on coastal processes
South end (south of SLSC)	Two pipes discharging onto sand with surrounding rock/concrete/gabion to stabilise bank	Potentially large scour across beach creating local depression in profile. Limited impact on processes. Potential future erosion leading to loss of fill material.
South end (350m north-east of SLSC)	Unknown outlet configuration (inaccessible), discharging through dune system at back of beach.	Potentially large scour across beach creating local depression in profile. Limited impact on processes
Middle of beach (550m north-east of SLSC)	Assumed naturally discharging flows through dune system at back of beach.	Potentially large scour across beach creating local depression in profile. Limited impact on processes.
Middle of beach (1km north-east of SLSC)	Assumed naturally discharging flows through dune system at back of beach.	Potentially large scour across beach creating local depression in profile. Limited impact on processes.
North end	Unknown outlet configuration (inaccessible), discharging through dune system at back of beach.	Potentially large scour across beach creating local depression in profile. Limited impact on processes.

5.9.8 MacMasters/Copacabana Beach

At MacMasters Beach, there are 13 properties assessed to be partially seaward of the *Immediate Zone of Slope Adjustment*. The MacMasters Surf club, carpark, Marine Parade carpark, power infrastructure at Marine Parade carpark; surf lifesaving viewing platform; dune fencing and accessways are subject to coastal erosion hazard in the Immediate timeframe. The MacMasters Beach surf club and carpark may be subject to coastal inundation hazard due to wave runup.

Coastal dune vegetation, including stands of coastal sand banksia scrub and coastal sand foredune scrub, are at immediate risk from erosion.

There are several items of stormwater infrastructure which are within the coastal hazard zones, including:

- Pipe discharging onto vegetated sand near the MacMasters Surf Life Saving Club
- Pipe discharging onto concrete with flow decelerating features and rock headwall about 100 m north of the MacMasters Surf Life Saving Club.
- Large box culvert under road and additional double pipe outlet with concrete headwall further seaward north of the Copacabana Surf Life Saving Club.

The roadway of Marine Parade, Copacabana Surf Club, 100 m length of water main, part of the roadway at Del Monte Place near Copacabana Surf Club, 22 lots and 9 dwellings on Tudibaring Parade lie partially seaward of the *2050 Zone of Slope Adjustment*.

In the 2100 planning horizon, 63 lots and 35 private dwellings lie partially seaward of the *2100 Zone of Slope Adjustment*. Significant lengths of Del Monte Place and Marine Parade are subject to coastal erosion hazard within this timeframe. Up to 85 lots and 66 buildings (an unknown number of which may be founded on deep pile foundations) are partially affected by reduced foundation capacity by 2100.

Table 12 provides a general description of the stormwater outlets at MacMasters-Copacabana Beach and potential impacts they may have on coastal processes.

Table 12 – Stormwater outlets at MacMasters-Copacabana Beach

Location	Description	Impact on coastal processes
South end (north of SLSC)	Pipe discharging onto vegetated sand	Local scour. Minimal impact on processes. Continued scour may give rise to future threat of outflanking of large pine tree and undermining of carpark.
100m north of southern outlet	Pipe discharging onto concrete with flow decelerating features and rock headwall.	Potentially large scour across beach creating local depression in profile. May exacerbate erosion and runup access to back beach region.
North end (north of Copacabana SLSC)	Large box culvert under road and additional double pipe outlet with concrete headwall further seaward. Rock wall protection on nth bank.	Potentially large scour across beach creating local depression in profile. May exacerbate erosion and runup access to back beach region.

5.9.9 Avoca Beach

At Avoca Beach, there are 38 properties (including 6 private dwellings), carpark, surf viewing tower, power poles and wires, fencing and signage, café, stormwater drainage, and sewer pipes affected by coastal erosion in the present day. Up to 71 properties, including 43 private dwellings and 1 commercial building, are impacted by reduced foundation capacity. Note that some unknown number of the buildings partly or wholly within the *Zone of Reduced Foundation Capacity* will be constructed on piled foundations and therefore would not be subject to reduced foundation capacity. By 2050, the number of buildings affected by reduced foundation capacity would increase to 71. By 2100, up to 86 buildings would be under threat from coastal erosion and 92 buildings impacted by reduced foundation capacity, as well as corner of Lake Street and Bareena

Avenue, 90 m length of Bareena Avenue, 220 m length of North Avoca Drive, and ends of View Street and Ocean Street and associated services would come under erosion threat. Following reassessment, the coastal erosion risk has increased when compared with the previous assessment undertaken in 1995.

Inundation from wave runup may affect 81 private dwellings, 2 commercial buildings and 3 public buildlings (2 SLSC and amenities block) on 99 lots.

The following assets are considered to be subject to coastal erosion or inundation risk:

Present Day:

- In the present day, 38 lots are at risk of coastal erosion, including 6 private dwellings;
- 44 buildings are potentially at risk of reduced foundation capacity, being partially located within the *Zone of Reduced Foundation Capacity*;
- The end of 1050 mm diameter stormwater pipe at Tarun Road, 375 mm diameter storwmater drainage under carpark on western side of Avoca Beach SLSC, approximately 100 m length sewer pipe on the seaward side of properties on Avoca Drive and approximately 50 m sewer pipe under carpark are at risk of erosion;
- The end of 450 mm stormwater pipe near 131 Avoca Drive, the 375 mm diameter storwmater drainage under carpark on western side of SLSC and approximately 250 m length of sewer pipe on the seaward side of properties on Avoca Drive are within the *Zone of Reduced Foundation Capacity*;
- Carpark on western side of SLSC, surf viewing tower near lagoon entrance, power poles and wires on seaward side of carpark, fencing and signage, café, beach accessways and dune fencing are at risk of erosion, being located within the *Present Day Zone of Slope Adjustment*.
- Coastal dune vegetation, including several stands of coastal sand foredune scrub are within the *Present Day Zone of Slope Adjustment*.

2050:

All the assets at risk of coastal erosion in the present day are also at risk in 2050, plus the following additional assets:

- By 2050, 78 lots are affected by coastal erosion, including 54 private dwelling and the SLSC are located partially within the *2050 Zone of Slope Adjustment*;
- 71 buildings are located partially within the *2050 Zone of Reduced Foundation Capacity;*
- The end of 1050 mm diameter stormwater pipe and end of water pipe at Tarun Road, end of 450mm stormwater pipe near 131 Avoca Drive, end of 600 mm stormwater pipe near 111 Avoca Drive, 375mm diameter stormwater drainage under carpark on western side of Avoca Beach SLSC, and approximately 250m length sewer pipe on seaward side of properties on Avoca Drive at risk of coastal erosion by 2050;
- Carpark of North Avoca SLSC at risk of erosion.

2100:

All the assets at risk of coastal erosion in by 2050 are also at risk in 2100, plus the following additional assets:

- By 2100, 94 lots are affected by coastal erosion, including 84 private dwellings, 1 commercial building and 1 SLSC, are located within the *2100 Zone of Slope Adjustment*;
- Up to 91 private dwellings are located partially within the *2100 Zone of Reduced Foundation Capacity;*
- Corner Lake Street and Bareena Avenue, 160m length North Avoca Drive north of surf club, ends of View Street and Ocean Street are within the *2100 Zone of Slope Adjustment*;
- Corner Lake Street and Bareena Avenue, 90m length Bareena Avenue, 220m length North Avoca Drive north of surf club, ends of View Street and Ocean Street are within the *2100 Zone of Reduced Foundation Capacity;*
- 125 m water main at Bareena Avenue, water pipe at Tarun Road, sewer pipe at Tarun Road, 145 m length sewer pipe at North Avoca Parade, sewer pipes at ends of Ocean and View Street, 40m length sewer pipe at Bareena Avenue at risk of erosion by 2100.
- 600 mm drainage pipe through reserve near Avoca Beach SLSC within the *2100 Zone of Reduced Foundation Capacity;* and
- Reserve behind Avoca Beach SLSC carpark, picnic facilities, large Norfolk Island Pine tree and poles and wires at ends of View Street, Ocean Street and Lake Street at risk of coastal erosion by 2100.

Table 13 provides a general description of the stormwater outlets at Avoca Beach and potential impacts they may have on coastal processes.

Table 13 – Stormwater outlets at Avoca Beach

Location	Description	Impact on coastal processes
South end (approximately 250m north of SLSC)	Pipe discharging approximately 1m above beach level onto sand (and miscellaneously dumped rock/concrete)	Local scour. Limited impact on processes. May exacerbate erosion and runup access to back beach region. Potential future threat to pine tree.
South end (approximately 430m north of SLSC)	Broken pipe discharging directly onto sand	Local scour. Minimal impact on processes. May exacerbate erosion and runup access to back beach region. Potential future threat to pine tree.
Northern corner	Channel with concrete wall on north side into a pipe	Local scour. Minimal impact on processes

5.9.10 Terrigal-Wamberal Beach

At Terrigal Beach, the SLSC is affected by inundation from wave runup due to potential overtopping of the seawall. The beach berm is backed by a seawall and relatively flat ground at a level of around 4 m AHD. For the design storm, the seawall would be overtopped with runup along this section reaching elevations of around RL 4 m AHD, overtopping the dune crest there and running onto the road, reaching distances up to some 20 m from the seawall. With projected sea level rise the degree of this inundation is projected to increase.

Following reassessment, the coastal erosion risk at Terrigal Beach has reduced slightly when compared with the previous assessment undertaken in 1995, due to the presence of the protective seawall.

At Wamberal Beach, there are 73 properties (including 61 private dwellings) affected by coastal erosion in the present day and 75 properties (including 66 private dwellings) are impacted by reduced foundation capacity. Note that some unknown number of the buildings partly or wholly within the *Zone of Reduced Foundation Capacity* will be constructed on piled foundations and therefore would not be subject to reduced foundation capacity. By 2050, the number of buildings affected by reduced foundation capacity would increase to 68, and up to 80 m length of Calais Road, up to 200 m length of Ocean View Drive and end of Dover Road becomes under threat. By 2100, up to 71 buildings would be under threat from coastal erosion and 102 are impacted by reduced foundation capacity, as well as 100 m length of Calais Road, 500 m length of Ocean View Drive and 200 m length Pacific Street, and associated services would come under erosion threat. Following reassessment, the coastal erosion risk has increased when compared with the previous assessment undertaken in 1995.

Inundation from wave runup may affect 72 dwellings and the SLSC on 82 lots.

The following assets are considered to be subject to coastal erosion or inundation risk:

Present Day:

- In the present day, 73 lots are at risk of coastal erosion, including 61 private dwellings;
- 66 buildings are potentially at risk of reduced foundation capacity, being partially located within the *Zone of Reduced Foundation Capacity*;
- Viewing platform, Beach accessways and dune fencing are at risk of erosion, being located within the *Present Day Zone of Slope Adjustment*.
- Coastal dune vegetation, including a stand of coastal headland shrubland at the southern end of Wamberal Beach adjoining the Terrigal Lagoon entrance, some coastal sand foredune scrub (mainly north of Wamberal Lagoon) and coastal sand banksia scrub (north of Wamberal Lagoon. A stand of the *Chamaesyce psammogeton* (Sand Spurge), which has been recorded in the Wamberal Lagoon Nature Reserve may also be at threat from coastal erosion.

2050:

All the assets at risk of coastal erosion in the present day are also at risk in 2050, plus the following additional assets:

- By 2050, 76 lots are affected by coastal erosion, including 67 private dwellings, are located partially within the *2050 Zone of Slope Adjustment*;
- 68 buildings are located partially within the *2050 Zone of Reduced Foundation Capacity;*
- 80 m length of Calais Road, 200 m length of Ocean View Drive and end of Dover Road are located within the *2050 Zone of Reduced Foundation Capacity;*
- Stormwater drainage from surf club carpark, approximately 80 m length of stormwater and water supply pipe along Calais Road, 400 m length of water supply pipe along Pacific Street and a short length of sewer pipeline from properties on Ocean View Drive and Pacific Street are located within the *2050 Zone of Reduced Foundation Capacity*; and
- SLSC carpark, piles and wires at end of Dover Rd and Calais Rd are located within the *2050 Zone of Reduced Foundation Capacity.*

2100:

All the assets at risk of coastal erosion in by 2050 are also at risk in 2100, plus the following additional assets:

- By 2100, 87 lots are affected by coastal erosion, including 71 private dwellings, are located within the *2100 Zone of Slope Adjustment*;
- Up to 102 private dwellings are located partially within the *2100 Zone of Reduced Foundation Capacity;*
- 100 m length of Calais Road, 500 m length of Ocean View Drive, 200 m length of Pacific Street and end of Dover Road are at risk of coastal erosion by 2100;
- 100 m length of Calais Road, 1 km length of Ocean View Drive, all of Pacific Street and end of Dover Road are within the *2100 Zone of Reduced Foundation Capacity; and*

Three cross drainage pipes at Ocean View Drive and sewer pipeline from properties on Ocean View Drive and Pacific Street are at risk of erosion by 2100.

Table 14 provides a general description of the stormwater outlets at Terrigal-Wamberal Beach and potential impacts they may have on coastal processes.

Table 14 – Stormwater outlets at Terrigal-Wamberal Beach

Location	Description	Impact on coastal processes
South end of Terrigal Beach	Box culvert with seven openings and surrounding rock protection	Local scour. Minimal impact on processes
Rock bluff on southern bank of lagoon	Pit discharging down rock (indurated sand) face	Local erosion of rock bluff. Minimal impact on processes

5.9.11 Forresters Beach

At Forresters Beach, the seaward sides of 4 beachfront properties are affected by coastal erosion in the present day and the number remained the same by 2050. By 2100, the number of properties affected by coastal erosion would increase to 5. Following reassessment, the coastal erosion risk has reduced significantly when compared with the previous assessment undertaken in 1995.

The following assets are considered to be subject to coastal erosion risk:

Present Day:

- In the present day, the seaward side of 4 lots are at risk of coastal erosion; and
- Beach accessways and dune fencing are at risk of erosion, being located within the Present Day *Zone of Slope Adjustment*.
- Dune vegetation, including coastal sand foredune scrub and coastal sand banksia scrub.

2050:

All the assets at risk of coastal erosion in the present day are also at risk in 2050.

2100:

All the assets at risk of coastal erosion in by 2050 are also at risk in 2100, plus the following additional assets:

By 2100, 5 lots are at risk of coastal erosion.

There is a stand of coastal headland grassland near the south-central portion of the beach which is listed as an Endangered Ecological Community.

Table 15 provides a general description of the stormwater outlets at Forresters Beach and potential impacts they may have on coastal processes.

Table 15 – Stormwater outlets at Forresters Beach

Location	Description	Impact on coastal processes
Middle of beach, opposite Forresters Reef	Damaged pipe elevated on piles 4m above beach level	Drop causes significant local scour. Minimal impact on processes, may exacerbate erosion and runup access to back beach region

6 EXISTING MANAGEMENT MEASURES

6.1 Introduction

This section of the report describes the existing coastal management measures already in place at each of the beaches within the study area, moving from south to north, and observed coastal management issues at each beach, as gleaned from site observations. Issues discussed in this section of the report include stormwater, beach access, dune vegetation, and presence of existing coastal protection works.

It is important to understand what management measures are currently in place at each of the beaches, so an assessment can be made of the effectiveness or otherwise of these measures. This assessment will allow us to make a judgment on what changes need to be made to the management regime at each beach and will inform the list of management actions and priorities for each precinct at each beach in the study area.

6.2 Patonga Beach

Patonga Beach is located on the northern shoreline of the Hawkesbury River and extends approximately 1.4km from Patonga Creek to Dark Corner.

At the entrance to Patonga Creek, Council constructed a training wall on the northern side of the entrance in 1969/70 to direct flows further to the south and another wall was constructed in 1971 immediately upstream of the training wall to prevent erosion in this area. Sand accreted against the northern side of the training wall until sand bypassing was re-established in the 1990s.

Dune revegetation has been undertaken between Patonga Creek and the Patonga Wharf. However the revegetation has not been well-maintained as evident by breached fences, the occurrence of weeds and exotic species and the decline of the previously dominating Coast Wattles (Terras Landscape Architects, 2010).

Scour was observed in front of the stormwater outlet from the Eve Williams Memorial Oval (Figure 20). Some of the trees appeared to be leaning due to the scour erosion. The scour has a limited impact on coastal processes at this location.

Previously the old boat ramp restricted sand transport to the west (ie.to the south of the Patonga Beach). The boat ramp has since been upgraded to a piered elevated concrete ramp that allows sand to flow underneath the ramp. Immediately adjacent to the boat ramp, erosion was observed behind a rock block seawall (Figure 21). A rock boulder sub vertical seawall has also been constructed to the west of the boat ramp over approximately 60m length as shown in Figure 22. Geotextile was observed behind the seawall. However the foundation of the rock seawall is not known and therefore its effectiveness during a severe storm cannot be determined. The sand level is relatively lower in this location and this may be due to increase in reflection from the sub vertical seawall.

The six houses located on a low bench in the lee of the headland in the Dark Corner are protected by various rock protection works that range from ad-hoc rock and bricks of varying sizes and quality (Figure 23) to a mortared block wall (Figure 24). The foundation condition of this mortared block wall is not known, however the undulating alignment of the wall suggests that sections of the seawall may not be structurally stable.

Figure 20 - Scour observed in front of stormwater outlet from Eve Williams Memorial Oval

Figure 21 - Erosion observed behind the rock block seawall adjacent to the boat ramp

Figure 22 - Rock seawall located west of the boat ramp

Figure 23 - Ad-hoc rock protection placed in front of a house in the Dark Corner

Figure 24: Mortared block seawall located in front of the houses in the Dark Corner

6.3 Pearl Beach

Pearl Beach is located between Green Point and Mt Ettalong, and comprises outlets for Green Point Creek, Middle Creek and Pearl Beach Lagoon. The entrance to Green Point Creek is located at the southern end of the beach. Middle Creek discharges to the ocean just north of Emerald Avenue. Pearl Beach Lagoon is located behind the northern part of the beach around Coral Crescent and discharges via a culvert under Coral Crescent just north of Agate Avenue.

South of the Green Point Creek outlet in Gem Road, there are four residences located on the low frontal dune. Land levels generally range from RL 2.5 m to 3.5 m AHD. At the seaward end of Gem Road, there is a sewage pumping station located further seaward than the residences. It is understood from Council records that two southern properties out of these four (Lots 492 and 493) have constructed a buried gabion wall to protect their seaward boundary from storm erosion (PBP, 1999).

There are also a number of residences on the northern slope of Green Point in Green Point Road overlooking the beach.

The frontal dune for the section of beach between Green Point Creek and the outlet of Pearl Beach Lagoon is well vegetated and maintained by the local Dune Care group. However, significant expanses of dune vegetation may be lost during significant storm events in current, 2050 and 2100 conditions. The primary vegetation communities vulnerable to damage (as identified with reference to Council's vegetation mapping) are identified below.

- Loss of E33bi Umina Coastal Sands Woodland (portion of dune between Middle Creek and Pearl Beach Lagoon);
- Loss of E50a Coastal Sand Foredune Scrub (portion of dune between Middle Creek and Pearl Beach Lagoon);
- Loss of E50a Coastal Sand Foredune Scrub (on seaward portion of dune on private properties between 20 and 34 Coral Cres);

Along the northern part of the beach, the residences on the eastern side of Coral Crescent are located on the frontal dune and the property boundaries extend onto the beach berm. The beach has suffered severe erosion on numerous occasions in which seaward portions of these properties have been eroded. Residents in the past have organised unauthorised works involving bulldozers to scrape sand from the lower portion of the beach following such storms to refill the eroded areas. The dune crest level in this area generally varies from about RL 6.7 m to 7.6 m AHD.

6.3.1 Green Point Creek

The entrance to Green Point Creek scours due to flows during rainfall. At other times, the beach berm opposite the entrance reforms to block flows. Typically, the dry weather base flows form a narrow and shallow channel flowing to the south along the back of the beach (**Figure 25**). It generally flows to the ocean along the rocky foreshore of Green Point. There is insufficient flow in the creek to maintain a direct channel to the ocean.

The entrance is mechanically opened when the water level in the creek threatens to flood residences. There are no formal guidelines controlling the means of the channel opening.

Macrophytes dominate the creek entrance area and these are mechanically cleared as required to decrease any restriction to wet weather flows to the ocean.

Retaining walls have been constructed on some property boundaries adjacent to the creek to prevent bank erosion.

Figure 25: Channel formed by Green Point Creek flowing along the back of the beach

6.3.2 Middle Creek

The entrance to Middle Creek scours due to flows during rainfall. At other times, the beach berm opposite the entrance reforms to block flows. Typically, Middle Creek has a closed entrance as there is insufficient flow to maintain an entrance channel.

The banks of the creek are high and there is generally not a requirement to mechanically breakout the entrance to prevent flooding.

There are significant retaining walls constructed in the creek to stabilize the banks. At the bend in the creek near the entrance, there are log bank protection works on the outside of the bend.

6.3.3 Pearl Beach Lagoon

The entrance is typically closed at the beach berm because there is little or no dry weather base flow. There is significant scour of the beach downstream of the road culvert following rain. A concrete block retaining wall has been constructed along the northern side of this channel to prevent scour undermining the adjacent property. The foundation level of this wall is unknown and hence the risk for undermining cannot be quantified.

Flows from the lagoon can be restricted by debris blocking the road culvert or sand on the beach berm. There are no measures to reduce the potential for blockage of the road culvert.

The entrance is mechanically opened by Council to reduce inundation threat to adjacent residents. The trigger for opening is when Council is notified, either through Council staff inspections or by local residents, that the water level reaches a white line at approximately 2.75 m AHD on the concrete block retaining wall. Pearl Beach Lagoon is opened by Council on average one or two times per year (BMT WBM, 2013).

6.4 Ocean-Umina Beach

Umina Beach occupies the western 1.2km of Ocean-Umina beach to Mount Ettalong. Ettalong Creek discharges to the ocean in the southern corner of the beach.

There are seven residences located at the southern end of the beach between Mt Ettalong and the Ettalong Creek entrance. It is understood that informal rock protection has been placed on the seaward side of the road during severe storm erosion. It is understood that the rock fill placed at this location is ripped sandstone of fairly low quality and may not offer a sound level of protection. The crest of the embankment seaward of the residences varies from about RL 4 m to 4.5 m AHD.

At the Ettalong Creek entrance, the northern side has been stabilised with a rock boulder seawall and the southern side has a vegetated sand bank (**Figure 26**). Typically, high flows discharge directly across the beach while in dry periods, a channel tends to migrate to the south and to the ocean along the Mt Ettalong foreshore. Entrance migration has exacerbated erosion of dunes immediately south of the creek entrance.

South of the Umina SLSC to the Ettalong Creek outlet, the dune has been well vegetated and fenced with accessways seaward of the caravan and camping ground. Development is located landward of the frontal dune.

Significant expanses of dune vegetation may be lost during significant storm events in current, 2050 and 2100 conditions. The primary vegetation community vulnerable to damage include is E50a Coastal Sand Foredune Scrub which currently exists on the portion of dune between Ettalong Creek entrance and the Umina Surf Club.

Figure 26: Rock boulder seawall on the northern side of Ettalong Creek and vegetated sand bank on the southern side of Ettalong Creek

Ocean Beach extends for approximately 1.3km to Wagstaff Point and includes the sand entrance to Brisbane Water.

Along the length of Ocean Beach, there is a relatively wide vegetated frontal dune system seaward of The Esplanade. The width varies from about 60 m at Ettalong Point to about 40 m immediately north of the Surf Club. Residential development is located on the northern (landward) side of the road. The crest of the dune or road varies from RL 5 m to 8 m AHD along the beach.

Significant expanses of dune vegetation may be lost during significant storm events in current, 2050 and 2100 conditions. The primary vegetation community vulnerable to damage is E50a Coastal Sand Foredune Scrub which currently exists on the portion of dune east from Umina Surf Club to the entrance of Brisbane Water.

The carpark adjacent to the surf club intrudes into the dune system leaving only a 30 m wide vegetated slope on the seaward side. The carpark is a raised concrete promenade (**Figure 27**). The foundation of the concrete promenade is not known and therefore its effectiveness during a severe storm cannot be determined.

At the stormwater outlet at Trafalgar Ave, there is a sandstone block apron recently constructed. Scour was observed on the beach in front of the apron (**Figure 28**).

The groyne constructed at Ettalong Point following erosion in 1973 may have enhanced the permanency of accreted sand at the northern end of Ocean Beach (PBP 1998).

Figure 27: Carpark adjacent to the Surf Club at Ocean Beach

Figure 28: Sandstone block apron in front of stormwater outlet and scour in front of the apron.

6.5 Putty-Killcare Beach

Putty-Killcare Beach is approximately 1.6km long with urban development restricted to the southern end of the beach.

At the southern end of the beach, a roadway extends along the back of the beach to provide access to a number of residences and the surf club. The surf club is located on fill placed at the toe of the escarpment. During the May-June 1974 storms, a large amount of this fill was eroded down to an extensive rock shelf and threatened to undermine the club. The fill was subsequently replaced and rocks placed at the seaward toe of the slope to mitigate future erosion. The details of the size and extent of the rocks are unknown (PBP, 1999).

There is rock protection provided around the two stormwater pipe outlets near the surf club (**Figure 29**). One of the stormwater pipe outlets does not appear to be operating with sand filling up the bottom half of the outlet. Some scouring of the beach was observed in front of the other stormwater pipe outlet.

Sand mining of the frontal dune north of Beach Drive was undertaken in the late 50's and 60's. The frontal dune was extensively lowered in the mining process. The dune was subsequently revegetated and has been successful in mitigating previous windblown sand losses. The vegetation has been maintained by the NPWS and Gosford City Council (GCC). The dune has been fenced to protect the vegetation and provide pedestrian accessways.

The northern portion of the back beach area forms part of Bouddi National Park. Significant expanses of dune vegetation may be lost during significant storm events in current, 2050 and 2100 conditions. The primary vegetation communities vulnerable to damage include:

- E50a Coastal Sand Foredune Scrub;
- E50b Coastal Sand Banksia Scrub, and
- E40a Phragmites Rushland.

Figure 29: Stormwater pipe outlets near the surf club

6.6 MacMasters-Copacabana Beach

MacMasters and Copacabana Beach extends for approximately 1.4km in a southeast-facing embayment. The entrance to Cockrone Lagoon is located in the centre of the beach.

Rock boulders have been placed in front of the stormwater outlet at the southern end of the beach (**Figure 30**). A scour channel was observed from the outlet to the ocean.

Along the central and northern section of the beach, the vegetated dune system has a width of 20 to 60m. Along the southern section of the beach, the vegetated dune system reduces to a width of 10 to 25m. At the southern end of the beach, there is a harder less erodible backshore and bluff material with little or no dune (WBM & Planning Workshop, 1995)

The entrance to Cockrone Lagoon is mechanically opened by Council when the water level reaches 2.53m AHD to reduce the risk of flooding problems (Cardno, 2010) in line with Councils Lagoon Entrance Management Policy. With a bed level of 0.4-0.6m AHD, the lagoon is opened an average of 2.4 times per year and remains open an average of nine days each opening (calculated over a 40 year period).

At the stormwater channel at the northern end of Copacabana Beach, there is a scour channel from the outlet to the ocean with rock boulders and vegetation at the back of the beach (**Figure**

31). Potentially significant stormwater erosion issues have been identified along this beach including:

- 1500mm pipe outlet immediately north of MacMasters Beach SLSC - Local scour has minimal impact on coastal processes, however continued scour may give rise to future threat of outflanking of large pine tree and undermining of carpark.
- Outlet 100m north of southern outlet – creates potentially large scour across beach which may exacerbate erosion and run-up access to back beach region.
- Large outlets with concrete headwall discharging 50m north-east of Copacabana SLSC. These outlets create significant scouring across beach creating local depression in the beach profile which may exacerbate erosion and run-up access to back beach region.

Extensive cobbles are exposed at both the northern and southern ends of this embayment during storms, which can lead to a temporary reduction in recreational amenity. Ocean baths have been constructed at MacMasters Beach.

Significant expanses of dune vegetation may be lost during significant storm events in current, 2050 and 2100 conditions. Vegetation community known as E50a Coastal Sand Foredune Scrub is identified as being vulnerable to damage in the immediate and future scenarios. Further, sections of the dune have been known to be subject to bitou bush infestations.

Figure 30: Rock boulders in front of the stormwater outlet near the MacMasters surf club (left) and scour channel from the outlet to the beach (right).

Figure 31: Rock boulders along the stormwater channel adjacent to Del Rio Drive at the northern end of Copacabana Beach

6.7 Avoca Beach

Avoca Beach extends for approximately 1.7km with the entrance to Avoca Lake located in the centre of the beach.

Rock protection works have been constructed along the embankment and promenade at the southern end of Avoca Beach (**Figure 32**).

Some ad-hoc protection works, such as seawalls, have been constructed by property owners along Avoca Beach. These works are not engineered designed and their effectiveness during severe storm conditions is unknown.

The entrance to Avoca Lagoon is mechanically opened by Council when the water level reaches 2.09 m AHD to reduce the risk of flooding problems (Cardno, 2010) in line with Councils Lagoon Entrance Management Policy. With a bed level of 0.8 - 0.9 m AHD, the lagoon is opened an average of 3.5 times per year and remains open an average of 21 days each opening (calculated over a 40 year period). Public access may be diminished on the northern foreshore of the lagoon entrance into the future. This issue is to be addressed through a review of Councils lagoon entrance management practices. Public access will be increasingly restricted into the future as sea levels rise, dune systems recede and oceanic inundation of the lagoon becomes more common.

Ad-hoc protection has been placed in front of the outlet at the stormwater outlet at 111 Avoca Drive. Scour was observed in front of the stormwater outlet at 131 Avoca Drive (**Figure 33**).

At the stormwater outlets south of the entrance to Avoca Lake and at Tarun Road, there are scour channels in front of the outlets (**Figure 34**).

Each of these outlets has been identified as having a limited impact on coastal processes. However, scour may exacerbate erosion and runup access to back beach region and pose potential future threat to adjacent pine trees.

Another outlet exists in the northern corner of North Avoca beach, however it does not pose significant impacts to the beach profile and coastal processes.

Along the central and northern section of the beach, the vegetated dune system has a width of approximately 10 to 60m (**Figure 35**). The southern end of Avoca embayment currently has minimal expanses of native dune vegetation. There may be loss of some E50a Coastal Sand Foredune Scrub on immediately south of the lagoon entrance which may be impacted by erosion and recession going forward. This same vegetation type continues in pockets along North Avoca and is all at threat from erosion damage in the present day.

Figure 32: Rock boulders along the embankment at the southern end of Avoca Beach

Figure 33: Ad-hoc protection placed in front of the stormwater outlet at 111 Avoca Drive (left) and scour in front of the stormwater outlet at 131 Avoca Drive (right).

Figure 34: Scour channels in front of the stormwater outlets south of the entrance to Avoca Lake (left) and at Tarun Road (right).

Figure 35: Vegetated dune system along central and northern Avoca Beach

6.8 Terrigal-Wamberal Beach

Terrigal and Wamberal Beach extends for approximately 2.8km and comprises entrances to Terrigal and Wamberal Lagoon.

The entrance to Terrigal Lagoon is mechanically opened by Council when the water level reaches 1.23 m AHD to reduce the risk of flooding problems (Cardno, 2010) in line with Councils Lagoon Entrance Management Policy. With a bed level of 0.5-0.7m AHD, the lagoon is opened an average of 12.9 times per year and remains open an average of eight days each opening (calculated over a 40 year period). Due to the risk of foreshore flooding the beach berm at Terrigal Lagoon entrance is maintained at <1.7m AHD to minimise opening response times.

The entrance to Wamberal Lagoon is mechanically opened by Council when the water level reaches 2.40 m AHD to reduce the risk of flooding problems (Cardno, 2010) in line with Councils Lagoon Entrance Management Policy. With a bed level of 0.9-1.0m AHD, the lagoon is opened an average of 2.9 times per year and remains open an average of 10 days each opening (calculated over a 40 year period).

Public access may be diminished on the northern foreshore of the lagoon entrance into the future. This issue is to be addressed through a review of Council's lagoon entrance management practices. Public access will be increasingly restricted into the future as sea levels rise, dune systems recede and oceanic inundation of the lagoon becomes more common. The dunes adjacent to this location include the vegetation community known as coastal headland shrubland.

The area north of Wamberal Lagoon encompasses the Wamberal Lagoon Nature Reserve which is managed under a separate (NSW Government) Management Plan.

The southern section of Terrigal Beach is backed by seawalls and these comprise a stepped seawall, subvertical seawall and access steps. The promenade along the central section of Terrigal Beach is backed by a block wall (**Figure 36**). The northern section of Terrigal Beach is backed by a vegetated dune system of a width of 10 to 20m.

A stepped seawall has been constructed along Terrigal Haven beach, with some sections constructed to contemporary coastal engineering standards, while other sections have been subject to engineering assessment

A box culvert with seven openings and surrounding rock protection is positioned at the far southern end of Terrigal Beach. The direction of flow and design results in only local scour which has minimal impact upon coastal processes at this location.

Along Wamberal Beach, some ad-hoc protection works, such as seawalls of a range of material including concrete, rocks and other materials, have been constructed by property owners along Wamberal Beach (**Figure 37**). These works are not engineered designed and their effectiveness during severe storm conditions is unknown. The vegetated dune system in front of these properties is relatively narrow and the embankment is at risk of erosion.

Protective action taken in the 1970's has resulted in the dune sand in the vacant `Pye' properties (Lots 10-11, DP 12022 No.s 71 and 69, Ocean View Drive, Terrigal) to be replaced with solid fill. This solid fill would act as a solid barrier in the event of dune erosion and recession (WBM & Planning Workshop, 1995). PWD (1985) noted that virtually all beachfront development at Wamberal Terrigal Beach was threatened from severe erosion in the 1974 storms, and that the State Emergency Service and Australian Army were called in and tipped rocks, sand bags and other materials seaward of the eroding dune face. Beachfront property owners also constructed a variety of structures in response, comprising rock rubble, corrugated iron, rubber tyres, besser blocks, concrete walls and gunite (cement, sand, and water applied through a pressure hose). Areas along Wamberal Beach known to have rock protective works placed in June 1974 are shown in **Figure 39**.

There is also the potential for sand from the beach to be lost onto the road by wind erosion (**Figure 40**).

Figure 36: Stepped sandstone block seawall along the southern section of Terrigal Beach (left) and block seawall and promenade along the central section of Terrigal Beach (right)

Figure 37: Rock gabion and terracotta pipes (left) and concrete retaining walls (right) constructed in front of properties

Figure 38: Erosion of the embankment in front of the properties, 10 June 2010

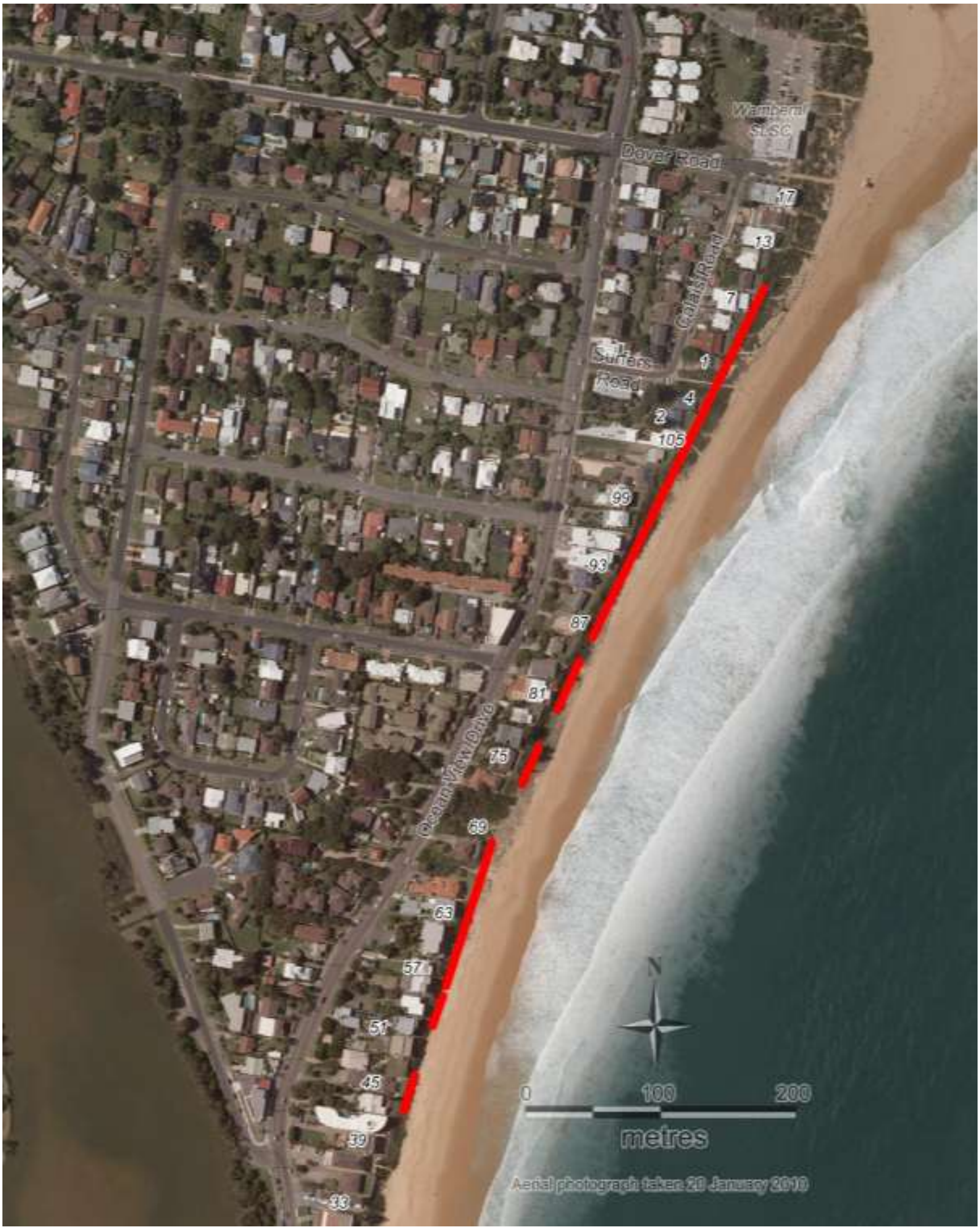

Figure 39: Extent of rock protective works placed in June 1974

Figure 40: Potential for sand from beach to be lost onto the road by wind erosion

6.9 Forresters Beach

Forresters Beach extends for approximately 1.5km long.

The majority of the dune along the beach is well-vegetated. The majority of the dune along the beach is well-vegetated. The significant bushland areas currently surrounding Forresters Beach include sections of Wamberal Lagoon Nature Reserve (southern escarpment) and Wyrrabalong National Park. There is a current and future risk to vegetation communities surrounding this beach including:

- E50a - Coastal Sand Foredure Scrub
- E51a - Coastal Headland Grassland
- E51b - Coastal Headland Shrubland
- E51c - Coastal Headland Low Forest

These vegetation communities are currently experiencing significant infestation of Bitou Bush. Ongoing dune management activities have been undertaken in this area.

At the southern section of the beach, there is a high and steep embankment at the back of the beach and there are a number of properties located at the top of this embankment. The properties along the central section of the beach are located at the top of a relatively lower embankment (**Figure 41**).

Geotechnical investigation undertaken in 1997 by Coastal & Marine Geosciences indicated that bedrock levels in the central and southern sections of the beach is generally around or below the mean sea level and therefore the dunes are at risk of erosion and slumping. In the northern section of the beach, the bedrock level is of a higher level and therefore may not be as susceptible to erosion.

A concrete apron has been constructed in front of a stormwater outlet located at the central section of the beach to reduce the potential scour erosion to the dune system (**Figure 42**).The stormwater outlet was previously a piled outlet elevated above the beach profile. The new concrete apron is currently suffering failure which may exacerbate scour at this location.

Figure 41: Well-vegetated dune along the back of Forresters Beach. Properties located at the top of a high and steep embankment along the southern section of the beach (left) and at the top of a relatively lower embankment along the central section of the beach (right).

Figure 42: Piled stormwater outlet (left) replaced with a stormwater outlet within the dune system and a concrete apron in front of a stormwater outlet (right)

7 REVIEW OF MANAGEMENT OPTIONS

7.1 Introduction

The Coastal Zone Management Plan should describe proposed actions to be implemented by Council, other public authorities and potentially by the private sector to address priority management issues in the coastal zone. The categories of available management options are discussed below, with reference to a risk management approach.

7.2 Risk Management Approach

The appropriate management actions for each beach within the LGA depend on the level of risk to public safety, public and private assets and infrastructure. The risk is usually defined as the product of *likelihood* and *consequence* at each location.

The Coastal Management Principles (OEH 2013) include Principle 6 which is to "adopt a risk management approach to managing risks to public safety and assets; adopt a risk management hierarchy involving avoiding risks where feasible and mitigation where risks cannot be reasonably avoided; adopt interim actions to manage high risks while long-term options are implemented." In accordance with this Principle, where the risks can be reasonably avoided, management options considered for the coastline are to be consistent with the key objective of finding reasonable risk avoidance strategies.

The Coastal Process and Hazard Definition Study for Broken Bay and the open coast beaches of Gosford assessed the risk of coastal erosion, inundation and slope instability for each beach, in the present day, 2050 and 2100 timeframes. For these timeframes, the *likelihood* of the risk has been assessed for a storm event having an annual probability of exceedance (AEP) of 1%.

The *consequence* of the risk is a function of the value of assets exposed to the hazards, whether there are any management measures in place already to deal with the hazards, and the resilience of the coastline and assets exposed to the hazard.

For the coastal hazards of beach erosion, shoreline recession, slope instability and coastal inundation, the following consequences on natural and built assets are considered:

- **Beach erosion** – Consequences of beach erosion can include social impacts (loss of beach access, impacts on beach amenity), ecological impacts (beach and dune ecology), and economic impact (damage to infrastructure). During cyclical erosion associated with major storm events, direct damage can occur to built assets such as dwellings, water and sewer infrastructure, roads, fencing and public amenities. Direct damage could be catastrophic, such as the destruction of dwellings or loss of life; or could be less serious, such as the temporary loss of services or damage to dune fencing, which can be restored for a known monetary cost. A loss of beach amenity can occur on a temporary basis due to beach erosion, which can have a direct impact on the economy or perceived values at the locality. Direct damage to natural assets such as beach dune ecology can also occur as a result of beach erosion – these systems are often resilient and may recover fully over time as the eroded dune system is restored under natural beach processes.

- **Shoreline recession** – Increases the likelihood that built or natural assets may be subject to catastrophic damage as the shoreline recedes. As for the beach erosion hazard, consequences of beach erosion can include social impacts (loss of beach access, impacts on beach amenity), ecological impacts (beach and dune ecology), and economic impact (damage to infrastructure, loss of property values, impact on tourism and loss of income from rates/taxes). The magnitude of shoreline recession has itself a varying likelihood of occurrence at each beach. This hazard may be exacerbated by future sea level rise which has been considered for the 2050 and 2100 timeframe.

- **Slope stability –** Damage to buildings not piled into the *Stable Foundation Zone* may occur in areas subject to reduced foundation capacity, where there is a reduced factor of safety for heavy structures (buildings) located within the *Zone of Reduced Foundation Capacity*. However, some types of infrastructure such as roads, services, dune fencing etc. and natural assets located in the *Zone of Reduced Foundation Capacity* would not normally be at direct threat of damage as they are not within the erosion hazard zone.

- **Coastal Inundation –** Built assets subject to inundation may not necessarily suffer catastrophic damage – for dwellings, inundation may cause damage to furniture, carpets, masonry, etc. depending on the depth and duration of the inundation; however, in most cases built assets would be able to recover from this damage, or the inundation risk can be managed by applying certain design criteria to the building. Assets such as sewer and water pipelines may not be damaged or adversely impacted by coastal inundation, and dune ecology may be relatively adapted to occasional inundation. Inundation due to wave runup may pose a threat to public safety and the consequence could be injury or loss of life. There may also be consequences to the local economy due to temporary loss of access to properties as a result of coastal inundation.

Other coastal hazards such as stormwater erosion may cause damage in a localised area, which may affect both natural and built assets. Sand drift may also be an issue at some locations within the study area but the consequence of this hazard is less severe within the study area than the consequence of direct hazards such as beach erosion or inundation.

The Guidelines for Preparing Coastal Zone Management Plans (OEH 2013) discuss several categories of management options that can be adopted for each beach, within a risk management framework. These option categories include:

- Avoiding the risk (i.e. building setbacks, planning/development controls, infrastructure setbacks and building design criteria)

- Changing the *likelihood* (i.e. coastal protection works, beach nourishment, compliance action on illegal works on beaches)

- Changing the *consequence* (i.e. building and infrastructure modification or relocation, access control and public education)
- Sharing the risk with another party (i.e. insurance)
- Retaining the risk by informed decision (i.e. emergency management).

Many of these management measures are already in place at some locations in the study area but their effectiveness needs to be reviewed in light of the updated coastal risk determined for each location.

In examining these options the Guidelines for Preparing CZMPs (OEH 2013) stipulate the following management approach:

- Management of high public safety risks takes priority over risks to built assets;
- if risks from a hazard are low, maintain this level of risk through appropriate land-use, development approval and infrastructure planning decisions;
- if the risks from a hazard are high:
  - avoid further development in the area or ensure the development can accommodate the hazard, including any likely increase in the severity of the hazard over time (e.g. due to projected sea level rise)
  - ensure appropriate emergency management arrangements are in place, and
  - consider works to reduce risk levels, focusing on the highest risks.

7.3 Spatial scale for application of Management Actions

It is considered that the management actions are best defined at a scale representing each beach or locality. While some management options defined in the CZMP would be applied city-wide (for example, changes to general planning controls in the DCP), and others at a local scale (for example, repair of a particular stormwater outlet on a particular beach), it is considered that the more significant management actions under the CZMP would require input from the entire community at a particular beach and could be defined on a beach-by-beach basis. In this Study, we have defined risks and management options on a precinct basis, where we have divided each beach into separate precincts based on physical attributes, natural boundaries and level of risk identified in each precinct.

7.4 Temporal scale for application of Management Actions

Management actions can be applied in the short-term (e.g. 0 – 5 years), medium term (e.g. 5 – 20 years) or long term (e.g. greater than 20 years).

The temporal scale for a particular action would depend upon how the risk is changing over time, as well how quickly they can be implemented from a regulatory and financial perspective. There is also a time scale associated with the planning, actual implementation and construction of a particular management option. For example, the option to build protective structures may be required in the medium term but may take over 5 years in the planning, design and funding phases.

7.5 Options to Avoid the Risk

Options to avoid the risk are discussed in the Guidelines for Preparing CZMPs (OEH 2013). In general, the following options are available:

- Planning/Development controls;
- Infrastructure setbacks;
- Building and infrastructure design criteria.

7.5.1 Planning and Development Controls

Planning controls have been implemented through the Gosford DCP 2013 which aims to:

(a) Minimise the risk to life and property associated with development and building on land which has a coastal beach and/or cliff frontage; and

(b) Provide guidelines for the development of land within the coastal frontage area.

The DCP stipulates that buildings or building structures not be constructed on, over or below land identified as being within the 2098 erosion line for the Broken Bay beaches, or the 2045 erosion line for the Open Coast beaches, except under special circumstances.

Implementation of planning controls for new development within the coastal hazard risk zones identified by the Coastal Hazard Study is a way to avoid the risk and reduce the quantum of the coastal risk. The planning controls could be implemented in conjunction with other options discussed in this report.

The implementation of planning controls reduces the existing costs and time involved with assessing DAs for coastal property development, and provides consistency for development assessment within the affected areas. They provide a consistent framework for assessment of DAs and provide guidance to Council officers in assessing applications fairly and equitably.

Planning and development controls are already in place for coastal development within the Gosford LGA, through the Gosford DCP 2013 (discussed in Section 3). The existing DCP guides what development is allowable in particular zones along each beach based on the level of coastal risk assessed at each beach. The Coastal Process and Hazard Definition Study (WorleyParsons 2014) has updated the risk assessment at each beach from the previous assessments undertaken in 1995 and 1999.

The existing planning controls may need to be refined at each beach, based on updated information on coastal risk and considering the nature of existing development in the area. Any changes to the DCP would need to reflect the management approach stipulated in the Guidelines for Preparing CZMPs (OEH 2013). The existing planning controls allow for some development to occur in the coastal hazard areas subject to certain conditions, as described in Section 3.1.

For example, at Pearl Beach, the risk is avoided by specifying design criteria for new buildings. This option may be appropriate for other beaches. Alternatively, buildings need to be founded on deep pile foundations which extend below the locally unstable foundation zone which relates to the 2098 prediction. A change to this planning control may be recommended as a management action of the CZMP. This would be done by amending the DCP, based on the implications of the change in the level of risk since the previous risk assessments carried out in 1995 and 1999. If proper building design involving appropriate floor levels and appropriate foundation design is undertaken (as per the Guidelines for Preparing CZMPs, OEH 2013) under development controls then the building and allotment amenity will be able to be maintained for the 40 year horizon nominated in the Report.

As the coastal hazard assessments undertaken for the 1995 and 1999 coastal zone management plans did not explicitly include an allowance for reduced foundation capacity, there is a risk under the existing DCP that buildings would be allowed without restrictions in areas subject to future reduced foundation capacity. The existing DCP would therefore need to be updated to take account of the following:

- Updated erosion hazard predictions;
- Consistency of application of the policy between various beaches; and
- Inclusion of additional requirements to address the hazard of reduced foundation capacity.

It is suggested that, where possible, the DCP be applied consistently across the LGA. Given that the Australian Tax Office allows the entire construction cost of a residential rental property to be deducted over a period of 40 years, it can be inferred that the economic life of a dwelling is 40 years. Based on this, the 2050 planning horizon may be the most appropriate planning horizon to adopt for new developments.

The effectiveness of the existing DCP, suggested changes to the DCP and suggested management options are discussed in Section 8, in light of the re-assessed coastal hazard at each beach in the study area.

7.5.2 Setbacks

Setbacks for properties within the coastal hazard areas are also defined in the DCP. It is considered that setbacks are a viable management option to avoid the risk, particularly for erosion and long term recession, where they allow the development of a property to still occur (i.e. the setback is not so great as to render a property unable to be developed). Where the required setback under the DCP would be so great as to render many of the properties in a particular precinct undevelopable, alternative management strategies need to be considered for that precinct.

Setbacks also exist for development from the road reserve (property boundary) and are generally set at a 6 m distance. However, there is scope to vary this distance to maintain a developable footprint which avoids placing development in coastal hazard zones.

7.5.3 Building and Infrastructure Criteria

Building and infrastructure design criteria can be implemented for new development through the Gosford DCP to minimise the consequence of the coastal hazards. Erosion and slope stability risks can be reduced by stipulating new development be founded on deep piled foundations which extend below the locally unstable foundation zone.

Review of the CZMP creates opportunity to think creatively in determining future DCP provisions to retain development potential in consideration of coastal hazards. The ultimate review of Council's DCP will involve revisiting concepts and established rules relating to development footprints, engineered design, cantilevering, building design (i.e. relocatable buildings) and setbacks from street to maintain development potential: all in a view to enabling ongoing development in the short to medium-term. In doing so, Council must be confident it does not create further legacy implications for future generations.

Inundation risk can be managed using design criteria in a variety of ways, including:

- using construction materials that would not be adversely damaged by inundation, such as concrete floors;
- placing electrical equipment, wiring, or any other service pipes and connections that could be damaged by water at a suitably high level;
- storing goods or materials that could potentially be water damaged or water polluting at a suitably high level;
- using impact resistant construction materials in areas that may be subject to direct wave action;
- maintaining seawalls seaward of development at a suitably high crest level; and
- stipulating minimum floor levels and free flow areas.

Such measures can be included in the Gosford DCP where appropriate.

7.6 Options to change risk likelihood

Options to change the risk likelihood are suggested in the Guidelines for Preparing Coastal Zone Management Plans and include:

- Coastal protection works;
- Beach nourishment;
- Dune revegetation.

Alternative engineering options are described below but have not been considered further as they have not been considered viable for implementation on the beaches at Gosford. These include:

- Groynes
- Artificial Reefs

"Protection" options require physical intervention to slow down or prevent coastal erosion, and provide some degree of protection to public and private property from coastal hazards.

Such options may involve construction of engineering works, such as seawalls, groynes and revetments, which can modify coastal processes and allow existing and future property and infrastructure to remain viable into the future by protecting them from damage caused by coastal erosion.

Some types of engineering works may be more effective than others at providing this protection, and all require maintenance. Some combinations of various engineering structures could be used to provide the dual goals of improvement in beach amenity as well as protection of infrastructure. Other structural interventions may improve protection at the expense of amenity, while still others can improve amenity but provide a lesser degree of protection. Future maintenance will become more costly, and this is a cost that will need to be borne by the community in future generations.

Such protection options would in most cases reduce the likelihood of the risk to coastal development, allowing it to persist in the short to medium term. However, future climate change impacts may increase maintenance requirements of structural coastline protection and it may not be viable in the longer term. Conversely, property values for the parcels protected by appropriately engineered works would be retained, and possibly increase. Further, rates and tax income that would otherwise be lost would be maintained and enhance the local economy.

Depending on financial modelling, maintenance costs may in fact be more than offset and potentially fund future protective works as the reality of Climate Change becomes clearer.

While some of these options may serve the dual purpose of improving beach amenity and improving beach access, they will have varying degrees of effectiveness depending on the level of intervention applied. Some of these types of options would not provide sufficient protection to property on their own.

Other types of options, termed "soft" options, may involve beach nourishment to improve beach amenity and provide a buffer of sand to lessen the impact of future storms on erosion of the embankment.

A combination of hard engineering or softer management approaches may be adopted. All of these options have a finite design life and would require regular maintenance. These costs would need to be borne by the community.

These types of options may be part of a medium term strategy, and could be combined with a longer term strategy of planned retreat of critical high risk infrastructure from the shoreline.

A discussion of potential coastal protection management options, their advantages and disadvantages, and relative costs are provided below.

Issues to be considered when considering defensive structures for coastal protection include the following:

- Whether the defensive structure would have adverse impacts on natural character, the local economy, scenic amenity, public access or cultural heritage values
- Advantages or disadvantages of 'hard' verses 'soft' coastal protection works (i.e. sea walls verses beach nourishment)
- Whether there would be an expectation that defences would be maintained 'forever', leading to ever increasing financial commitment to maintain and upgrade such defences
- Funding arrangements for such works – whether the costs would be borne by property owners who directly benefit or borne by the broader community
- Maintenance costs versus the value of the assets being protected
- Whether there is allowance for foreshore ecosystems to migrate landward as the sea level rises and what value is placed on the foreshore ecosystems (e.g. for fishery resources or tourism)
- Knowledge gained from experience with historical storm events (e.g. 1974 and 1978)
- Whether hard defences would prevent the discharge of water and increase the risk of flooding of land by rain water runoff
- What land tenure considerations and potential approval processes are applicable for coastal defences
- Whether 'hard' defences could cause erosion remote from their locations and, therefore, potentially generate the need for more hard defences on neighbouring beaches.

7.6.1 Revetment or Terminal Protection Structure

Seawalls are structures designed to prevent or alleviate overtopping or flooding of the land and the structures behind, due to storm surges and waves. They also work to reduce coastal erosion and hold the coastline in place. Seawalls are often used to protect promenades, roads, and houses located on or immediately landward of the frontal dune.

Similar to seawalls, revetments are a more specific structure type with a similar purpose of protecting the shoreline from wave-induced erosion by placing an erosion resistant cover directly on an existing slope or embankment (Coastal Engineering Manual, 2003). Seawalls are often a vertical front wall, whereas revetments are often set at a slope and are designed to absorb rather than reflect wave energy.

Revetments share some common concepts and structural elements with seawalls, with the common purpose of protection against coastal erosion. Three major features of revetments are a stable armour layer, an underlayer, filter layers and toe protection (Coastal Engineering Manual, 2003). The filter layer and the underlayer supporting the armour allow for the passage of water through the structure. Toe protection prevents undercutting and provides support for all the layer materials. A wide range of designs and materials is available for use in revetments. Typical revetment options are summarised in Figure 43.

Revetment armour can be either flexible or rigid, although rigid concrete or asphalt slabs generally are unable to accommodate any settling. While performing the same purpose, large artificial concrete armour units have been developed and designed over the last 50 years to provide an alternative to using large rocks, where such resources cannot be sourced. Generally, the casting and constructing process requires significant financial input and may also detract from visual amenity of the environment in some cases. In the case of rock revetments, they may be buried in native sand to restore beach amenity and re-vegetated to form a dune. Following a storm event the sand will erode and the revetment will act to prevent further erosion. Rock revetments generally tend to have a slope ranging between 1V:1.5H and 1V:5H.

An example of a revetment is the proposed Terminal Protection Structure at Wamberal Beach, which is proposed to be constructed using Seabees. An example of a Seabee revetment is illustrated in Figure 44. An example of a seawall is the concrete block seawall at Terrigal.

Revetment structures are an effective hard engineering solution that protects a coastline from the general landward recession caused by wave-induced erosion. If they are coupled with beach nourishment and covered in a vegetated dune, natural aesthetics can be improved. The loss of sand in front of a revetment structure would be lower when compared with a vertical face seawall because there is much less wave reflection in front of the structure.

The stability of the structure slope is very dependent on intact toe support, which means that loss of toe support will likely result in significant damage to the armour layer, if not complete failure of the armoured slope. Higher rates of beach erosion may also occur at the ends of the revetment seawall due to edge effects. Due to their potential vulnerability to scour, revetment seawalls often are complemented with another beach control system, such as groynes and beach nourishment (Coastal Engineering Manual, 2003).

Advantages of revetments include:

- They can be effective in protecting the landward infrastructure from erosion;
- They can be covered with beach nourishment sand and planted over with native vegetation to reduce their visual impact and in this way, may only become visible after a major storm;
- They absorb wave energy and result in less erosion on the seaward side of the structure when compared with a vertical seawall. However, they can still cause erosion on the seaward side of the structure depending on the structure slope; and

- They would allow development to continue to occur in its current location as they effectively reduce the coastline risk to those properties.

Disadvantages of revetments include:

- They can be costly to construct;
- A revetment may not necessarily mitigate inundation, and it may provide the community with a false sense of security in developing the area behind the revetment;
- They can detract from the visual and recreational amenity of the beach if they are not combined with beach nourishment;
- They have a large footprint area and would disturb a large width of embankment during their construction;
- They can result in higher rates of beach erosion at the ends of the revetment due to edge effects and therefore require more beach nourishment; and
- They require on-going maintenance.

While protection can be implemented on an individual property scale it is more successful when applied along an entire beachfront precinct. This minimises the potential for pockets of erosion which may damage neighbouring property and cause failure of the protective structure.

The stability of revetments will depend on the maximum breaking wave height in front of the structure, which in turn is dependent on the depth of water at the toe of the structure. Thus the limiting case for design (i.e. the worst conditions that the structure would be subjected to) will occur when the beach berm is scoured and the nearshore water levels are high. The following parameters are important for design:

- **Beach scour level**: The beach berm potentially can scour down to 1 m below mean sea level to the level of the underlying hardpan reef material following a large storm event, allowing large waves to reach the structure.
- **Water Level**: The offshore water level can reach over 1 m above mean sea level in the deep ocean, with water levels increasing to 3.6 m above mean sea level as a result of storm surge and wave setup. Higher water levels can allow large waves to reach the toe of the structure.
- **Structure Slope**: The stability of the structure against wave attack and geotechnical failure is dependent on the slope.
- **Crest Level**: The crest level is an important consideration in determining revetment stability. A revetment with a low crest level may be subject to wave overtopping which can result in erosion of the underlying material and failure of the structure. A structure with higher crest level on a relatively steep slope may be subject to reduced slope stability.

- **Armour unit mass**: The mass of the individual geotextile bags has a bearing on the stability of the units against wave attack.
- **Thickness of armour layer**: The thickness of the armour layer has an impact on the stability of the structure. A structure with two or three layers of armour units would be more stable against wave attack than a structure with a single layer.
- **Soil and Geotextile properties**: The properties of the underlying soils are an important consideration when determining the stability of the structure against sliding failure. In particular, the internal friction angle of the underlying soil, the friction angle between the geotextile fabric and the soil and the friction angle at the interface between the individual armour units.

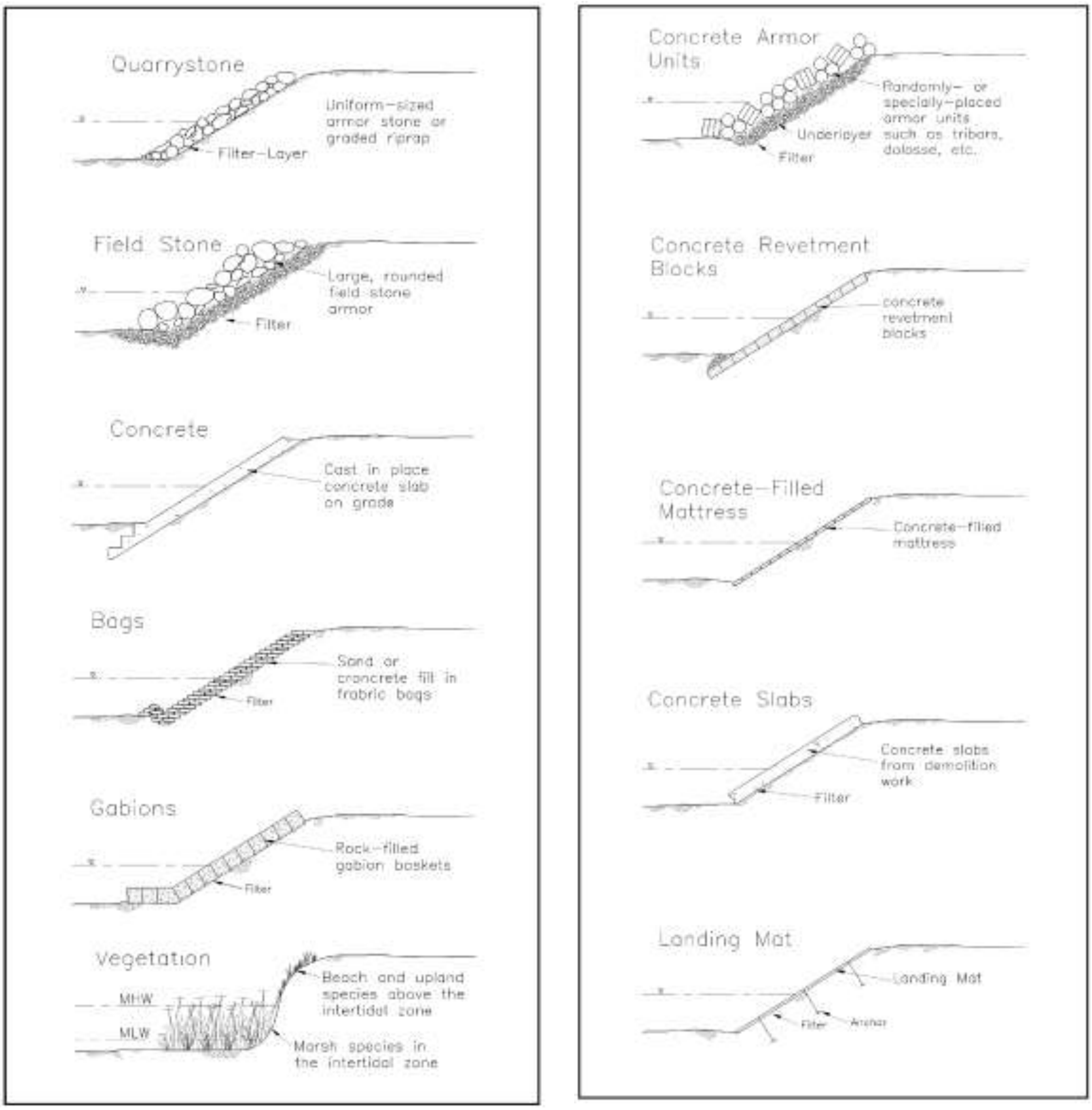

Figure 43 - Typical Revetment Options (after Coastal Engineering Manual, 2003)

Figure 44 –Example of Seabee seawall.

7.6.2 Geotextile coastal protection works

Geotextile sand-filled containers have been used in some coastal locations worldwide to provide an alternative to conventional rock and concrete coastal protection structures. Various products are available from different manufacturers, including ELCOROCK® geobags of various sizes (a geotextile designed to be filled with sand, soil or gravel and providing puncture, abrasion and UV resistance), and geotubes or "sand sausages".

There is little experience with geotextile container revetments in severe storm erosion events on the open coast and it is unlikely that such works would be competent in these type of events.

A typical example of a geotextile sand-filled container revetment is shown in Figure 45.

Figure 45 – Typical sand-filled geotextile container revetment at Byron Bay, NSW Australia

A geotextile container structure would need to be safe with respect to slope stability, particularly in areas frequented by the public. The structure should have an acceptable Factor of Safety against slip failure. Generally, for most engineering projects, an acceptable Factor of Safety is 1.5 (Nielsen and Mostyn, 2011). Therefore, geotextile container structures may need to be designed as mass gravity seawalls, often with comparatively flat seaward batters.

It should be noted that a geotextile container revetment with a flatter slope, while more stable with respect to slope stability, would be less stable against wave action than a geotextile revetment with a steeper slope. There is, therefore, a conflict between achieving dynamic stability against wave action and static stability against geotechnical failure.

The stability of the individual geotextile containers will depend on the maximum breaking wave height in front of the structure, which in turn is dependent on the depth of water at the toe of the structure. Thus the limiting case for design (i.e. the worst conditions that the structure would be subjected to) will occur when the beach berm is scoured and the nearshore water levels are high. The following parameters are important for design:

- **Beach scour level**: The beach berm potentially can scour down to 1 m below mean sea level to the level of the underlying hardpan reef material following a large storm event, allowing large waves to reach the structure.
- **Water Level**: The offshore water level can reach over 1 m above mean sea level in the deep ocean, with water levels increasing to 3.6 m above mean sea level as a result of storm surge and wave setup. Higher water levels can allow large waves to reach the toe of the structure.
- **Structure Slope**: The stability of the structure against wave attack and sliding failure is dependent on the slope (Coghlan et al., 2009).
- **Crest Level**: The crest level is an important consideration in determining revetment stability. A revetment with a low crest level may be subject to wave overtopping which can result in erosion of the underlying material and failure of the structure. A structure with higher crest level on a relatively steep slope may be subject to reduced slope stability.
- **Geobag mass**: The mass of the individual geotextile bags has a bearing on the stability of the units against wave attack. Geotextile containers generally are available in standard sizes of 0.75 m^3 or 2.5 m^3.
- **Thickness of armour layer**: The thickness of the armour layer has an impact on the stability of the structure. A structure with two or three layers of geotextile bags would be more stable against wave attack than a structure with a single layer.
- **Soil and Geotextile properties**: The properties of the underlying soils are an important consideration when determining the stability of the structure against sliding failure. In particular, the internal friction angle of the underlying soil, the friction angle between the geotextile fabric and the soil and the friction angle at the interface between the individual geotextile units.

Geotextile coastal protection works are allowable in some areas within the Gosford LGA as “temporary coastal protection works” as identified in the NSW Government Code of Practice under the Coastal Protection Act 1979. The term “Temporary coastal protection works” has a specific meaning in relation to the *Coastal Protection Act 1979*, generally being sand or sand-filled geotextile containers temporarily placed on a beach to reduce beach erosion impacts. They are only permitted at authorised locations, namely only at Wamberal Beach, North and South Avoca Beach, Forresters Beach, Copacabana-MacMasters Beach, Pearl Beach and Patonga Beach in Gosford.

The Coastal Erosion Emergency Action Subplan for Wamberal-Terrigal Beach identifies specific properties along that beach where temporary coastal protection works under Part 4c of the *Coastal Protection Act 1979* are allowable.

7.6.3 Groynes

Groynes are structures constructed perpendicular to the shoreline to act as a physical barrier to trap sand and hold it within a beach segment in the direction of longshore transport through the system. They are effective where there is a net transport of littoral drift material in one direction.

Groynes can be constructed from wood, concrete, steel or rock armour, although temporary structures may also be constructed from geotubes filled with sand as a trial to observe the effect of a groyne on the system without the full cost or process impacts of a permanent structure.

In designing a groyne field it is important to ensure that the amount of sediment trapped is limited and excess sediment transport is free to continue through the system. It is necessary that the coastal processes at a site where groynes are being considered be well understood and quantifiable to ensure that sand is available to fill the groyne compartment and that the resultant downdrift erosion is acceptable. Groynes that are too long may trap all the sediments and cause significant reduction in beaches on the down-drift side as no sediments can pass the groyne. Conversely, groynes that are too short, low or permeable may become ineffective in trapping sand and little sand accretion is witnessed. Usually, groynes are not suitable where a large tidal range permits too much bypassing at low tide and overpassing at high tide or where there is little alongshore sediment transport.

The construction of groynes may be accompanied by sand nourishment. This would reduce beach recession on the downdrift side of the groyne, compensating for the accretion on the updrift side of the groyne.

The groynes could consist of temporary or trial structures such as sand-filled geotubes, which could be removed over time if ineffective, or replaced with a more durable permanent structure if they prove to be effective. The beach nourishment sand could be shaped into a dune, replanted and fenced to provide formalised beach accessways for the public.

Groynes can have the following advantages over other forms of foreshore protection:

- They are effective in creating a usable beach on the updrift side if there is a strong rate of longshore drift
- They can increase the width of the beach berm and, therefore, provide an area of beach that can be used by the public
- They allow the beach to accrete on the updrift side, providing a buffer of sand to protect infrastructure against storm erosion
- They can be installed as temporary geotube structures to study their effectiveness and optimise their location.

Disadvantages of groynes include:

- They can be costly to construct
- The structure itself can detract from the visual and recreational amenity of the beach

- They can cause erosion on the downdrift side of the structure
- They can create a hazard to swimmers at their seaward end
- They require careful design and detailed understanding of the coastal processes
- They can cause loss of sand from the beach system if they are too long
- They require on-going maintenance following large storm events
- Groynes are not a certifiable coastal protection measure and do not guarantee full or continual protection of the coastline from landward recession. In severe storm events, any accreted sand will be transported away from the beach profile and wave action from an extended storm event will continue to erode the coastline.
- They can generate rip currents causing sand to be transported seaward

A typical groyne field and its impact on the shoreline is shown in Figure 46.

Groynes are not expected to be very effective for the beaches within Gosford LGA as they work best in areas where there is a strong rate of longshore drift, which is not the case for most of the beaches in Gosford. For this reason, groynes have not been considered in detail when discussing appropriate management measures at each beach.

7.6.4 Beach Nourishment

Beach nourishment involves placement of sand onto the beach profile, which provides a buffer against erosion due to storms. The term beach nourishment usually refers to nourishment of the entire beach profile, including the dune, beach berm and the portion of the active beach below the shoreline. Such nourishment depends on locating a suitable source of sand. It works best when the sand placed on the eroded beach closely matches the grain size and characteristics of the native beach sand, or when the sand is sourced from within the same coastal sediment compartment as the beach. It should be noted that while beach nourishment usually involves importing sediment to a particular beach compartment, in this report we have included the recycling of sediment from within the same sediment compartment under the umbrella category of beach nourishment.

An example of beach nourishment work is shown in Figure 47. Typically, this work is followed by vegetation planting on the dune to stabilise the sand and preventing sand from being blown away by wind. Fencing off the dune and limitation of the number of accessways would avoid dune destabilisation caused by informal access.

Sediment sieve analysis of sands at various locations would be useful in identifying a suitable source of beach nourishment sand for the shoreline in the study area, by comparing the characteristics of the sand from various sources to the characteristics of the native sand of the foreshore in the placement area. There has been previous work undertaken in this regard within the study area, including the Gosford City Beach Nourishment Feasibility Study (NSW Department of Public Works and Services, Stage 1, 1997 and Stage 2, 2002).

Beaches can be nourished using sand sourced from nearshore or even redistributed from one place to another. Sand could be moved by off-road vehicles along a beach and re-distributed from areas where there is a surplus of sand to areas where there is a deficit of sand.

Beach nourishment could be undertaken on the beach berm only, but is generally more effective when undertaken over the full profile depth within the area in equilibrium with the prevailing wave climate.

Dune fencing can be constructed at the top of the dune face to help stabilise the dune. Once the fencing is implemented, vegetation can be planted to further stabilise the dune and capture the sand. This option would require time to allow the vegetation to establish. An example of such a dune configuration is illustrated in Figure 48.

Advantages of beach nourishment include:

- It can work with rather than disrupt the natural coastal processes to replace the sand on the beach
- It can be a cost-effective means of coastal protection where there is a viable source of sand and placement mechanism
- It provides a buffer of sand to help protect infrastructure from dune erosion due to storms
- It can provide a certifiable level of coastal protection provided it is closely monitored
- It can improve the visual and recreational amenity of the beach by providing an area of sand that can be used by the public
- It can allow revegetation and rehabilitation of dune vegetation
- It can provide a mechanism to allow bypassing of sand which is currently trapped updrift by artificial structures.

Disadvantages of beach nourishment include:

- Beach nourishment conducted in isolation could be transported rapidly out of the beach system
- It can be costly to implement if there is no viable source of sand nearby
- Beach nourishment sand can be lost in subsequent storms and would need periodic replenishment and maintenance (depending on the suitability of the sand source, sediment transport rates in the study area and quantity of available sand)
- If the grain size distribution of the source of sand is unsuitable it could lead to large losses of sand from the beach during storms

- In some cases, it can cause temporary water quality impacts due to dredging and smothering of seagrasses or live coral due to fine material being released into the water column
- It does not guarantee continual protection of the coastline from landward recession or storm events.

Typically, sand nourishment would require revegetation and fencing works to be carried out at the dune, which would provide a measure of protection to the dune against erosion.

While beach nourishment works best when the borrow sand has the same characteristics as the native sand from the nourishment area, sand from outside the littoral compartment can be used to provide a supply to augment the natural sand reserves of the beach. Detailed studies of sediment budgets could be required to determine the most appropriate source region for the sand, and a detailed environmental assessment should be carried out to determine the impact of sand nourishment.

Rather than undertaking one large beach renourishment exercise, smaller quantities of sand could be placed on the foreshore at regular intervals - or possibly after severe storms. The advantages of staged nourishment are that shoreline changes would be less dramatic, and initial losses would be reduced. A disadvantage would be the periodic disruption to foreshore activities caused by carting sand along the beach. Costs may also be higher because of the need to mobilise for a number of nourishment campaigns. The performance of the beach nourishment would require monitoring over time, and the exercise repeated when required.

Beach nourishment was identified by the Environmental Impact Statement for Wamberal Beach (MHL 2003) as accompanying the potential construction of a terminal protection structure for Wamberal Beach. A discussion on beach nourishment for Wamberal Beach and the other Gosford open coast beaches including potential sand sources and required quantities is provided in MHL (2003). That investigation concluded that the most viable source for sand nourishment of Terrigal/Wamberal Beach is the existing offshore sand reserves.

MHL (1997, 2002) examined the feasibility of beach nourishment for MacMasters, Avoca, Terrigal/Wamberal and Forresters beaches, including costs and feasibility of various sand sources. It was found that the most favourable source for sand nourishment is the offshore sand resources. However, these offshore resources are currently not available for extraction due to the prohibition on offshore minerals extraction enforced in the *Offshore Minerals Act (1999)* (Withycombe *et al.*, 2009). A suitable sand source for beach nourishment is identified at a scale large enough to counteract the erosion threat and enhance beach amenity. However, the ability to access this sand source is inhibited at this time.

Figure 46 - Top - Example of a geotube groyne (Geofabrics Australasia Pty. Ltd.); Bottom – example of a groyne field at Botany Bay, NSW Australia showing the impact of the groynes on the planform of the beach.

Figure 47 - Beach Nourishment construction, Jimmys Beach Port Stephens, NSW Australia

Figure 48 - Stabilisation of the dune by a dune fence and vegetation planting

7.6.5 Artificial Reefs

Artificial Reefs are coast-parallel, long or short submerged or emergent structures built with the objective of reducing the wave action on the beach by inducing wave breaking over the reef (Coastal Engineering Manual, 2003).

These are built offshore and may consist of rubble-mound structures constructed of rock or concrete armour units. They can be designed to be stable or allowed to reshape under wave action. Artificial reefs may be narrow crested like detached breakwaters in shallow water or, in deeper water, they may be wide crested with lower crest elevation like most natural reefs that cover a fairly wide rim parallel to the coastline. They may be fully submerged or have a crest level above water.

Artificial reefs modify the nearshore wave climate by inducing wave breaking and subsequent energy dissipation, and they can also be used to regulate wave action by refraction and diffraction. Attempts have been made to design these to improve surfing conditions while at the same time protecting the beach from erosion, although these attempts have been largely unsuccessful. A major disadvantage of artificial reefs is that they often present a non-visible hazard to swimmers and boats.

Such structures have been constructed elsewhere, such as by Gold Coast City Council at Narrowneck (Figure 49 and Figure 50), and a smaller scale reef has been constructed at Semaphore Park in South Australia. It is noted that the HMAS Adelaide was scuttled offshore from Avoca in 2011 – however the role of this reef is not for coastal protection but rather as a tourist attraction for divers.

The Narrowneck Artificial Reef was intended as an off-shore defence mechanism against beach erosion, but also aimed to improve surfing conditions at Narrowneck Beach. The reef construction involved using sand filled geotextile bags dropped onto the seabed. The reef has been in place for around 15 years and monitoring has been continually undertaken to assess whather it has been successful in maintaining a wider nourished beach. The reef is part of an ongoing beach protection strategy which includes regular beach nourishment.

The Northern Gold Coast Beach Protection Strategy was implemented at a cost of $9 million and involved the dredging of more than 1.1 million cubic meters of sand from the Broadwater and deposited as beach nourishment on Surfers Paradise beaches.

An artificial reef of the scale of the Narrowneck Reef is likely to be too large and not practical for the beaches of Gosford. A smaller scale structure such as one used for Semaphore Park in South Australia, could be designed for individual beaches (Townsend, 2005).

Advantages of offshore breakwaters and artificial reefs include:

- They can lead to build up of sand on the beach in the lee of the structure

- They can enhance surfing conditions if properly designed, and
- If they are located underwater they are visually unobtrusive.

Disadvantages of offshore breakwaters and artificial reefs include:

- They can be costly to construct
- They can have a significant environmental impact as they can smother benthic ecosystems
- They can pose a navigation hazard or hazard to swimmers
- They can cause erosion of the beach on either side of the structure
- They do not work very well when the dominant sediment transport mechanism is longshore transport.
- They require maintenance, and
- They are not a certifiable coastal protection measure and do not guarantee full or continual protection of the coastline from landward recession. Development Controls will be needed.

Artificial Reefs are not a practical option for the beaches in Gosford – because of their high cost and the difficulty in predicting their effectiveness.

Figure 49 - Artificial Reef - Narrowneck Reef, Gold Coas

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Figure 50 - Artificial Reef – Aerial View of Narrowneck Reef, Gold Coast (GCCC, 2007)

7.6.6 Dune Management

Dune management is the combination of activities to maintain vegetative cover on the foredune to prevent sand blowing inland where it is lost from the coastal system. Key elements of successful dune management include, dune management planning, reconstruction, revegetation, protection and maintenance. To be most successful, dune management programs require the community to be aware of, and actively or passively support, dune management works.

The Coastal Dune Management Manual (DLWC 2001) outlines techniques and guidelines for rehabilitating coastal dunes. The Manual outlines guidelines for re-building and reshaping of dunes, re-shaping of dunes after storms, stabilization of dunes using mulches, use of fencing and construction of beach accessways. It also outlines techniques for management of weeds in coastal dune areas, as well as techniques for planting and establishing functional ecosystems on coastal dunes.

Dune vegetation can prevent wind erosion by decreasing wind speed at ground level, provide a protective cover over the dune, provide habitat for native fauna and reduce (but not prevent) damage from wave erosion. Dune vegetation can also regenerate after storm activity and facilitate natural recovery of the dune.

Dune management is currently being undertaken by a number of groups in the study area, with the support of Councils Bushcare program.

7.6.7 Beach Scraping

Beach scraping is a technique used for accelerating beach recovery following erosion by changing the slope of a beach, periodically, to allow the energy of the sea to bring additional sand onshore. This is achieved by removing a small amount of sand from the beach berm at low tide and adding the sand to the dune system. This process serves to assist nature in beach enhancement by systematically speeding up the natural dune recovery process (Nature Assisted Beach Enhancement or NABE).

Beach scraping comprises a soft engineering technique of responsible beach sand management. The technique has been used successfully at many places. For example, Byron Shire Council has been using the beach scraping technique at New Brighton for many years. Figure 51 shows such beach scraping activity.

It is recognised that the restoration works proposed would not, *per se*, form a permanent solution to an erosion problem and scraping may need to be done again at some future time. However, such soft engineering techniques are encouraged as they do not interfere with the natural processes and they have minimal adverse impacts on the environment. It should be noted also that beach scraping would not work at high energy open-coast beaches and is best suited to beaches subject to a long, low swell wave climate such as Pearl Beach.

Beach scraping has higher uncertainty as a protection measure than other coastal management options, so should only be undertaken in conjunction with a comprehensive monitoring program (Carley et al., 2010).

Figure 51 – Example of Beach Scraping at Callala Bay, NSW.

The impact of removing sand from around the low tide mark is to lower the upper part of the sub-aqueous beach profile and, thereby, to flatten that portion of the beach slope. A flatter slope would tend to induce onshore transport of sand under wave action from the nearshore zone, thereby replacing the sand that was won to reinforce the dune by scraping. As the low tide zone is replenished by the natural onshore movement of sand, more sand can be won from this zone and transferred to the dune. In this way, therefore, the dune can be reinforced at an accelerated rate to provide a sand buffer to future storm erosion.

The process is schematised in **Figure 53**. With the scraping of sand from the lower beach face at low tide to be deposited on the dune, when the tide rises the waves find a hole that was not there before, and the effective nearshore beach slope is reduced. This will accelerate the onshore rate of sand movement to a level higher than that it would have been had the hole not been created. The hole fills in faster than the otherwise natural rate and it does this over the higher stages of the tide. When it is low tide again the operation is repeated, winning more sand and accelerating the onshore sand movement rate at the next high tide and so on.

It is important to note here that in building up the upper beach face or dune, while it is causing it to be steeper, this has no effect on the beach recovery rate because it is beyond the reach of the waves and, therefore, outside the active beach system under the lower wave climate.

Beach scraping was used at Pearl Beach following the severe storms that caused dune erosion in 1974. As shown in Figure 52, a bulldozer was used to transfer sand from the lower beach to the dune. This work restored the dune protection to the development without any longer term adverse impacts having been experienced on the beach.

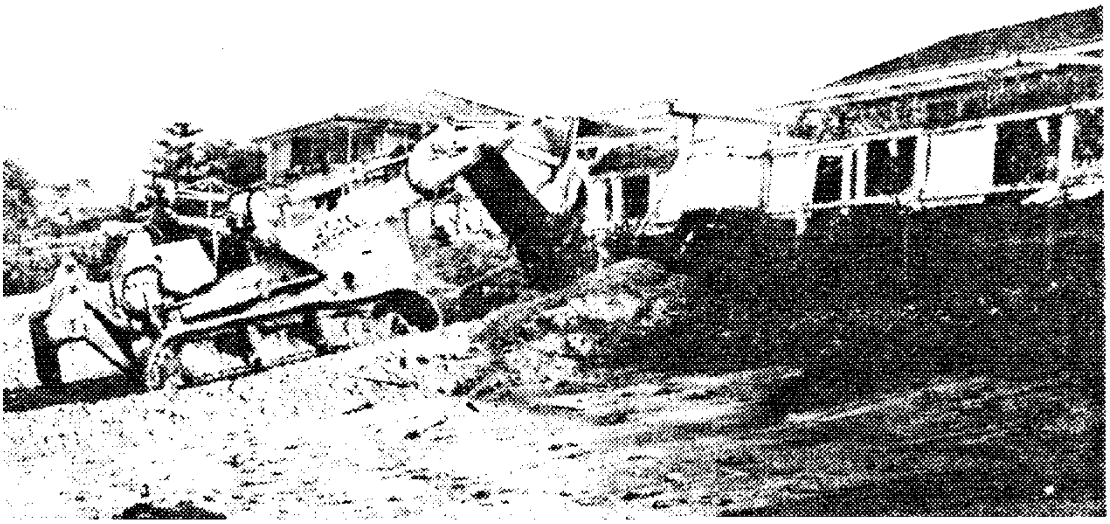

Figure 52 - Beach scraping at Pearl Beach following the 1974 storms

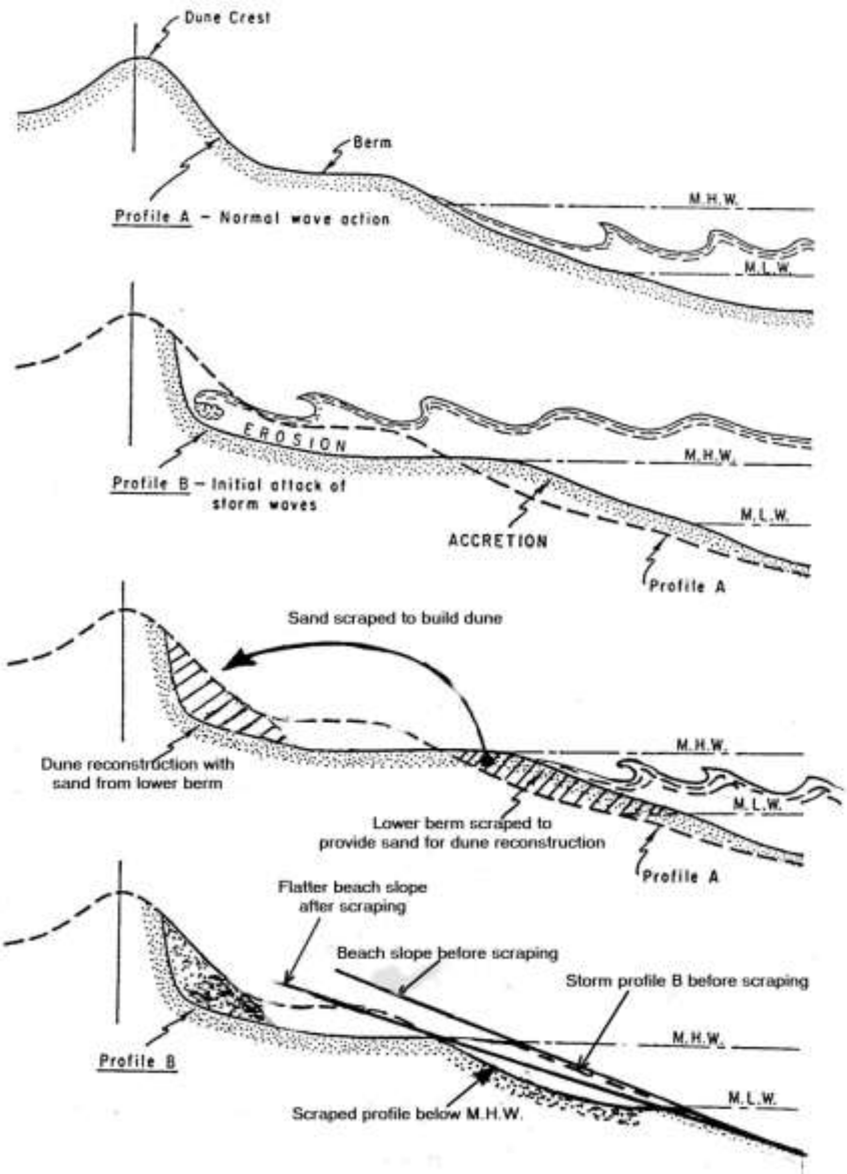

Figure 53 - Schematic diagram illustrating the application of beach scraping

7.7 Options to change risk consequence

This class of management options can change the consequence of the hazard in a particular area. Examples of this type of approach are to relocate critical infrastructure landward where possible, or making modifications to existing infrastructure to reduce the quantum of damage that could occur following the design storm event.

Issues to be considered when considering options to change the risk consequence include the following:

- Public perception of changes in coastal land use
- Design requirements to accommodate coastal hazard impacts to the year 2100
- Circumstances under which new development (and services) need to undergo adaptive design
- Potential for this management approach to result in increased demand for emergency services
- Types of early warning systems and preparedness that could be accommodated to increase community awareness of, and preparation for, coastal hazard threats.

7.7.1 Retreat

'Managed retreat' is defined as any strategic decision to withdraw, relocate or abandon private or public assets that are at risk of being impacted by coastal hazards.

The various scales of managed retreat include:

- micro-retreat, where the elevation of the building floor is raised, for example, by elevating a building on piles (suitable only for inundation-related hazards)
- relocation within a property boundary
- relocation to another site
- large-scale relocation of settlements and infrastructure

A "retreat" approach recognises that coastal processes and coastline hazards are impacting on the coastline, and that the nature of this impact is likely to worsen in the future. As the impact of coastline hazards worsens, and in the absence of actions to change likelihood of risk, the ability of the community to maintain infrastructure and keep existing properties in their current locations begins to decline. Infrastructure such as water supply, electricity and sewer becomes increasingly exposed to coastal erosion, and eventually it will be more difficult to maintain services for some of the more exposed seaside properties. With future coastal erosion and beach recession due to sea level rise, seaside properties may eventually lose their access, as portions of the roadway are lost due to future coastal erosion. Eventually, if no action is taken, loss of structural integrity of seaside buildings themselves may result and the existing housing may become unsuitable for habitation.

A retreat option provides a strategy for gradual movement of infrastructure inland to avoid potential threats. It may in the first instance involve providing temporary access for properties that have lost their road access due to coastal erosion, and restrictions on future development, recognising that the threat to property will increase in the future.

It is noted that the notion of “retreat” depends upon the availability of an alternative location to retreat to – in some areas, infrastructure can retreat landward within the same beachfront lot but in others this may not be possible and the infrastructure may need to be abandoned –through voluntary or compulsory purchase of the infrastructure at threat.

Such options must take into account social equity principles and compensate the community adequately for the loss of their land, while at the same time being consistent with the principles of Ecologically Sustainable Development (ESD). Such options may also allow the community to continue working and living on the coastline for the present, as long as they are informed of the long term risk.

This type of option could be implemented in the following ways:

- Acquisition of properties at greatest risk under the *Land Acquisition (Just Terms Compensation) Act 1991.*
- Implementing development controls through the DCP that stipulate the type of allowable construction on a lot as being lightweight and able to be moved landward as the hazard risk increases – i.e. designating a trigger point at which infrastructure may be moved landward.
- Relocation inland by public authorities of services and public infrastructure such as roads, sewer, water, electricity as the risk increases.

Planned Retreat permits development for a limited life and allows use and occupation of the coastal site until coastline hazards threaten or damage property. Voluntary Purchase schemes bring certain coastal properties threatened by hazards, into public ownership. Following purchase, structures could be removed and dune vegetation regenerated.

There are a number of key considerations in implementing the planned retreat, many of which require assistance and guidance from the NSW and Commonwealth Governments, including:

- Clarification of the processes relating to transition mechanisms and timeframes for staging a strategic approach to managed retreat
- Anticipated public perception and timing for advising property owners of potential future retreat in relation to trigger points
- Provision and amount of land (if any) available for a retreating coastal community
- Existing land-use rights
- Whether financial assistance is available for relocation (e.g. purchase of property, subsidies for relocation)
- Value of property at risk
- Incentives (or disincentives) available for property owners vacating land
- Mechanisms to inform existing or new property owners of future risk

- Whether there is opportunity to redistribute risks, uncertainties, benefits and costs among stakeholder groups to ensure they bear future costs from development.

A retreat type strategy may be staged as the coastline hazard risk increases with time. The stages involved may typically include:

1. Informing beachside owners of the coastline hazard risk to their property; (short term)
2. Adoption of planning controls on the type and scale of future beachfront development as discussed in Section 7.5.1; (short term)
3. Reducing the width of the beachside access road to accommodate the receding coastline; (short-medium term)
4. Movement of services and infrastructure landward to accommodate the future coastline hazard; (medium term)
5. Providing rear access to properties as coastline recession continues; (medium term)
6. Voluntary purchase of affected properties at market value and return of the land to public ownership (or uses compatible with coastline hazards); (medium-long term)
7. Compulsory acquisition of properties that are no longer serviceable. (long term).

Strategies for planned retreat are discussed below as are the advantages and disadvantages of each strategy.

7.7.2 Land Acquisitions

7.7.2.1 Voluntary Purchase

A *Voluntary Purchase* program for housing under threat from coastal processes could be implemented, with Council and Government purchasing properties either as they come onto the market, or through offers to existing landholders. Such a strategy would necessitate property being purchased at market value.

The land purchased by Council would then be returned to public ownership, and its use changed to be more compatible with the nature of the coastline hazard. For example, purchased land can be converted into public reserve, can be rehabilitated as coastal dune environment, or be converted to community use such as for passive recreation, or to provide additional car parking for day visitors to the beach. The transfer of lands to public ownership is authorised under the Local Government Act (LG Act).

As there is no legal requirement for the NSW Government to purchase properties under threat, advice from the Government has indicated that financial assistance for a voluntary purchase scheme could only be considered on a case-by-case basis as and when funds become available.

Such a voluntary purchase scheme would require capital outlay to buy each property, as well as demolition works, removal of services and rehabilitation of the area as public open space. Such a scheme could realistically only apply to those dwellings at greatest risk- i.e. those already under direct threat from coastal erosion, located seaward of the immediate *Zone of Slope Adjustment*.

It should be noted that, even though a building may be located within the immediate *Zone of Slope Adjustment*, it does not necessarily mean that the building is no longer viable as it may be constructed on deep piled foundations. During cyclical erosion associated with major storm events, direct damage can occur to built assets such as dwellings, water and sewer infrastructure, roads, fencing and public amenities but the beach can often recover from these events in the months following a major storm event.

7.7.2.2 Leaseback Of Properties

Properties purchased under a voluntary purchase scheme may be able to be "leased back" from Council by their occupants.

Such an option could involve possible voluntary buyback of property at market value, with the occupant leasing it back on a rolling 10 or 20 year lease arrangement until the coastline hazards become too severe.

This option may allow homeowners to stay on their properties, while realising existing market value of the property but with future re-development of the land restricted to buildings which are able to be physically relocated landward as the coastline hazards worsen.

The advantages of this approach include:

- It allows property owners concerned about future property prices to obtain a fair market price for their property;
- It allows property owners to occupy their houses under a rolling 10 or 20 year lease, which allows the owners to still enjoy the benefits of their seaside location
- It allows Council to recover some of the cost of purchase of the property
- It allows the leases to be re-negotiated following updated information about coastal hazards

Such a scheme would ensure that property owners are fully compensated for the eventual resumption of their property, while at the same time allowing them to live and enjoy full benefits of their current location in the medium term. If at the end of the term of the lease the coastal hazard risk to the property makes the property unviable, the land can be brought back into public use and rehabilitated. A disadvantage of such a scheme is that the occupier would need to be evicted once the coastal hazard risk becomes too great for the property to remain viable.

The total cost of such a scheme would be somewhat reduced over time compared to a more conventional voluntary purchase scheme, as the rehabilitation of the land would be delayed. It may also be more acceptable to existing property owners as it allows them to enjoy the benefits of their seaside location for longer.

Such an arrangement would need to be entered into with the consent of the current landowners, and could be undertaken under standard contractual processes.

7.7.2.3 Compulsory Acquisition

Compulsory acquisition of properties at very high risk from coastal hazards may be required in the future. Such properties may include those that are no longer able to be serviced or accessed due to accelerated coastal erosion, or that are no longer safe for habitation due to the risk of catastrophic consequences such as loss of the building in a large storm event. Such an acquisition should be carried out at a fair value for the property. It is noted that there is a potential difficulty in determining what a fair value would be, as this would be in part dependent on what coastal management arrangements are in place in the precinct. For example, in areas where there exists a direct threat to property, a fair price would be the value of the property as protected, discounted by the cost of the protection.

Councils have the power to compulsory acquire land under the Local Government Act. However, the purposes for which land can be compulsory acquired are defined within the Act and relate primarily to infrastructure. The council would require consent of the Minister to allow for the compulsory acquisition of land outside the scope set in the Act.

7.7.3 Relocation of Public Infrastructure

As the coastal hazard risks increase with time, public infrastructure will continue to come under threat from coastal hazards, and will need to be relocated inland. Such infrastructure includes water supply, electricity, sewer and other services. To continue to keep the properties within the coastal hazard areas serviceable as coastal hazards increase, a staged retreat strategy for public infrastructure could be put into place. Such a process could involve:

- Relocation of essential services to the rear of the properties in the coastal hazard zone;
- Provision of rear vehicle access to properties where the access road is in the coastal hazard zone and conversion of the existing roadway into public reserve in front of threatened lots.
- Retreat within the existing lots.

The costs and problems associated with this would involve engineering works to relocate the essential services and would also involve coordination between all the relevant agencies, authorities and service providers responsible for provision of the various services. Disruption to the community caused by these works would be likely over an extended period of time, however the extent would be relatively localised.

7.7.4 Physical Relocation of Private Property (Relocatable Homes)

Coastal land can be planned to permit development that has a limited life and this approach allows use and occupation of the coastal site until coastline hazards threaten or damage property. This permits a flexible approach in the future if hazards become more severe, for example in response to climate change, or in cases where there is moderate to high coastal recession.

At the time development is approved, a specified period can be identified before consent lapses (i.e. time-limited consent). Alternatively, approval may specify that consent only remains valid while a beach erosion scarp does not encroach within a set distance from a development. At this stage, consent lapses and the structure must be moved back, relocated or demolished.

Local planning instruments (LEP's and DCP's) can be used to outline policies for planned retreat of development on hazardous coastline and can be coupled with other conditions on development and buildings to further limit potential damage to structures.

The provision of development controls on land affected by coastal hazards would restrict the type of development that can take place. Where dwellings have reached the end of their design life, landowners could be allowed to redevelop their land by constructing relocatable buildings rather than fixed dwellings.

Relocatable homes are houses that can be assembled together from multiple modules or sections which have been manufactured at a remote facility before being transported to the desired location for complete assembly. These relocatable homes are typically built to local state or council codes and are governed by the regulatory requirements set out in the *2005 Local Government (Manufactured Home Estates, Caravan Parks, Camping Grounds and Moveable Dwellings) Regulation*. This would require the rezoning of land to accommodate moveable dwellings and related infrastructure.

Several advantages exist for relocatable homes.

- The ability to relocate an already built house to another location if necessary
- Versatility in building a house at a much wider range of locations, where traditional housing may not be possible
- Typically a more cost and time effective alternative to the construction of a regularly built home
- The ability to enjoy the benefits of coastal living at a reduced risk associated with coastal hazards

Such homes can then be moved landward within the same lot in response to the increasing coastal recession threat. Note that the design of a relocatable building can incorporate use of deep-piled foundations with contingency deep piles used to allow the building to be moved landward onto the contingency piles.

Disadvantages of this option include that it would still allow people to reside close to the zone of hazard. In addition, there may be a negative perception from residents about these types of homes and their urban design impact (i.e. built amenity), and the degree of coastal hazard affecting the beachfront lots may not allow this approach to be taken in many areas.

7.7.5 Trigger-limited Consents

When coastal development is approved, a condition could be specified that consent will lapse when certain triggers are activated. Council could impose a covenant on the title of the land under the provisions of Section 88E of the *Conveyancing Act 1919*, requiring the relocation or removal of the development.

Examples of such triggers may include:

- Where the most landward part of an erosion escarpment is within a predefined trigger distance of the most seaward point of a development or structure
- Where a public road cannot provide legal access, unless it can be shown that legal access to the lot can be achieved by other means.
- When the most landward part of an erosion escarpment is within the predefined trigger distance of the most seaward point of a public road providing legal access to the lot, Council will commence routine monitoring of the structural integrity of the road. The public road will be closed when safe access for fire fighting vehicles cannot be achieved, requiring legal access to be achieved by other means.
- When water, sewage or electricity to the lot is no longer available as they have been removed/decommissioned by the relevant authority due to coastal hazards.

7.7.6 Advantages of Managed Retreat

A managed retreat strategy would be consistent with the principles of ESD and the requirements of the NSW Coastal Policy, in that land at risk due to coastal processes is eventually transferred into public ownership, improving public access to the beach and restoring the coastal environment on that land.

A retreat strategy conforms to the principles of inter-generational equity, in that the coastline hazard threat is not passed onto future generations, and provides an opportunity to improve the health, diversity and productivity of the environment within the resumed land areas.

Social equity considerations must also be taken into account in terms of equal access opportunities to resources. With land at threat from coastal erosion coming into public ownership, the recreational amenity of the area can be improved for the wider community by returning the land to the coastal dune system.

While the resumption of coastal land is expensive, the benefit of returning the land to public ownership and enhancing its ecological value is clear but difficult to quantify in terms of currency.

Returning the land to public ownership could also improve public access to the foreshore, as this access would otherwise become restricted over time with ongoing coastline recession. Providing for appropriate public access and use is one of the objectives of the NSW Coastal Policy 1997.

Retreat reduces the coastline risk by progressively removing the risk, and is therefore consistent with the conduct of coastline planning using a risk-averse approach.

7.7.7 Disadvantages of Managed Retreat

If a retreat strategy is implemented by way of voluntary or compulsory purchase of several beachfront properties, this would collectively present a high cost outlay to the wider community (in the order of tens or hundreds of millions of dollars in the long term). Alternative access arrangements may be necessary for some beachfront properties in the longer term, due to the risk of erosion of the access road in front of them. Relocation of infrastructure would cause disruption to the community while the relocation works are taking place.

There will also be a social impact on the communities involved due to changes in the make-up of the community as properties are bought back, and potential for loss of property values over time as the coastal hazard risk becomes more apparent in the future. Furthermore, should a "planned retreat" strategy be adopted, a proliferation of unauthorised or *ad hoc* protection works may occur as residents undertake works in an attempt to protect their assets. During future storms the *ad hoc* protection could result in increasing damage to adjacent properties that are not protected.

Voluntary purchase and planned retreat from hazardous coastlines may be viable means of management in undeveloped or partly developed areas, of which there are limited such areas within the study area. Such an approach becomes increasingly expensive and difficult in more intensively developed areas such as those in the Gosford LGA.

In such cases, coastal protection may be the only economically viable and socially acceptable means of management. In cases where no overall management program is adopted, individual property owners may resort to a variety of approaches to protect their properties. Moreover, individual efforts may exacerbate problems at neighbouring properties. In these circumstances, the community suffers the visual blight of a variety of "protective" features along the beach, the cost of emergency services in times of hazard, and ultimately the cost of remedial measures to repair damage and address the problem.

If retreat is implemented by way of landward relocation of at-risk coastal assets within the existing lots as stipulated by development controls, this may not be physically possible at many areas due to the degree of coastal hazard affecting the beachfront lots.

7.8 Emergency Management

A "beach erosion emergency" can be defined as an actual or imminent occurrence of a beach erosion event which "endangers, or threatens to endanger, the safety or health of persons or animals" or "destroys or damages, or threatens to destroy or damage, any property, being an emergency which requires a significant and co-ordinated response."

In practice, expert engineering judgement would need to be applied at times of storms to assess when to initiate particular actions as required. This approach relies on regular monitoring of environmental conditions and beach behaviour, and seeking appropriate advice when required.

Emergency management arrangements in the context of a Coastal Zone Management Plan are outlined in Coastal Erosion Emergency Action Subplans. A Coastal Erosion Emergency Action Subplan for Wamberal-Terrigal Beach has been developed and publicly exhibited and outlines the roles and responsibilities of the State Emergency Service, Gosford Council, Office of Environment and Heritage, Bureau of Meteorology and NSW Police in coastal emergency management. The Subplan also outlines before, during and after-storm actions to be taken by Council during a coastal erosion emergency.

In the *Coastal Protection Act 1979*, an "emergency action subplan" is defined as that part of a coastal zone management plan that deals with the matter referred to in Section 55C(1)(b) of the Act relating to emergency action during periods of beach erosion, namely:

> "A coastal zone management plan must make provision for emergency actions carried out during periods of beach erosion, including the carrying out of related works, such as works for the protection of property affected or likely to be affected by beach erosion, where beach erosion occurs through storm activity or an extreme or irregular event."

In an emergency action subplan, Council's intended response to a coastal erosion emergency should be outlined, as well explanation being provided on ways in which beachfront property owners can undertake placement of "emergency coastal protection works" (Office of Environment and Heritage [OEH], 2011).

OEH (2011) noted that the following are considered to be key elements of an emergency action subplan:

- a clear and concise description of the emergency response actions Council would take when coastal erosion is imminent, occurring or has occurred;
- determination of the criteria or thresholds that would be used to initiate actions under the emergency action subplan;
- identifying actions that would be undertaken before, during and after an erosion emergency; and,
- identifying any site-specific issues that might limit landowners placing "Part 4c sand/sandbags TCPW" at authorised locations.

Note that an emergency action subplan must not include matters dealt with in any plan made under the *State Emergency and Rescue Management Act 1989* (such as an State Emergency Service Local Flood Sub Plan).

7.8.1 Roles and Responsibilities during a coastal emergency

The roles and responsibilities of the State Emergency Service, Gosford Council, Office of Environment and Heritage, Bureau of Meteorology and NSW Police in coastal emergency management are described below in turn. Further discussion on these matters is provided in the *NSW State Storm Sub Plan* (currently dated June 2007).

Landowners also have responsibilities if they want to install emergency protective works.

7.8.2 Role of the State Emergency Service

The role of the State Emergency Service (SES) in coastal erosion and inundation emergencies is essentially warning and evacuation of residents at risk, and lifting and/or relocating readily moveable household goods and commercial stock and equipment. These activities would be carried out in accordance with a Coastal Erosion Annex to the SES Local Flood Sub Plan.

SES is not authorised to undertake coastal emergency protective works (such as placement of rocks or sand-filled geotextile containers) of any form.

SES use the release of a "Severe Weather Warning for Damaging Surf" or "Severe Weather Warning for Storm Tides" from the Bureau of Meteorology as a primary test of whether or not they should be involved in a potential coastal erosion (and/or inundation) event. If required (that is if an emergency developed) when neither of these warnings had been issued, it is expected that Council would call on SES for assistance in matters that SES deal with.

7.8.3 Role of Gosford Council

The carrying out (or authorising and coordinating) of coastal emergency protective works is Gosford Council's role, if it chooses to undertake such measures to protect public assets from coastal erosion and inundation. In the *Coastal Protection Act 1979*, Council is the designated coastal authority with responsibility for care of public land within its control. However, private landholders are responsible for private land, and Council does not consider it has a responsibility to protect private property.

Council could choose to undertake physical erosion protection measures to protect public assets from coastal erosion and inundation if considered to be appropriate (assuming adequate environmental assessment had been carried out and the NSW Coastal Panel had been notified).

If a "Severe Weather Warning for Damaging Surf" or "Severe Weather Warning for Storm Tides" had been released or SES was mobilised in some other manner, Council would assist SES as required and where resources permit.

If SES was not mobilised (e.g. if neither of the above warnings had been released by the Bureau of Meteorology), Council may undertake some of the activities that would otherwise be conducted by SES (where resources allow, although not obligated to), but note that Council cannot order evacuation. If required, Council could request SES taking on a Combat Agency role if an actual emergency was occurring.

7.8.4 Role of Office of Environment and Heritage

The Office of Environment and Heritage (OEH) is the NSW government authority responsible for advising on coastal zone management. OEH staff would also be responsible for assessing any landowner applications for "Part 4c sand/sandbags ECPW", as Gosford Council has elected not to have any staff trained as an "authorised officer" (as per Section 7 of the *Coastal Protection Act 1979*) in this regard.

7.8.5 Role of Bureau of Meteorology

The release of a "Severe Weather Warning for Damaging Surf" or "Severe Weather Warning for Storm Tides" by the Bureau of Meteorology is the trigger adopted by SES for involvement in a coastal erosion/inundation episode.

A "Severe Weather Warning for Damaging Surf" is issued if waves in the nearshore zone are forecast to exceed a significant wave height of 5m (irrespective of wave period) in the next 24 hours. A "Severe Weather Warning for Storm Tides" is included if storm surge, wave setup or and/or outflow from river flooding are expected to raise ocean water levels significantly above Highest Astronomical Tide.

7.8.6 Role of NSW Police

The NSW Police Force is the agency responsible for:

- law enforcement and search and rescue;
- controlling and coordinating the evacuation of victims from the area affected by the emergency in conjunction with the combat agency; and,
- being the combat agency for terrorist acts.

Some members of the NSW Police may also be appointed as Emergency Operations Controllers.

Police would typically become involved in a coastal erosion event as follows:

- assisting SES where required (for example controlling and coordinating evacuation) when SES was acting in its Combat Agency role; or,
- if SES was not mobilised, police may undertake or coordinate activities such as evacuation, barricading, removal of the contents of buildings and the like.

In either case (if SES was or was not the Combat Agency), some argue that it is possible that Police may act according to their statutory powers to protect life and property, and therefore authorise emergency protective works. However, it is expected that in making such a decision, police would need to recognise the Combat Agency's authority (if applicable), ensure appropriate approvals are in place for any proposed works, and seek proper advice before acting (such as from a qualified engineer and Council)[13].

7.8.7 Role of Fire and Rescue NSW

Fire and Rescue NSW has a Mutual Aid Agreement with the SES and would have a support role assisting the SES during a coastal emergency. In particular, Fire and Rescue NSW would become involved during a coastal emergency in the following ways:

- Assist the SES in monitoring / reconnaissance of areas potentially damaged by storms;
- Provide storm damage response teams to assist the SES, including strike teams when
- requested, to assist the SES;
- Assist with the evacuation of at-risk communities; and
- Provide staff to support a spatial information group established by the SES.

7.8.8 Council Actions in an emergency

It is not considered to be appropriate or practical to attempt to protect minor assets such as dune fencing, bins and signage in any emergency. These would be removed to prevent damage, repaired or replaced as required (where appropriate).

Council intend to undertake actions to warn the public of and/or reduce the risks associated with storm damage and severe beach erosion hazards. All Council units have a responsibility to document records of decisions made and the reasoning in making those decisions (before, during and after coastal erosion emergencies).

7.8.8.1 Criteria/Thresholds for Action

Pre-storm actions are to be undertaken as soon as practicable and are independent of the occurrence of a coastal emergency.

During a storm, it is considered that a prescriptive set of trigger conditions that would be used to initiate individual Council actions in relation to coastal erosion emergencies are impractical to stipulate. This is because such conditions would be exceedingly complex to devise, and would still

[13] Mr Phil Watson (Office of Environment and Heritage) considers that although a requirement for protection of life and property may exist within Police powers, a memorandum of understanding was reached between the combat agencies relating to coastal erosion emergency event roles and responsibilities in the update of the *NSW State Storm Plan 2007*, leaving the responsibility for protection works on beaches only with local government authorities (personal communication, 1 December 2011).

be unlikely to cover every situation[14]. Examples of complexities include variability in storm conditions (wave height and period, wave direction, water level, location of rips), state of the tide, antecedent conditions, forecasts, existing protective works, and existing structure types (in particular foundations). In the case of protective works and foundations, there may also be unknowns regarding the nature of the works. In practice, expert engineering judgement would need to be applied at times of storms to assess when to initiate particular (during-storm) actions as required. This approach relies on regular monitoring of environmental conditions and beach behaviour, and seeking appropriate advice when required.

7.8.8.2 Before a Storm

The following actions that should be undertaken before a storm are listed in OEH (2011), with discussion relevant to the responses of Gosford Council provided in footnotes:

- informing the community of the council's intended erosion emergency responses under its emergency action subplan;
- preparing a communication strategy to advise the community of the likelihood of an impending beach erosion emergency that would initiate actions under the subplan;
- identifying areas where landowners may install temporary protection works in accordance with the Code of Practice under the *Coastal Protection Act 1979* (2013) and any applicable site-specific requirements for those works;
- preparing for planned emergency actions;
- undertaking necessary environmental assessments and any development approval processes, where necessary, to facilitate emergency works and,
- preparing up-to-date personal contact details for key council staff involved in coordinating actions under the subplan (include responsibilities of staff who prepare for, manage and coordinate recovery from an erosion emergency event) and individuals the council may need advice from, such as OEH staff, or to integrate with from other emergency sectors).

Other relevant actions for Council before a storm are listed below:

- monitoring beach erosion and weather/wave conditions and forecasts;
- ensuring sufficient warning signage and barricades are available for use if required (e.g. to close off damaged and potentially dangerous beach access points);
- provision of information and advice to affected beachfront landowners and the wider community; and,

[14] There is also no single quantitative parameter, such as an offshore significant wave height of a certain magnitude, minimum beach width of a certain value, or distance from an erosion escarpment which can be adopted as <u>the</u> trigger for imminent damage to an asset since there are a combination of many factors involved.

- consulting with SES and other relevant agencies such as OEH as required.

Monitoring is the key to maximising warning time, preparedness and predictive capability in regard to emergency coastal erosion events.

Monitoring of physical environmental conditions would include weather conditions (measurements, warnings and forecasts), wave forecasts (height and direction), water level (tidal) predictions, real time wave data (height, period and direction), real time water level data (including consideration of elevated water levels due to storm surge), and beach behaviour (extent of erosion, beach width, understanding of historical beach behaviour at times of storms, location of rips).

In a potential emergency event, it would be expected that beach areas would be inspected at least daily, particularly at high tide, where resources permit.

Council is also intending to consider the need to develop a communications strategy to keep affected communities informed during an erosion emergency, and developing the strategy if required.

7.8.8.3 During a Storm

In OEH (2011) it is stated that actions undertaken during an erosion emergency should be managed by Council officers who clearly understand the subplan and know the roles and responsibilities of key personnel. It is also stated in OEH (2011) that:

- no actions undertaken should impede, conflict or overlap with those of response agencies under the *State Emergency and Rescue Management Act 1989* unless there is prior agreement between the relevant parties;
- actions should focus on the safety of personnel who might be working under the extreme adverse weather conditions that gave rise to the emergency;
- a communication strategy needs to be in place during an erosion emergency, keeping affected communities informed of the Council's intended responses (this should include giving regular warnings where erosion is likely to sever public access and result in relatively high, unstable, near-vertical erosion escarpments along beaches; in this case, it is vital to advise the public of the dangers these conditions may present); and,
- the communications strategy may need to be complemented by erection of temporary safety fencing and associated warning signage.

Council actions during a storm shall include:

- regular monitoring of environmental conditions and beach behaviour;
- assessing the need for barriers and safety signage to be erected at damaged and potentially dangerous beach access points, to minimise risk to public safety;
- erecting barricades and safety signage if required;

- assessing the need to remove existing beach signage, bins and dune fencing where threatened by coastal erosion (and removing these assets where safe to do so to prevent damage or being washed away);
- seeking coastal and geotechnical engineering advice where required;
- seeking advice from OEH staff as required;
- supporting SES as required and where resources allow;
- releasing information to the media; and,
- provision of information and advice to beachfront landowners and wider community.

7.8.8.4 After a Storm

Actions after an erosion emergency listed in OEH (2011) comprise the following, with discussion relevant to the responses of Gosford Council provided in footnotes:

- restore services and public access, and remove any threats to public safety (such as debris deposited or exposed on beaches);
- continue temporary safety fencing and associated warning signage (as necessary);
- monitor the performance and impact of any coastal protection works including any temporary coastal protection works installed and take remedial action where necessary;
- assess the structural integrity of unprotected infrastructure, buildings and other assets exposed during the erosion event and take appropriate action where necessary;
- continue to maintain a communication strategy warning of the dangers of any persisting high, unstable or near-vertical erosion escarpments drying out and collapsing without notice (in high-use public areas, the Council may consider collapsing these escarpments with machinery);
- replenish any emergency materials and supplies for use in any future erosion events; and,
- critically review the subplan to ensure it achieved its performance objectives and revise it to address any identified shortcomings.

Council actions after a storm are likely to include:

- cleansing the beach of debris and other inappropriate materials;
- remedial works to restore safe beach access;
- repairing or replacing damaged infrastructure, such as dune fencing and beach accessways once the dune has sufficiently recovered;

- rehabilitation of damaged dune vegetation;
- beach scraping and/or sand nourishment to restore beach amenity;
- maintaining photographic and written records of events and decision making processes; and,
- monitoring unauthorised coastal protection works and enforcement of penalties under the *Coastal Protection Act 1979* (this may also be undertaken before and during a storm).

Dune fencing along access ways running perpendicular to the beach, bins and signage (s632 notices, dog area signs, dune restoration signs) would be repaired and/or replaced as soon as practicable after an event. Beach accessways could be closed if necessary until the beach has recovered sufficiently to allow them to be re-graded.

7.9 Insurance

Insurance is a means of sharing the coastal hazard risk with another party. The approach of insurance companies towards meeting the cost of hazard-induced asset loss has, in the past, been largely reactive (NZ Ministry for the Environment, 2014). Insurance premiums and refusal of reinsurance are often based on previous losses incurred. These can provide a disincentive for asset investment within high-risk hazard areas that have previously suffered financial loss.

Note that the coastal risks of storm surge, coastal erosion and gradual sea level rise are excluded by many general insurance policies in Australia (Insurance Council of Australia, 2014). This means that there is limited scope for use of insurance as a coastal management option.

Insurance companies are becoming increasingly proactive in hazard risk management and are working in partnership with Government to identify sustainable options for mitigating hazard risks. It is likely that insurance companies will take a greater role in future coastal hazard risk management, including for hazards induced by climate change effects.

The Insurance Council of Australia is working with State and Federal Governments to implement the following:

- Strengthening building codes, to prevent brittle building syndrome in the future.
- Risk appropriate land use planning, to limit exposure to current and future hazards.
- Upgrading mitigation infrastructure, to protect existing communities.
- Removing taxation disincentives on insurance products, to encourage individual to take responsibility for their own recovery.

Whilst insurance could be an efficient market-based economic tool to distribute and reflect actual risk for coastal properties, it does not necessarily reflect long-term changes in risk. Its efficient application may require intervention and collaboration between councils and insurance companies – and require detailed risk assessment information, at the property level.

According to NRMA Insurance (2011), damage that is covered by home building and contents insurance that is related to extreme weather events include:

- Storm - covers violent wind, cyclone and tornado, thunderstorm, hail, rain or snow and the sudden excessive run-off of water as a direct result of a storm in your local area;
- Flood - the covering of normally dry land by water that has escaped or been released from the normal confines of any lake, or any river, creek or other natural watercourse, whether or not altered or modified; or any reservoir, canal, or dam;
- Lightning;
- Bush/ grass fire; and
- Storm surge (cover is offered by some but not all insurers).

Losses from sea level rise and coastal erosion are not covered by insurance in any country. According to the insurance industry, sea level rise is not a weather event like a storm or a flood. It is a gradual, background process that will occur over a long period of time, with change only becoming obvious over several decades. It is considered by the insurance industry to be a certainty rather than a probability.

7.10 Monitoring Research and Data Collection

Ongoing monitoring of the beaches, coastal hazards and coastal parameters would inform future actions and allow the performance of existing coastal management measures to be assessed. Maintenance of recreational amenity and public safety can be achieved through ongoing monitoring of the beaches and coastal protection works and through implementation of Councils Beach Management Policy.

Monitoring of the beaches and continued data collection on waves, water levels and beach survey (via LiDAR and on-ground survey) would further inform the magnitude of the coastal hazards at the various beaches and how they would evolve in the future with sea level rise.

7.11 Site-specific (localised) management actions

Specific localised management actions could be implemented to deal with a localised issue of importance to the community or a coastal hazard which is confined to a specific location. For example, a site specific management option to deal with the propensity for Ettalong Creek to cause erosion of the southern end of Ocean-Umina Beach may be required, or a particular stormwater outlet that has caused local erosion in a particular location may need to be repaired and this stipulated as a management action in the CZMP. These localised actions may be required to improve local beach amenity, dune ecology and recreational values.

Damage to local Council-managed infrastructure such as sewer or water infrastructure can occur as a result of coastal erosion and inundation, which would require repairs or relocation as a management action in the CZMP. Water mains, hydrants, stop valves and sewer rising mains are typically laid shallow, and therefore there is a risk of foundation destabilisation and collapse during extreme scour conditions. Sewer pumping stations, civil structures as well as some mechanical, electrical and telemetry component foundations may also be at risk of foundation destabilisation in a coastal erosion event. Sewer gravity mains and maintenance holes may be at risk of saline water infiltration, as well as risk of destabilisation where the mains are shallow.

7.12 Combination of Various Approaches

A combination of the above management options could be implemented to protect the vulnerable areas from erosion and improve the amenity of the beach at the same time. Such combinations could include:

- Combination of a terminal protection structure and beach nourishment. This option would involve the burial of a revetment constructed along the foreshore with beach nourishment sand, so that the revetment would not be visible normally;
- Planning controls implemented (to reduce the erosion risk on re-development of existing properties, to enable development to move landward of the coastal hazard area where possible, to encourage re-development with deep piling and/or facilitated retreat of transportable modular buildings, combined with planning for terminal protection works to be implemented as necessary in the future);
- Planning controls implemented in conjunction with a policy of retreat, whereby voluntary purchase of at risk properties at market value is offered at a set trigger point, and public infrastructure is moved landward in response to the increasing coastal hazard.

Other site specific coastal management measures to address local issues are proposed for specific locations and are described below.

7.13 Funding options for coastal management measures

The Guidelines for Preparing Coastal Zone Management Plans (OEH 2013) recognise three categories of coastal hazard responses – these are listed below:

- **Category A** - Coastal protection works are considered technically feasible and cost effective – funding is being sought for implementation
- **Category B** - Coastal protection works are considered technically feasible but not cost-effective for public funding – unlikely to be implemented by a public authority
- **Category C** - Coastal protection works are not considered technically feasible – no intended public authority works.

Funding under the NSW Coastal Management Program is limited, and funding priorities are for works that improve public safety and protecting valuable publicly-owned assets, and then to private land. Coastal protection works for the beaches within Gosford LGA would therefore fall under Category B above, due to the high cost associated with the scale of the required works for beaches such as Wamberal. It could be argued that the bulk of the benefit would be directed toward the local beachfront property owners, through direct protection of private property. There would also be some benefit to the broader community, through the economic contribution provided by the protection of public assets where these are under threat, and allowing the income generated by beachfront properties to be retained. There is also a secondary public benefit in preventing ad-hoc works from being constructed and an associated improvement in recreational amenity. Funding options for such works should therefore seek to apportion the costs toward the parties who would benefit most.

Funding options could therefore be explored which involve some contribution from the landholders who would directly benefit from such works. Such funding options may include:

- Funding provided by local property owners through a contribution payment toward the construction costs, with commissioning of the design and construction undertaken through funding from the NSW Coastal Management Program and part funding from Council. Maintenance would then be the responsibility of the local landowners, which could be undertaken by Council but funded by the residents.

- Funding through a special contribution by landholders levied onto Council rates, similar to a Section 94 contribution, with funds held in trust for the purposes of design and construction of a terminal protection structure.

It should be noted that Land Tax is collected by the NSW Government on investment properties, where the *unimproved capital value* (UCV) of that property is greater than $432,000. For beachfront residential properties not used as a principal place of residence, there will therefore be a significant contribution to the NSW Government from Land Tax. For example, if the UCV value of a typical beachfront non-principal place of residence property is $2 million at Wamberal, the land tax applicable would be given by:

Land Tax Assessment Calculation (based on UCV $2m)

Taxable Land Value	$ 2,000,000
Less Threshold	$ 432, 000
Tax $100 Plus Balance at 1.6%	$1,568,000 = $25,188
Total Tax Payable	$25,188

If, for example, 30% of the properties along the beachfront were subject to Land Tax and these properties had an average UCV of $2 million, then the total land tax collected from beachfront properties at Wamberal could be in the order of $530,000. The amount collected in Land Tax specific to beachfront properties may therefore be able to be set aside from the State Budget, specifically for the purpose of funding coastal management measures which would benefit those properties.

Financial mechanisms for funding large scale capital cost items and ongoing costs relating to the implementation of CZMPs throughout NSW are currently being investigated through the NSW Government's Stage 2 Coastal Reforms.

8 PRELIMINARY MANAGEMENT OPTIONS

8.1 Introduction

Preliminary management options have been recommended for each beach based on the specific coastal hazard risks identified at each beach, the values in the study area, the effectiveness of the existing coastal management measures, and specific issues of importance identified by the local community and in previous studies. Options have been divided into those which address the identified coastal hazards and those which address other coastal management issues.

The list of options presented in this Section have been further developed and refined based on feedback from the public exhibition process, with the refined list of management actions for each beach presented in Section 9.

8.2 Landuse and Development Issues

The major challenges for coastal management across Gosford's beaches relate to land use and development.

Coastal adaptation options have been developed for each beach within the study area. These management options align with four broad strategies for managing coastal risk into the future being:

- **Defend (protect)**: Protect portions of the coastline identified as being vulnerable to storm tide inundation or erosion risks. Defend strategies may include maintaining the existing use or intensifying development on the land. Coastal defence may combine long-term strategies for defence and maintenance including regenerative and structural options such as beach nourishment.
- **Accommodate:** Maintain the current level of use within coastal hazard areas and raise the tolerance to periodic storm tide inundation or erosion events by means of innovative designs for buildings and infrastructure (e.g. elevating, strengthening or change in use). This entails undertaking actions that will reduce the impacts from coastal hazards to an acceptable level.
- **Retreat:** Includes actions to remove the assets at risk from the area impacted by the coastal hazard. This option could be achieved through various mechanisms such as relocating the community (e.g. through a land swap arrangement) or abandoning the area (e.g. through buy back mechanisms or rezoning the land to an open space or recreational use).
- **Maintain the Status Quo:** Maintaining the status quo refers to a continuation of the existing use in an area while not supporting any further intensification of those uses. It does not restrict land owners from defending their own land (e.g. collaboratively with adjoining landowners) or accommodating the impact of coastal hazards. Maintaining the status quo would need to be supported by actions such as:

  - Planning scheme modifications (e.g. in the LEP/DCP) to reflect the decision not to intensify land use;
  - Ongoing monitoring and review of hazards;
  - Targeted public education on hazards;
  - A hazard note on Property Certificates;
  - Regular review of the emergency plan of the Local Disaster Management Plan to recognise the changing risk profile;
  - Regular update of the Council's infrastructure plan to reflect longer term intentions regarding services and infrastructure in the area as the risk profile changes; and
  - Rates reduction of properties in the area.

Discussed in this section are coastal management options specifically formulated to address these issues, for each beach.

8.3 Assumptions for Costing of Options

An indicative capital cost has been provided for each option and the cost is based on the following assumptions:

- Sand nourishment
  - The quantity of sand nourishment is assumed to be the design storm demand above 0 m AHD as per the *Coastal Processes and Hazard Definition Study* (WorleyParsons, 2014);
  - Sand nourishment at a rate of $\$25/m^3$;
  - Mobilisation and demobilisation of plant for sand nourishment operation at $200,000;
  - Nourishment campaign would need to be periodically repeated and so there is a recurrent cost associated with this – we have assumed for the purposes of providing a Net Present Value[15] cost to 2050 that the exercise would need to be repeated on average once every 10 years.
- Beach scraping
  - Beach scraping volume of 8 m^3/m, which is approximately equal to a scraping depth of 0.2 m (Carley *et al.*, 2010). The recommended beach scraping depth is less than 0.5 m and effects on intertidal species such as pipis can be minimised by using a shallow scraping depths of approximately 0.2 m (Carley *et al,.* 2010).
  - Beach scraping at a rate of $\$8/m^3$. This is based on the adopted rate for beach scraping from the Carley *et. al.* (2010) escalated to 2014; and

[15] The net present value of costs is a measure of the total costs of each option if they were undertaken today, with future costs discounted because of the time value of money.

    - There is a recurrent cost associated with beach scraping which has been included in the Net Present Value cost to 2050, with the exercise typically undertaken every two years on average.
- Stabilisation of dunes with vegetation and associated fencing and accessways at a rate of $45/m^2. There is also a recurrent cost associated with this option which has been taken into account in the Net Present Value to 2050.
- Erosion protection works:
    - Erosion protection works for exposed areas at a rate of $10,000/m;
    - Erosion protection works for less exposed areas, such as shallow depth areas or within lagoons or lakes, at a rate of $4,000/m; and
    - "tripper" structure to control opening location of creek at a rate of $2,000/m.
- Infrastructure repair or relocation:
    - Carpark or road repairs to pavement following inundation at a rate of $80/m^2 (source: Council Infrastructure Planning department);
    - Road relocation at a rate of $150/m^2, subject to geotechnical conditions and exclusive of property resumption (source: Council Infrastructure Planning department);
    - Reconstruct pavements using materials resistant to erosion and inundation damage – 30% additional construction cost (source: Council Infrastructure Planning department);
    - Pumping station and surf club relocation or redevelopment at a rate of $1,500/m^2;
    - Restaurants relocation or redevelopment at a rate of $2,000/m^2; and
    - Relocation of sewer or water infrastructure at a rate of $400/m.
- Stormwater works:
    - Scour protection design and construct $50,000 per outlet (source: Council Infrastructure Planning department);
    - Relocation of stormwater outlet $50,000 per outlet (source: Council Infrastructure Planning department).
- Dune Management:
    - Council allocation for Dunecare for works supervision $5,000 p.a. per location (source: Council);
    - Dunecare dune vegetation management works $10,000 - $20,000 p.a. per location (source: Council).

Cost estimation for the various coastal management options if undertaken in isolation would normally take into account a complex set of factors and influences, some of which have not been able to be defined at a high level of detail based on available information. For the purposes of this Study, the process has been simplified using the below assumptions for the sole purpose of comparing the relative costs of the various options against each other. Net present value costings to 2050 for the options presented below have been based on the following assumptions:

1. Probability of damage seaward of Immediate ZSA = 2% p.a.
2. Probability of damage seaward of 2050 ZSA = 1% p.a.

3. Probability of damage seaward of Immediate Wave Impact Zone = 3% p.a.
4. Probability of damage to unprotected properties seaward of immediate ZSA and adjacent to properties with ad-hoc protection = 5% p.a.
5. Risk of damage seaward of 2050 ZRFC for buildings not piled = 1% p.a. x $1 million
6. Damage potential for existing buildings piled but within wave impact zone = $100,000
7. Damage potential for redeveloped buildings piled but within wave impact zone = $150,000
8. Value of minor structures seaward of building subject to storm damage = $50,000
9. Property values estimated as per www.onthehouse.com.au
10. Cost of terminal protection = $10,000/m + 1% maintenance cost p.a.
11. Properties purchased at full market value
12. 10% of property value costed for purchase of an easement for alternative access
13. Environmental damage and social impacts not costed as insufficient data is available to assign a dollar value to these items. Based on previous studies (SA Department of Environment and Heritage 2005) the value to the local economy of a beach visit is approximately $5 per visit and this has been included in the costs and benefits where appropriate.
14. Beach scraping done bi-annually; reduces risk of erosion and inundation by 50%
15. Beach nourishment needs to be repeated every 10 years but is effective in reducing coastal hazard risk.
16. Loss of development potential at a lot either through erosion or application of development controls reduces property value by 10%.
17. Inundation is assumed to cause 15% damage to housing with 1.0 m average overfloor depth.
18. Shifting of the burden of rate income to the broader community has been estimated for the voluntary purchase options based on average rate figures provided by Council, with an assumed 3% p.a. increase[16]. This cost has been included in the net present costs for the voluntary purchase options. There will also be a loss of income to the NSW Government associated with the purchase of beachfront property - due to a loss of land tax revenue from those beachfront investment properties that have an unimproved capital land value over $432,000[17].

Net present values for costs and benefits have been estimated to 2050 based on an annual discount rate of 7% as recommended in the NSW Government Guidelines for Economic Appraisal (2007). Specific assumptions for costs and benefits for particular options are provided in the options tables for each beach.

"No regrets" options have been identified also which describes options which have a high benefit for little or no cost and where the options are in accordance with current practice.

[16] The total pool of rates income a Council receives is essentially fixed at each rates cycle and does not depend on the value of properties in the LGA. Therefore, if (for example) beachfront property lowers in rateable value (or disappears altogether), this does not reduce Council's overall rates income, but means that non-beachfront property owners have to pay a greater share of the fixed overall rates burden.

[17] Note that the State Land Tax paid is an income tax deduction (Federal) and so reduces income to the Government from other sources.

The cost estimates and rates above are based on WorleyParsons' experience and judgement as a firm of practising professional engineers familiar with the construction industry. The cost estimates for the management options can NOT be guaranteed as we have no control over Contractor's prices, market forces and competitive bids from tenderers. The cost estimates may exclude items which should be considered in a cost plan. Examples of such items are design fees, project management fees, authority approval fees, contractors risk and project contingencies (e.g. to account for construction and site conditions, weather conditions, ground conditions and unknown services). The cost estimates provided for the options are indicative only for the purposes of comparing various options against each other and estimating cost/benefit ratios and would require refinement in the detailed design phase.

8.4 Patonga Beach

8.4.1 Issues and Options

The major coastal hazards identified at Patonga Beach are:

- **Coastal inundation** due to wave runup affecting the beachfront residences;
- **Coastal erosion** having the potential to impact on the carpark near the centre of the village, parts of Patonga Drive and associated stormwater and power services;
- **Coastal erosion** affecting the access road to the boat ramp and associated services.

The consequences of these coastal hazards being realised include:

- Present day potential for overfloor inundation of houses by wave runup, causing damage to existing buildings and services supplying those buildings;
- Present day threat to public safety due to wave runup over Patonga Drive during a storm event;
- Present day potential damage to the access road to the boat ramp caused by coastal erosion, that would require repair;
- Present day potential damage to the existing main village carpark and associated drainage (and any vehicles parked there) caused by storm erosion that would require repair;
- By 2050, risk that parts of Patonga Drive are damaged by erosion, which would result in a temporary loss of access to the village and require repair.

Erosion has been identified in previous studies (Terras Landscape Architects 2013) as an issue for the cottages at Dark Corner.

Management actions relevant to coastal hazards and other management issues have been identified in the Broken Bay Coastal Zone Management Plan (Patterson Britton & Partners 1999), and the Patonga Draft Plan of Management Crown Reserves and Dark Corner Cottages (Terras Landscape Architects 2013).

Potential management actions that are relevant in addressing the identified coastal hazards for Patonga include:

- Undertake **erosion protection works** to protect the main village carpark and/or parts of Patonga Drive under erosion threat;
- Monitor the performance and assess the effectiveness of the existing erosion protection works on the western side of the boat ramp;
- Upgrade existing **erosion protection works** if necessary to protect the boat ramp access road;
- **Development controls** to ensure new developments are located with a floor level 0.5m above the maximum wave runup level (identified in the Coastal Process and Hazard Definition Study to be between 2.0 and 2.5 m AHD at Patonga) or 100 year ARI flood level (whichever is higher), allowing for future sea level rise;
- **Relocation of infrastructure** subject to potential damage due to coastal erosion e.g. services, carparking. A potential future management scheme for re-location of the carpark and future at-risk infrastructure is shown in Figure 55;
- **Maintenance of the dune crest** above the level of wave runup to prevent wave runup reaching the buildings;
- **Placement of sand** on the beach in front of the main carpark and near the boat ramp to increase the buffer of sand available and provide some protection against storm erosion. This sand could potentially be sourced from the sand shoals at the western end of the beach;
- **Maintaining the status quo** or doing nothing different from the existing coastal management arrangements for the beach, and making no changes to the existing planning scheme for the beachfront lots. The consequences of this option would be that the existing management issues identified at Patonga would continue to exist into the future.

Other management issues identified in previous studies (Patterson Britton & Partners 1999; Terras Landscape Architects 2010) and within the investigations for this study are illustrated in Figure 54 and include:

- Shoaling of the entrance to Patonga Creek caused by longshore sand transport from east to west along the beach;
- Erosion and inundation affecting the cottages at Dark Corner;
- Sand being trapped on the eastern side of the boat ramp;
- Catchment-derived flooding of residential areas;
- Beach amenity and recreational values;
- Scour on the beach berm due to creek and stormwater flows;
- Wind erosion and mobile sand affecting carpark and resulting in loss of sand from the beach;

- Maintaining and improving dune ecology.

A suite of 24 specific management options for actions that could be undertaken by Council have been developed to address the coastal hazards identified at Patonga for consideration. Each option has been provided with an identifier (P1 to P24) as illustrated in Table 16. A more detailed summary of these main options for coastal zone management including advantages and disadvantages, timeframe for adoption and indicative costs is provided in Table 17.

Further to the management options below, Patonga Beach has been named as an “Authorised Location” for placement of temporary protection works in the Code of Practice under the *Coastal Protection Act 1979* (OEH 2013). Under the Code of Practice, landowners may place temporary protection works comprising either:

- sand filled geotextile containers each of maximum 0.75 m^3 filled volume stacked in a single layer up to 1.5m high (at a slope flatter than 34° from the horizontal, that is flatter than 1:1.5 vertical:horizontal); or,
- clean sand placed up to the crest on the seaward side of an eroding escarpment (under the Code of Practice, this is not permitted to be sourced from the beach on which the works are to be placed).

Given that the risk of storm erosion for the beach front properties is currently relatively low due to the extensive sand supply available on the beach, these works are not considered to be necessary at the present time. It is emphasised that landowners must act well (generally months) in advance of a storm to consider implementing these works. It should also be noted that landowners are not permitted to install coastal protective works without following the procedures outlined in the Code of Practice (OEH 2013), and severe penalties may apply if they are not followed.

8.4.2 Landuse and Development

At Patonga Beach, the most recent coastal hazard assessment indicates that there are no buildings or private lots subject to coastal erosion or reduced foundation capacity hazard by 2100. The provisions of the existing DCP are therefore adequate to address this hazard. If the updated DCP were to require buildings or building structures not be constructed on, over or below land identified as being seaward of the 2100 Zone of Reduced Foundation Capacity line (except subject to special conditions), there would be no lots impacted on Patonga Beach. Similarly, should a planning period of 2050 be adopted, there would be no impact on any of the lots in Patonga.

It is suggested that the existing provisions in the DCP relating to coastal inundation should still apply, to the lots marked in blue on the updated coastal hazard maps.

1. Shoaling at the entrance channel at Patonga, making navigation hazardous

2. Sand bypassing of the entrance training wall at Patonga Creek;

3. Ad-hoc protection works at Dark Corner cottages

4. Sink-hole below boatramp

5. Build up of sand against training wall at southern end of beach

6. Potential for sand from beach to be lost onto the road by wind erosion

7. Existing erosion protection works at boat ramp and minor erosion adjacent to works

8. Scour on beach berm due to creek flows onto beach

Figure 54 – Management issues identified at Patonga

Table 16 – Coastline Management Options for Patonga

Issue/Hazard	Management Option
Immediate risk of erosion damage to main carpark	Erosion Protection works at main carpark (short term) (P1)
	Repair damage to carpark should storm erosion occur using erosion resistant pavements (P2)
	Placement of sand sourced from western shoals at creek entrance to provide buffer against storm erosion (P3)
	Beach scraping to build vegetated dune in front of carpark (P4)
	Future relocation of carpark and associated infrastructure to an area landward of the coastal hazard area (refer Figure 55) (P5)
	Stabilisation of dunes in front of carpark with vegetation and/or fencing (P6)
Future risk of erosion damage to Patonga Drive	Erosion Protection works at site of main carpark (future) (P7)
	Future relocation of main access into village (refer Figure 55) (P8)
Immediate erosion risk to boat ramp and access road	Monitor and assess existing erosion protection works (P9)
	Relocate boat ramp access road as erosion occurs (P10)
	Reinstate access road and erosion works following erosion event (P11)
	Periodic nourishment of area with sand sourced from Patonga Creek entrance (P12)
Inundation due to wave runup	Development controls (P13)
	Beach scraping to maintain crest level of dune above wave runup level (P14)
	Investigate raising floor levels of existing buildings (P15)
Erosion in front of cottages at Dark Corner	Monitor and assess existing erosion protection works (P16)
	Implement erosion control works in front of cottages in accordance with Patonga Draft Plan of Management Crown Reserves and Dark Corner Cottages 2013 (P17)
Shoaling at entrance channel of Patonga Creek	Investigate periodic maintenance dredging of sand from the creek entrance (P18)
	Lengthen existing entrance breakwater (P19)
	Beach scraping of built-up sand adjacent to creek entrance (P20)
Scour from stormwater and creek flows at eastern end of beach	Investigate installation of stormwater energy dissipation to reduce discharge velocities at outlet (P21)
	Post storm beach scraping to assist natural recovery of the dune and repair scour caused by stormwater discharge (P22)
All issues	Emergency response (P23)
	Maintain status quo (P24)

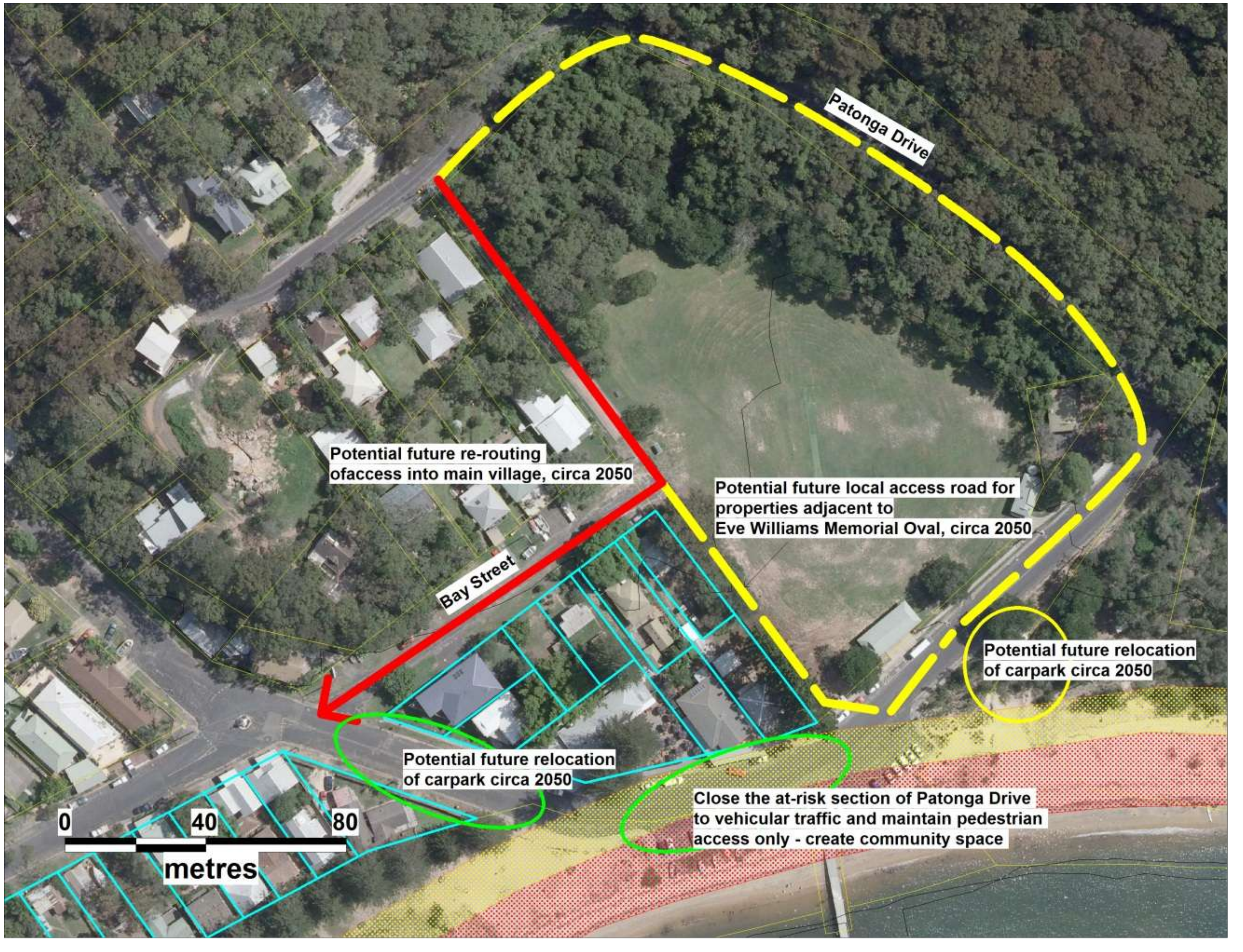

Figure 55 – Potential future relocation of at-risk infrastructure at Patonga, circa 2050 (Management Option P8)

Table 17 – Management Options for Patonga

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050 years)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
Immediate risk of erosion damage to main carpark	Erosion Protection works at main carpark (P1)	Short term (0 – 5 years), as carpark already under erosion threat	• Works may consist of a sheet pile wall in front of existing carpark or rock seawall similar to the one at the boat ramp.	• Would provide protection for the carpark and wharf access against a design storm. • Would protect services against future erosion risk of carpark and Patonga Drive • Would protect future access to village for residents and emergency services should the design storm occur. • Works could offer the opportunity to enhance amenity if well designed.	• Cost to design, construct and maintain works • Potential for loss of recreational amenity through loss of access to foreshore and storage area for small craft • Potential for increased erosion impacts in front of and on either side of the works due to wave reflections • Potential for future loss of access along the beach in front of structure • Potential for erosion protection works to interrupt longshore transport and impact on coastal processes	$400,000 to $600,000	$450,000 - $680,000	$35,000 - $50,000 (assumes loss of income from loss of carparking spaces plus savings from maintenance of pavement due to erosion damage)	0.05 – 0.1
	Repair damage to carpark should storm erosion occur (P2)	As required	• Re-instate carpark, pedestrian pathway and beach berm should erosion occur using erosion resistant pavements	• No capital outlay • No change to the status quo • Use of erosion resistant pavements would reduce future maintenance requirements	• Temporary loss of carparking and access to wharf should storm erosion occur, affecting local businesses and residents • Recurring cost of repair to carpark and associated infrastructure would increase over time as risk of erosion to carpark increases (but this would be partly offset if erosion-resistant pavements are used)	$50,000 to $100,000	$50,000 to $100,000	$14,000 - $28,000 (assumes 2% probability p.a. of damage to pavement causing $50,000 - $100,000 per event)	0.14 – 0.56
	Placement of sand sourced from western shoals at creek entrance to provide buffer against storm erosion (P3)	Short term, then repeat as required	• Sand to be scraped along beach by over-land equipment from western end of beach adjacent to training wall, sand could also be sourced from maintenance dredging at the creek entrance.	• Potential to improve navigation around Patonga Creek entrance and vessel access to Patonga Creek residents • Sand would provide buffer against storm erosion which could prevent damage to the carpark • Opportunity to create a dune crest which may reduce the risk of inundation at the carpark due to wave runup	• Approvals and detailed studies required to access the sand source for placement • Sand would rapidly re-distribute itself along the beach and buffer protection would be limited without construction of a retaining structure such as a groyne (which would add significantly to the cost) • Potential for sand drift problem if sand is not stabilised by vegetation and fencing • Works would need to be undertaken periodically and there would be a recurrent cost associated with this. • Loss of views from the carpark if dune crest is constructed too high.	$300,000 to $500,000	$600,000 - $1.4 million (assumes would be required every 10 years on average)	$200,000 estimate (includes benefit of improved navigation in creek and reduction in damage from inundation)	Around 0.2

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050 years)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
	Beach scraping (P4)	As required after storms	• Sand could be scraped across the beach from the shore line up to the carpark, or along the beach from the large sand supply available at western end of beach adjacent to training wall.	• Opportunity to create a dune crest which may reduce the risk of inundation at the carpark due to wave runup • Opportunity to create a buffer of sand which may provide some erosion protection in front of the carpark.	• Cost of environmental assessment and planning activities. • Disruption to beach users during works.	$9,000 to $12,000	$120,000 to $160,000 (assumes would be required every year)	$60,000 (assumes reduction in inundation damage)	0.375 – 0.5
	Future relocation of carpark and associated infrastructure to an area landward of the coastal hazard area (P5)	Medium term (5 – 20 years)	• Close the existing carpark and replace asphalt with grassed area or dune vegetation. Create a new carpark in a suitable nearby location chosen in conjunction with local stakeholders.	• Removes the carpark and associated infrastructure from threat of erosion • Potential to create additional public space for use by community at site of existing carpark • Retains carparking for use of the village residents and visitors	• Loss of direct carparking at the wharf and potential for reduced access to village centre • Loss of existing public space elsewhere for use as a carpark • Cost of constructing and removing carpark	$150,000 to $180,000	$150,000 to $180,000	$14,000 - $28,000 (assumes 2% probability p.a. of damage to pavement causing $50,000 - $100,000 per event)	0.08 – 0.19
	Stabilisation of dunes in front of carpark with vegetation and fencing (P6)	Short term	• Plant dune vegetation on sandy area in front of carpark to arrest wind erosion	• Addresses problems with windblown sand across the carpark • Improvement in dune ecology • Stabilisation of dunes against wind erosion and some protection against minor wave erosion • Improved local beach amenity	• Does not protect the dune against erosion caused by major storms • If planting not carefully chosen may change the existing character of the area and ability to access the foreshore	$20,000 to $30,000	$45,000 - $70,000 (assumes maintenance required every 10 years)	Improved beach amenity – increase in visitor numbers – extra 5 visitors/day = $100,000	1.4 – 2.2
Future risk of erosion damage to Patonga Drive	Erosion Protection works at site of main carpark (P7)	Long term (>20 years), as road not yet under erosion threat	• Construction of a sheet pile wall or gravity-type rock seawall similar to the one at the boat ramp	• Would protect services against future erosion risk of Patonga Drive • Would protect future access to village for residents and emergency services should the design storm occur. • Works could offer the opportunity to enhance amenity if well designed.	• Cost to design, construct and maintain works • Potential for increased erosion impacts in front of and on either side of the works due to wave reflections • Potential for future loss of access along the beach in front of structure	$400,000 to $600,000	$450,000 - $680,000	$35,000 - $50,000 (assumes loss of income from loss of carparking spaces plus savings from maintenance of pavement due to erosion damage)	0.05 – 0.1
	Future relocation of main access into village (P8)	Long term (>20 years), as road not yet under erosion threat	• Closure and removal of section of road and replacement with grassed area or community open space • Construction of new road	• No loss of access to village if alternative access provided • Potential to enhance amenity in front of main village area	• Potential for loss of public space and change in existing traffic patterns should road access arrangements be altered • Long term loss of direct road access in front of the village and the wharf, leading to loss of connectivity between western	$150,000 to $200,000	$50,000 approx. if done in 20 years' time	Future enhancement of amenity and savings on pavement repair costs	Likely to be much greater than 1

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050 years)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
			access from Patonga Drive along western edge of oval linking to Bay Street or other suitable location to be chosen after consultation with local stakeholders		and eastern side of the village • May not be feasible due to gradients at this location.				
Immediate erosion risk to boat ramp and access road	Monitor and assess existing erosion protection works (P9)	Short term	• Undertake inspections and monitoring of performance of works after major storm events • Undertake engineering assessment of adequacy of works should future inspections indicate damage.	• Would provide an understanding of the degree of protection currently afforded to the access road	• None	N/A	N/A	N/A	"No regrets" option to be implemented
	Relocate access road as erosion occurs (P10)	Medium term	• Remove sections of the existing asphalt access to the boat ramp, reinstate sandy beach in this area, and improve existing access and parking area.	• There is ample space within the public reserve to move the access road further landward should erosion occur • Opportunity to upgrade facilities at the same time in accordance with Terras (2013)	• Rehabilitation cost of damaged road • Reduced turning circle for trailers in future • Reduced parking area for vehicles with trailers	$100,000 to $150,000	$23,000 to $35,000 approx. if done in 20 years' time	Benefit from reduced maintenance costs and continued use of boat ramp. Assume 250 boat trips per month (based on monthly average resident usage of camping area boat ramp as reported in Peninsula News 2008), $250 per use (based on average spend of recreational fishing expenditure per trip, McIlgorm, and Pepperell, 2013) = $750,000 p.a. x 2% probability of loss of boat ramp p.a. from 2034 = $35,000 + $7,000 reduced	Approx. 1.2 – 1.8

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050 years)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
								maintenance cost = $42,000	
	Reinstate access road and erosion works following erosion event (P11)	As required	• Reconstruct erosion works and boat ramp access should erosion damage occur	• Degree of access to boat ramp is maintained to current levels	• Cost of reinstatement • Future interference of the works with the coastal processes if long term beach recession were to occur	$250,000 to $300,000 per event	$110,000 - $120,000 (2% probability of damage p.a.)	Benefit from use of boat ramp. Assume 250 boat trips per month (based on monthly average resident usage of camping area boat ramp as reported in Peninsula News 2008), $250 per use (based on average spend of recreational fishing expenditure per trip, McIlgorm, and Pepperell, 2013), 2% probability of loss of boat ramp p.a = $15,000 p.a. = $200,000	Approx. 1.7 – 1.8
	Periodic nourishment of area with sand sourced from Patonga Creek entrance (P12)	Short term, then repeat as required	• Sand could be scraped along the beach by land-based equipment or dredged from the shoals at the creek entrance	• Potential to improve navigation around Patonga Creek entrance and vessel access to Patonga Creek residents • Sand would provide buffer against storm erosion which could prevent damage to the carpark • Improvement to beach dune ecology • Opportunity to provide buffer against storm erosion for Dark corner cottages	• Approvals and detailed studies required to access the sand source for placement • Sand would rapidly re-distribute itself along the beach and buffer protection would be limited without construction of a retaining structure such as a groyne (which would add significantly to the cost), or regular repeating of the nourishment exercise • Potential for sand drift problem if sand is not stabilised by vegetation and fencing • Works would need to be undertaken periodically and there would be a recurrent cost associated with this.	$300,000 to $500,000	$600,000 - $1.4 million (assumes would be required every 10 years on average)	$200,000 estimate (includes benefit of improved navigation in creek and reduction in damage from inundation)	Around 0.2
Inundation due to wave runup	Development controls (P13)	Short term	• Can be added to or based upon existing DCP	• Protects new development against inundation due to wave runup • Can be easily implemented within	• Additional controls may place additional impost onto beachfront property owners and could affect property resale values	N/A	N/A	N/A	"No regrets" option which is already in

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050 years)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
				existing DCP as existing controls already in place – no need to adjust existing controls.					place i.e. status quo.
	Beach scraping to maintain crest level of dune above wave runup level (P14)	Short term	• Sand could be scraped across the beach from the shore line up to the carpark, or along the beach from the large sand supply available at western end of beach adjacent to training wall. • Dune vegetation to be maintained and enhanced to assist in stabilising dune.	• Would protect beachfront development against inundation due to wave runup	• Loss of views due to increased height of dune • Cost of environmental assessment and planning activities. • Disruption to beach users during works. • This will provide no protection against inundation from tidal or catchment derived sources.	$9,000 to $12,000	$120,000 to $160,000 (assumes would be required every year)	$60,000 (reduction in inundation damage, assumes 10% damage to housing with 0.5 m average overfloor depth and probability of occurrence of 1% p.a.)	0.375 – 0.5
	Investigate raising floor levels of existing buildings (P15)	Medium Term	• Undertake survey of existing floor levels – raising buildings could be examined as an action under a local floodplain management plan. Landowners would be responsible for the raising of the floor levels.	• Would protect beachfront development against inundation due to wave runup and flooding	• Increased height of beachfront development • May not be feasible for all beachfront dwellings • Would need to be done across entire village where housing is at inundation risk – cost.	$300,000 to $500,000 (to be borne by landholders over time)	$300,000 to $500,000 (to be borne by landholders over time)	$60,000 (reduction in inundation damage, assumes 10% damage to housing with 0.5 m average overfloor depth and probability of occurrence of 1% p.a.)	0.12 – 0.2
Erosion in front of cottages at Dark Corner	Monitor and assess existing erosion protection works (P16)	Short term	• Undertake inspections and monitoring of performance of works after major storm events • Undertake engineering assessment of adequacy of works should future inspections indicate damage.	• Would provide an understanding of the degree of protection currently afforded to the cottages	• None	N/A	N/A	N/A	"No regrets" option to be implemented
	Implement erosion control works in front of cottages in accordance with Patonga Draft Plan of Management Crown Reserves	Medium Term	• Design and construct new erosion protection works in accordance with recommendations in	• Would improve the erosion protection to the cottages • Opportunity to improve local amenity and public access to the area when	• Cost to design, construct and maintain works • Potential for increased erosion impacts in front of and on either side of the works	$400,000 - $600,000	$450,000 - $680,000	$20,000 (assumes 2% probability of $10,000 erosion damage p.a. to 5 cottages)	0.05 approx.

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050 years)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
	and Dark Corner Cottages 2013 (P17)		Patonga Draft Plan of Management Crown Reserves and Dark Corner Cottages 2013.	compared with present conditions	due to wave reflections • Potential for future loss of access along the beach in front of structure • Inundation protection not provided.				
Shoaling at entrance channel of Patonga Creek	Investigate periodic maintenance dredging of sand from the creek entrance (P18)	Short term	• Investigate the possibility of dredging the entrance to Patonga Creek to improve navigation access	• Would improve navigation access into the creek for residents and recreational boating • May provide a source of sand suitable for beach nourishment of areas experiencing erosion	• Cost of dredging design and environmental assessment for works • Possible impact of dredging on water quality and hydrodynamics of creek	$300,000 - $500,000	$600,000 - $1.4 million (assumes would be required every 10 years on average)	$200,000 estimate (includes benefit of improved navigation in creek and reduction in damage from inundation)	Around 0.2
	Investigate lengthening existing entrance breakwater (P19)	Medium-long term	• Investigate the design of the existing breakwater at the creek entrance to improve sand trapping efficiency and reduce shoaling of creek entrance	• Potential to improve navigation access into the creek for residents and recreational boating by reducing sand build-up at the creek entrance • Would potentially reduce the frequency of maintenance dredging and/or beach scraping required to keep the creek entrance clear.	• Cost of design and environmental assessment for works • Possible impact on hydrodynamics of creek • Would require regular maintenance and periodic removal of accreted sand to prevent future creek entrance shoaling	$1.0 - $1.5 million	$1.1 to $1.7 million	$150,000 estimate (benefit of improved navigation in creek)	Around 0.1
	Beach scraping of built-up sand adjacent to creek entrance (P20)	Short term	• Sand could be scraped along the beach by land-based equipment or dredged from the shoals at the creek entrance	• Potential to improve navigation around Patonga Creek entrance and vessel access to Patonga Creek residents • Sand would be available to provide buffer against storm erosion which could prevent damage to the carpark • Improvement to beach dune ecology • Opportunity to provide buffer against storm erosion for Dark corner cottages	• Sand would rapidly re-distribute itself along the beach and buffer protection would be limited without construction of a retaining structure such as a groyne (which would add significantly to the cost), or regular repeating of the nourishment exercise • Potential for sand drift problem if sand is not stabilised by vegetation and fencing • Works would need to be undertaken periodically and there would be a recurrent cost associated with this.	$50,000 - $100,000	$110,000 - $230,000	$200,000 estimate (includes benefit of improved navigation in creek and reduction in damage from inundation)	Approx. 1.0
Scour from stormwater and creek flows at eastern end of beach	Investigate installation of stormwater energy dissipation to reduce discharge velocities at outlet (P21)	Short term	• Dissipate energy in front of stormwater outlet by installing energy dissipation blocks, rock apron, or by other method to reduce velocity of outflows from stormwater outlet	• Would reduce scour on the beach berm from stormwater discharge • Would improve public safety during rainfall events • Would encourage natural buildup of dune in this location which would enhance the sand buffer in front of the main carpark	• Needs to be designed well to not exacerbate flooding in the upstream catchment area • Cost to design, construct and maintain. • May be limited technical scope to improve existing scour potential.	$50,000	$55,000 (estimate 1% p.a. maintenance)	N/A	"No regrets" option to investigate technical feasibility.

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050 years)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
	Post storm beach scraping to assist natural recovery of the dune and repair scour caused by stormwater discharge (P22)	As required	• Undertake beach scraping to repair the scour hole caused by stormwater discharge in the area in front of the surf club	• Would improve public safety and beach amenity following rainfall events • Would enhance the sand buffer in front of the main carpark.	• Cost of environmental assessment • Disruption to beach users during works	$10,000 to $20,000	$140,000 - $280,000 (assume required annually)	$35,000 - $50,000 (assumes loss of income from loss of carparking spaces plus savings from maintenance of pavement due to erosion damage)	0.125 – 0.35
All issues	Emergency Management (P23)	As required	• Undertake pre, during and post storm actions as described in Section 7.8 when trigger for action is reached	• Public safety	• N/A	N/A	N/A	N/A	"No regrets" option to be implemented
	Maintain Status Quo (P24)	Short term	• Continue existing management measures	• No additional capital outlay	• Ongoing maintenance costs and opportunity cost of poor recreational amenity	N/A	No net costs over existing	No net benefits over existing	1.0 (no benefits, no costs)

8.5 Pearl Beach

8.5.1 Issues and Options

The major coastal hazards identified at Pearl Beach are:

- **Coastal inundation** due to wave runup affecting the beachfront residences at Coral Crescent and near Green Point Creek;
- **Coastal erosion** having the potential to impact on the **beachfront** residences at Coral Crescent and near Green Point Creek, as well as the public reserve, playground and amenities block along the southern end of the beach;
- **Slope Instability** having the potential to result in reduced foundation capacity for buildings on up to 38 beachfront lots along Coral Crescent and near the entrance to Green Point Creek in the present day, with this number increasing to 51 lots by 2100;
- **Future coastal erosion** and recession affecting up to 135 m length of Pearl Parade by 2100, as well as dwellings, services including stormwater, sewer, water and power along Pearl Parade and Gem Road;
- **Erosion associated with estuary entrance instability** at Green Point Creek and Middle Creek.

The consequences of these coastal hazards being realised include:

- Present day potential for overfloor inundation of houses by wave runup, causing damage to existing buildings and services supplying those buildings;
- Present day threat of erosion damage to the two buildings identified as being within the Present Day *Zone of Slope Adjustment*, to the amenities block and to the playground area along Pearl Parade;
- Present day threat of erosion damage to fencing, private gardens and minor structures on the seaward side of Coral Crescent;
- Threat of erosion damage to sewer pipe at end of Gem Road and sewage pumping station;
- Damage to stormwater infrastructure at the public park at the southern end of the beach;
- Future erosion risk to parts of Pearl Parade, impacting future access to dwellings along Pearl Parade;
- Future erosion risk to services and properties along Coral Crescent is expected to increase, increasing the risk of damage to private property due to erosion and reduced foundation capacity, as well as risk to public safety increasing with time.

- Future increased potential for overfloor inundation of houses by wave runup, and also inundation due to increased tailwater levels due to future sea level rise at the entrances to Pearl Beach Lagoon, Middle Creek and Green Point Creek.

Management actions relevant to coastal hazards and other management issues have been identified in the Broken Bay Coastal Zone Management Plan (Patterson Britton & Partners 1999).

Pearl Beach has been divided into a number of precincts moving from south to north, considering particular characteristics within each precinct, namely:

- **Precinct 1** – Southern end of the beach south from the restaurant;
- **Precinct 2** – Between Green Point Creek and Middle Creek entrances;
- **Precinct 3** – Middle Creek to Pearl Beach Lagoon Outlet;
- **Precinct 4** – Coral Crescent beachfront residences.

Potential management actions that are relevant in addressing the identified coastal hazards for Pearl Beach include:

- **Development controls** to ensure new developments within the coastal hazard areas are unlikely to be damaged within a chosen planning period by coastal erosion and inundation (i.e. founded on deep piled foundations into the local 2050 or 2100 *Stable Foundation Zone* and located with a floor level 0.5m above the maximum wave runup level, allowing for future sea level rise);

- **Relocation** of existing buildings landward following re-development (e.g. the restaurant, and residences);

- Undertake or allow residents to undertake **erosion protection works** to protect the residences and sewage pumping station at the southern end of the beach and/or the seaward boundaries of residences along Coral Crescent;

- Undertake post-storm **beach scraping** at the foreshore adjacent to Coral Crescent to accelerate beach recovery following erosion by changing the slope of the beach, periodically, to allow the energy of the sea to bring additional sand onshore;

- Undertake periodic beach nourishment to provide a buffer against erosion;

- Entrance management guidelines for opening Green Point and Middle Creeks as well as Pearl Beach Lagoon - provide defined opening line/s and angles which will minimise bank erosion, cliff instability and minimise damage to the beach front, and include the opening guidelines within Council's Lagoon Opening Policy and Procedure.

- **Monitor** the performance and assess the effectiveness of the existing erosion protection works already in place at the properties south of Green Point Creek entrance;

- Improve **maintenance of dune vegetation**, planting and fencing along length of beach, in areas under both private and public control;

- Improve stormwater management at the outlets south of Middle Creek entrance to prevent scour due to stormwater runoff;
- **Relocation of infrastructure** subject to potential damage due to coastal erosion e.g. services, amenities, carparking;
- **Maintenance of the dune crest** above the level of wave runup to prevent wave runup reaching the beachfront buildings;
- **Maintain the status quo –** do nothing apart from maintain existing planning controls and existing coastal management regime.

Other management issues identified in previous studies (Patterson Britton & Partners 1999; BMT WBM 2013, Pearl Beach Progress Association 1998) include:

- Beach cleanliness and amenity;
- Water quality and ecology within Green Point Creek, Middle Creek and Pearl Beach Lagoon;
- Dune management and ecology.

Beach cleanliness and amenity, in addition to the specific management actions identified below, can be addressed by Council's regular maintenance activities, such as removal of rubbish or accumulated sea grass wrack where this has reached nuisance levels, in accordance with Council's existing Beach Management Policy (Gosford Council 2006). The objective of that Policy is to create and establish management standards for all Beaches under the management and control of Council.

Dune management and ecology have been addressed within the specific management actions listed below. Water quality and ecology within the local estuaries have been addressed in the Management studies for those water bodies (BMT WBM 2012) and are outside the scope of this Study.

A suite of 41 specific management options have been developed to address the coastal hazards identified at each of the four precincts in Pearl Beach for consideration. Each option has been provided with an identifier (Pe1.1 to Pe4.10) as illustrated in Table 18. A more detailed summary of these main options for coastal zone management including advantages and disadvantages, timeframe for adoption and indicative costs is provided in Table 19.

Further to the management options below, Pearl Beach has been named as an "Authorised Location" for placement of temporary protection works in the Code of Practice under the *Coastal Protection Act 1979* (OEH 2013). Under the Code of Practice, landowners may place temporary protection works comprising either:

- sand filled geotextile containers each of maximum 0.75m^3 filled volume stacked in a single layer up to 1.5m high (at a slope flatter than 34° from the horizontal, that is flatter than 1:1.5 vertical:horizontal); or,
- clean sand placed up to the crest on the seaward side of an eroding escarpment (under the Code of Practice, this is not permitted to be sourced from the beach on which the works are to be placed).

It is emphasised that landowners must act well (generally months) in advance of a storm to consider implementing these works. It should also be noted that landowners are not permitted to install coastal protective works without following the procedures outlined in the Code of Practice (OEH 2013), and severe penalties may apply if they are not followed.

8.5.2 Landuse and Development

At Pearl Beach, building is permitted seaward of the 2098 erosion line but landward of the building/hazard line for Coral Crescent, subject to the following (clause 6.2.6.1(d) of the DCP):

a) The building shall be founded on deep pile foundations which extend below the locally unstable foundation zone which relates to the 2098 prediction;

b) the owner executing a positive covenant as detailed in clause 6.2.6.1(f).

c) Not give rise to any increased hazard.

8.5.2.1 Southern End of Pearl Beach

The most recent coastal hazard assessment has identified that there are two lots at the southern end of the beach which are largely seaward of the *Present Day Zone of Slope Adjustment* and landward movement of buildings within these two lots is not feasible. The previous coastal zone management plan (Patterson Britton & Partners, 1999) identified these properties as ones which may be able to self-protect. Given that two of these properties already have buried terminal protection in place, self-funded protection may be a feasible strategy for the remaining two unprotected properties. Council infrastructure, including a sewage pumping station and sewer main at the end of Gem Road, is also at risk in this area. There may therefore be an opportunity to provide buried terminal protection for the sewer and adjacent unprotected properties in a coordinated manner.

The alternative strategy is to retreat – for two properties, 1 Tourmaline Avenue and 8 Gem Road, there is insufficient scope within the existing lots to retreat landward of the 2050 erosion hazard line. For these properties, voluntary purchase may be offered as an alternative. Current market value for each of these properties is estimated to be at least \$2.2 million each, based on data obtained from www.onthehouse.com.au. Market value for these properties may be even higher, given that 5 Gem Road sold for \$2.71 million in November 2013.

For the remaining properties, restricting new development to be landward of the 2050 *Zone of Slope Adjustment* line is feasible, as the existing developments are already landward of this line. Properties seaward of the 2100 *Zone of Reduced Foundation Capacity* limit along the entire beachfront (including properties on Pearl Parade) could be required to be constructed on piled foundations and be subject to the provisions of the Gosford DCP. However, the sewerage infrastructure in this area would still be at risk due to coastal erosion.

Table 19 provides the alternative strategies for this section of beach, including costs and benefits of each.

8.5.2.2 Northern end of Pearl Beach (Coral Crescent)

The most recent coastal hazard assessment has identified that the lots on the seaward side of Coral Crescent are subject to coastal hazards of erosion and inundation. All the dwellings within this area are landward of the 2050 *Zone of Slope Adjustment* line and many are landward of the 2100 *Zone of Slope Adjustment*. For these properties, a building line is currently in place. The *Present Day Zone of Slope Adjustment* dissects many of these properties through their seaward side. Options for modifying the DCP for this area include:

- Allowing development landward of the *2050 Zone of Slope Adjustment* with piled foundations into the *2100 Stable Foundation Zone*. This would be similar to the provisions of the existing DCP. The clause that development not give rise to any increased hazard could be applied to prevent building re-development from being allowed to move seaward of the existing location;
- Allowing development landward of the *2100 Zone of Slope Adjustment* with piled foundations into the *2100 Stable Foundation Zone*. This would be more restrictive than the existing DCP, with 11 dwellings currently having a portion slightly seaward of this line;
- Reassessing a building line for this area which encompasses the existing building envelopes (i.e. a constant setback from the seaward or landward property boundary, with new development to be constructed on deep piled foundations into the *2100 Stable Foundation Zone.*

The existing provisions relating to coastal inundation could be retained for this precinct.

Alternative options for this precinct would include terminal protection or voluntary purchase.

8.5.2.3 Voluntary Purchase

It is considered that development within these lots landward of the 2100 *Zone of Slope Adjustment* is technically feasible. Given that no dwellings are seaward of the 2050 *Zone of Slope Adjustment*, a voluntary purchase scheme is not considered to be a feasible option for this precinct at present, given the cost of such a scheme when compared with the value of the assets at risk within the 2050 planning horizon. However, such a scheme may become more feasible beyond the 2050 planning horizon once the quantum of assets at risk from coastal erosion increases.

Property values for these properties are considered to be in excess of $3 million each, with the most recent sale found for 20 Coral Crescent being $3.275 million in 2010 based on data obtained from www.onthehouse.com.au. Purchase of 32 properties within this precinct at an estimated cost of $3.2 million each would require an outlay of $102.4 million.

Additional costs associated with this option would be the loss of rate income to Council currently provided by the properties. Council has provided the average value of rates obtained for beachfront properties at Coral Crescent of $8874/year, which for 34 properties totals $301,716/yr. For an average rate increase of 3% p.a. and a discount rate of 7% p.a., the net present cost of loss of rate income for the properties at Coral Crescent is $5.9 million to 2050.

8.5.2.4 Terminal Protection

Terminal protection for these properties is not considered to be a feasible option for this precinct at present, given the cost of such a scheme when compared with the value of the assets at risk within the 2050 planning horizon. However, such a scheme may become more feasible beyond the 2050 planning horizon once the quantum of assets at risk from coastal erosion increases.

It should be noted that there are no public assets at risk in this area, and that any terminal protection in this area would benefit the property owners directly. To prevent ad-hoc protection works being constructed at individual properties, a terminal protection scheme would need to be agreed to by all the property owners in the precinct. Such a scheme would need to be subject to a detailed design and environmental assessment. Funding could be provided by local property owners through a contribution payment toward the construction costs, with commissioning of the design and construction undertaken through funding from the NSW Coastal Management Program and part funding from Council. Maintenance would then be the responsibility of the local landowners, which could be undertaken by Council but funded by the residents.

Given that the benefit of terminal protection is presently low, and that there are environmental risks associated with this option in terms of impact on the beach environment, this option may not be feasible at present but could be investigated further in the future.

8.5.2.5 Beach Scraping

Beach scraping is a technique used for accelerating beach recovery following erosion by changing the slope of a beach, periodically, to allow the energy of the sea to bring additional sand onshore. This is achieved by removing a small amount of sand from the beach berm at low tide and adding the sand to the dune system. Beach scraping is discussed in more detail in Section 7.6.7.

Beach scraping has higher uncertainty as a protection measure than other coastal management options, so should only be undertaken in conjunction with a comprehensive monitoring program (Carley et al., 2010).

Beach scraping was used at Pearl Beach following the severe storms that caused dune erosion in 1974. A bulldozer was used to transfer sand from the lower beach to the dune. This work restored the dune protection to the development without any longer term adverse impacts having been experienced on the beach.

As at May 2014, an environmental assessment is currently being undertaken for this activity to be allowable at this precinct. It is considered that this strategy would improve the post-storm beach amenity and erosion protection available to the properties in this precinct.

1. Green Point Creek meandering along beach berm in front of properties at southern end of beach

2. Scour of beach berm at entrance to Middle Creek;

3. Scour of beach berm at entrance to Pearl Beach Lagoon

4. Erosion damage to beach escarpment at Coral Crescent

Figure 56 – Pearl Beach coastal management issues

1. Example of estuary entrance "tripper wall" to prevent scour due to meandering of estuary entrance (Dee Why, NSW)

2. Example of Beach Scraping (Callala Bay, NSW);

Figure 57 – Example management options which could be applied at Pearl Beach

Table 18 – Coastline Management Options for Pearl Beach

Precinct	Management Issue	Management Option
Precinct 1 – Southern end of the beach south from the restaurant	Immediate and future risk of erosion and reduced foundation capacity to four properties and sewage pumping station	Erosion Protection works to be allowed for four properties south of Green Point Creek entrance (funded jointly by residents, Council and State Government through Coastal program) (Pe1.1)
		Monitor performance of existing erosion works at properties south of Green Point Creek entrance (Pe1.2)
		Erosion protection works for sewage pumping station and sewer line at end of Gem Road and south from Gem Road (Pe1.3)
		Relocate sewer line infrastructure and pumping station further landward (Pe1.4)
		Beach nourishment (Pe1.5)
		Beach scraping to build dune in front of residences, Gem Road and restaurant (refer Figure 57) (Pe1.6)
		Continue dune vegetation management at southern end of beach (Pe1.7)
		Develop entrance management guidelines for mechanical opening of Green Point Creek (Pe1.8)
		Future relocation of restaurant landward on redevelopment (Pe1.9)
		Development controls for residences and restaurant to be on piled foundations on redevelopment of properties within 2050 or 2100 hazard area (Pe1.10)
		Construct "tripper" structure to control opening location of creek (refer Figure 57) (Pe1.11)
		Voluntary purchase of restaurant (Pe1.12)
	Coastal inundation of lots south of Green Point Creek entrance	Development controls for residences and restaurant to be above inundation levels on redevelopment of properties (Pe1.13)
		Develop entrance management guidelines for mechanical opening of Green Point Creek (Pe1.8)
		Beach scraping to build dune crest level to minimise wave overtopping in front of residences, Gem Road and restaurant (Pe1.6)
		Survey floor levels to determine degree of inundation hazard (Pe1.14)
Precinct 2 – Between Green Point Creek and Middle Creek entrances	Immediate and future risk of erosion to playground area	Erosion Protection works in front of playground area (Pe2.1)
		Repair of playground area, toilet block, beach accessways and landscaping works following erosion in a large storm event (Pe2.2)
		Beach scraping following storm event to build dune crest level and revegetation (Pe2.3)
		Beach nourishment to increase erosion buffer in this area (Pe2.4)
		Develop entrance management guidelines for mechanical opening of Middle Creek (Pe2.5)
		Long term removal and relocation of playground should erosion escarpment move landward in future (Pe2.6)
	Future risk of erosion to Pearl Parade and associated services	Future installation of erosion protection works once erosion escarpment reaches set trigger distance from road edge (Pe2.7)
		Future closure of road and installation of alternative access (e.g. rear lane access to properties along Pearl Parade) (Pe2.8)
		Repair and restoration of Pearl Parade should it be damaged by a future storm (Pe2.9)
		Landward relocation of water supply and electricity should it be damaged by future erosion (Pe2.10)
		Development controls for residences on Pearl Parade to be on piled foundations on redevelopment of properties within 2050 or 2100 hazard area (Pe2.11)

Precinct	Management Issue	Management Option
Precinct 3 – Middle Creek to Pearl Beach Lagoon Outlet	Immediate erosion risk to dune	Encourage and assist Dunecare group to maintain and revegetate dune after a storm (Pe3.1)
		Post storm beach scraping to assist natural recovery of the dune and repair scour caused by breakout from Pearl Beach Lagoon and Middle Creek (Pe3.2)
		Formalise entrance management guidelines for mechanical opening of Middle Lagoon and Pearl Beach Lagoon entrances (Pe3.3)
		Monitor effectiveness of concrete wall on northern bank of outlet (Pe3.4)
Precinct 4 – Coral Crescent beachfront residences	Immediate and future erosion risk to Coral Crescent properties	Development controls as per existing DCP i.e. defined building line (e.g. existing building line or 2050 Zone of Slope Adjustment) with new buildings to be founded into 2100 Stable foundation Zone (Pe4.1)
		Development controls with building line based on 2100 Zone of Slope Adjustment with new buildings to be founded into 2100 Stable foundation Zone (Pe4.2)
		Post storm beach scraping to assist natural recovery of dune (Pe4.3)
		Terminal protection once erosion escarpment reaches trigger distance from defined building line (Pe4.4)
		Voluntary purchase of individual properties once erosion escarpment reaches set trigger distance from defined building line (Pe4.5)
		Trigger limited consents (Pe4.6)
		Encourage and assist Dunecare group to maintain and revegetate dune after a storm (Pe4.7)
		Beach nourishment to increase buffer against storm erosion (Pe4.8)
	Immediate and future inundation risk to Coral Crescent properties	Beach scraping to maintain crest level of dune above wave runup level (Pe4.9)
		Encourage beachfront residents to maintain crest level of dune and vegetate dune on private property in accordance with dune management practice (e.g. community education, provision of free plants (Pe4.10)
		Development controls as per existing DCP i.e. requirement for floor levels to be above wave runup level and be compatible with inundation hazard (Pe4.11)
All precincts	All issues	Emergency Management (Pe4.12)

Table 19 – Coastline Management Options Description for Pearl Beach

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050 years)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
Immediate and future risk of erosion and reduced foundation capacity to four properties and sewage pumping station	Erosion Protection works to be allowed for four properties south of Green Point Creek entrance (funded jointly by residents, Council and State Government through Coastal program) (Pe1.1)	Short to medium term (0 – 20 years), two of these properties already have protection installed	• Works may comprise similar design to existing adjacent works • Coordinated buried terminal protection funded jointly by residents, Council and State Government through Coastal program	• Would provide protection for the properties in a design storm. • Would be consistent with works already installed at adjacent properties. • Would protect services (sewer lines) against future erosion risk • Works would not adversely affect amenity if well designed, as per existing works. • Benefit is individual value of properties protected plus replacement cost of sewer infrastructure	• Cost to design, construct and maintain works • Potential for increased erosion impacts after a large storm in front of and on either side of the works due to wave reflections • Potential for future loss of access along the beach in front of structure • Potential for erosion protection works to impact on coastal processes in the future	$300,000 to $400,000	$1.36 million (construction plus 1% maintenance cost p.a. to 2050)	$5 million (assumes risk of property loss reduced to zero)	3.7
	Monitor performance of existing erosion works at properties south of Green Point Creek entrance (Pe1.2)	Immediate and ongoing	• Monitor effectiveness of existing works in a future storm event	• No capital outlay • Would provide information on the effectiveness of the works in a large storm	• Fails to remove coastal erosion risk to existing unprotected properties	N/A	$0.9 million (risk to properties based on 1% annual risk of 50% property damage over 50 years)	None	"No regrets" option to be implemented
	Erosion protection works for sewage pumping station and sewer line at end of Gem Road and south from Gem Road (Pe1.3)	Short term (0 – 5 years)	• Works may comprise similar design to existing adjacent works	• Would provide protection against storm erosion damage to the sewer line and pumping station and at the same time protection to residences on the southern side of the creek • Would be consistent with works already installed at adjacent properties. • Works would not adversely affect amenity if well designed, as per existing works.	• Cost to design, construct and maintain works • May adversely impact on the coastal hazard at adjacent properties unless works extended along entire frontage south of Gem Road • Potential for increased erosion impacts after a large storm in front of and on either side of the works due to wave reflections • Potential for future loss of access along the beach in front of structure • Potential for erosion protection works to interrupt longshore transport and impact on coastal processes in the future	$450,000 to $600,000	$500,000 to $700,000	$500,000 approx. (2% p.a. probability of damage to infrastructure and cost to landholders of loss of sewer infrastructure)	Around 1.0
	Relocate sewer infrastructure and pumping station further landward (Pe1.4)	Short term (0 – 5 years)	• Sewer currently located at the seaward end of the properties – this option would involve	• Would protect sewer and pumping station against damage by erosion in future storms	• Could be technically difficult or not feasible to move sewer landward due to the topography of the area.	$400,000 to $500,000	$450,000 to $550,000	$500,000 approx. (2% p.a. probability	Around 1.0

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050 years)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
			investigating the feasibility of moving the sewer landward out of the hazard area along the entire street frontage of Gem Road and Green Point Road					of damage to infrastructure and cost to landholders of loss of sewer infrastructure)	
	Beach nourishment (Pe1.5)	Medium term (5 – 20 years)	• Source sand for beach nourishment and place on the beach to build up dune and create buffer against storm erosion	• Would allow protection of the sewer, pumping station and residences against storm erosion and inundation by augmenting the existing dune • Would be aesthetically pleasing and would not detract from the beach amenity	• Pearl Beach sand is very coarse and suitable source of sand must also be coarse, may be difficult to find or inaccessible • Considerable study would be required to source sand and undertake environmental assessment • Pearl Beach planform is in equilibrium with the wave climate and beach nourishment unlikely to be effective without a control structure e.g. a groyne, to control outflow location from Green Point Creek and prevent sand from being lost from the system • Significant cost required as sand must be sourced from outside the Pearl Beach system.	$600,000 to $800,000	$1.4 – 1.8 million (assumes required every 10 years)	$700,000 approx. (reduction in damage potential)	Approx. 0.5
	Beach scraping to build dune in front of residences, Gem Road and restaurant (Pe1.6)	After storm events as required	• Build up sand from the beach berm into a dune and vegetate as per standard dune management practice in accordance with the Coastal Dune Management Manual (DLWC 2001).	• Would provide some buffer of sand for the sewer, pumping station and residences against storm erosion and inundation by creating a dune • Would be aesthetically pleasing and would not detract from the beach amenity • Would assist the natural post-storm recovery of the beach • Would assist the management of erosion/recession risk through dune building and management.	• Would be difficult to maintain a larger dune than existing at this location because of scour caused by meandering of Green Point Creek onto beach berm. Could be more effective if implemented in conjunction with entrance 'tripper' structure. • Potential conflict between dune maintenance and preservation of beach views • Cost of environmental assessment and planning activities. • Disruption to beach users during works.	$10,000 to $13,000	$17,000 (assume 10% probability that this would be required in any one year)	$25,000 (reduction in inundation damage for 6 buildings, assumes 15% damage to housing with 1.0 m average overfloor depth and probability of occurrence of 1% p.a.) and improved	1.5

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050 years)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
								public safety	
	Continue dune vegetation management at southern end of beach (Pe1.7)	Ongoing	• Continue providing support to local Dunecare groups and local residents to maintain dune as required and repair after a storm	• Would maintain existing beach amenity at this location • No additional cost	• May need to be carried out more frequently in the future	$100,000 to $150,000	N/A	N/A	"No regrets" option to be implemented
	Develop entrance management guidelines for mechanical opening of Green Point Creek (Pe1.8)	Short term	• Formulate an entrance management policy whereby Green Point Creek entrance can be opened at a defined trigger water level and at a defined location on the beach berm to prevent scour in front of the dunes	• Would reduce erosion due to scour across the beach berm and along the dune adjacent to the properties along the southern end of the beach • Would reduce the risk of catchment based flooding to properties adjacent to the creek.	• Would require regular deployment of equipment to put the strategy in place and monitoring to assess whether trigger conditions have been reached.	$3,000	N/A	N/A	"No regrets" option to be implemented
	Future relocation of restaurant landward on redevelopment (Pe1.9)	Short term	• Upon redevelopment of the restaurant move building further landward (i.e. as far landward as practicable)	• Would reduce the erosion hazard to the building	• There is limited available scope to move the building landward within the same lot as most of the lot is within the Immediate Zone of Slope Adjustment.	$1.5 to $2.0 million	$1.5 to $2.0 million	$140,000 (reduction in damage cost)	Approx. 0.1
	Development controls as per existing DCP i.e. defined building line (e.g. existing building line or 2050 Zone of Slope Adjustment) with new buildings to be founded into 2100 Stable foundation Zone (Pe1.10)	Short term	• Can be added to or based upon existing DCP	• These requirements are already within the DCP i.e. no change to status quo	• There is no scope for redevelopment of No. 8 Gem Road or the restaurant as these buildings are within the immediate hazard area.	N/A	$70,000 (assumes 2% risk p.a. of $50,000 damage to minor structures per property affected by immediate coastal erosion hazard)	$7 million (value of buildings within Immediate Zone of Reduced Foundation Capacity benefiting from being constructed on piled foundations)	100
	Construct "tripper" structure to control opening location of creek (Pe1.11)	Short term	• Construct a short buried training wall using reno mattresses to prevent	• Relatively low cost measure with minimal aesthetic impact as would be buried most of the time	• Buried reno mattress may become a danger to beachgoers if damaged due to exposed wire and rock	$50,000 to $100,000	$55,000 - $110,000	$70,000 (assumes 2% risk p.a. of	Approx. 1.0

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050 years)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
			creek from meandering in front of properties at southern end of beach	• Minimal ecological impact to the creek as would allow macrophytes to grow in the creek entrance • Would prevent erosion caused by creek flow in front of the residences, by controlling location of the creek opening and reducing the need for mechanical intervention at the entrance				$50,000 damage to minor structures per property affected by immediate coastal erosion hazard)	
	Voluntary Purchase (Planned retreat) for two unprotected properties including restaurant (Pe1.12)	Once appropriate trigger is reached e.g. erosion escarpment reaches set trigger distance e.g. 5m from edge of building	• Council/State Government can offer to purchase the building through voluntary means once trigger distance is reached via negotiations with the owners.	• Would remove the erosion hazard from the restaurant and existing house • Opportunity to improve local amenity by provision of additional community space	• Very high cost of purchase • Voluntary purchase may not be taken up by the property owners • Loss of restaurant, social and economic impact on the Pearl Beach community • Loss of rate income	$2.0 to $3.0 million	$8 million (including loss of revenue from restaurant and cost of moving sewer infrastructure)	$0.8 million (reduction in risk to properties based on 1% annual risk of 50% property damage by 2050). Intangible environmental benefit difficult to quantify but minimal.	0.10
Coastal inundation of lots south of Green Point Creek entrance	Development controls for residences and restaurant to be above inundation levels on redevelopment of properties (Pe1.13)	Short term	• Can be based upon existing DCP	• Protects new development against inundation due to wave runup • Can be easily implemented within existing DCP as existing controls already in place – no need to adjust existing controls.	• None	Extra construction cost (assume $50,000 per building)	Extra construction cost (assume $50,000 per building, = $300,000 for six buildings	$67,000 (reduction in inundation damage for 6 buildings, assumes 15% damage to housing with 1.0 m average overfloor depth and probability of occurrence of 1% p.a.) and improved public safety	0.22 (not including benefit from improved public safety)

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050 years)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
	Develop entrance management guidelines for mechanical opening of Green Point Creek (Pe1.8)	Short term	• Formulate an entrance management policy whereby Green Point Creek entrance can be opened at a defined trigger water level and at a defined location on the beach berm to prevent scour in front of the dunes	• Would reduce erosion due to scour across the beach berm and along the dune adjacent to the properties along the southern end of the beach and hence reduce the risk of wave runup onto existing properties • Would reduce the risk of catchment based flooding to properties adjacent to the creek.	• Would require regular deployment of equipment to put the strategy in place and monitoring to assess whether trigger conditions have been reached.	N/A	N/A	N/A	"No regrets" option to be implemented
	Beach scraping to build dune crest level to minimise wave overtopping in front of residences, Gem Road and restaurant (Pe1.6)	After storm events as required	• Build up sand from the beach berm into a dune and vegetate as per standard dune management practice in accordance with the Coastal Dune Management Manual (DLWC 2001).	• Would provide some buffer of sand for the sewer, pumping station and residences against storm erosion and inundation by creating a dune • Would be aesthetically pleasing and would not detract from the beach amenity • Would assist the natural post-storm recovery of the beach • Would assist the management of erosion/recession risk through dune building and management.	• Would be difficult to maintain a larger dune than existing at this location because of scour caused by meandering of Green Point Creek onto beach berm. Could be more effective if implemented in conjunction with entrance 'tripper' structure. • Potential conflict between dune maintenance and preservation of beach views • Cost of environmental assessment and planning activities. • Disruption to beach users during works.	$10,000 to $13,000	$17,000 (assume 10% probability that this would be required in any one year)	$25,000 (reduction in inundation damage for 6 buildings, assumes 15% damage to housing with 1.0 m average overfloor depth and probability of occurrence of 1% p.a.) and improved public safety	1.5
	Survey floor levels to determine degree of inundation hazard (Pe1.14)	Short term	• Survey floor levels and compare against wave runup levels	• Degree of inundation hazard to residences would be better known and appropriate response can be formulated if required	• None	$ 10,000	N/A	N/A	"No regrets" option
Immediate and future risk of erosion to playground area	Erosion Protection works in front of playground area (Pe2.1)	Medium term (5 – 20 years)	• Construct erosion protection works in front of playground	• Would protect public area against threat of erosion	• Loss of amenity through destruction of dune vegetation for construction of works • Potential for increased erosion impacts after a large storm in front of and on either side of the works due to wave reflections • High cost compared to cost of replacing the playground facilities	$1.1 to $1.5 million	$1.2 – 1.7 million	$70,000 approx. (replacement of community facility 2% probability p.a.)	0.05
	Repair of playground area, toilet block, beach accessways and landscaping works following erosion	As required	• Restore public reserve and playground area if damaged by future storm	• The existing use of the area is compatible with the coastal hazard	• Maintenance costs will increase in the future as erosion risk increases, if playground is maintained in the same	$200,000 to $250,000	$70,000 approx. (replacement of	Incalculable economic benefit of this	Not known

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050 years)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
	in a large storm event (Pe2.2)		erosion		location		community facility 2% probability p.a.)	facility due to tourist and local community use	
	Beach scraping following storm event to build dune crest level and revegetation (Pe2.3)	After storm events as required	• Build up sand from the beach berm into a dune and vegetate as per standard dune management practice in accordance with the Coastal Dune Management Manual (DLWC 2001).	• Would provide some buffer of sand for the playground and public reserve against storm erosion and inundation by building upon the existing dune • Would be aesthetically pleasing and would not detract from the beach amenity • Would assist the natural post-storm recovery of the beach	• Would require environmental assessment • Cost of environmental assessment and planning activities. • Disruption to beach users during works. • Benefit may be limited at this location	$7,000 to $10,000	$9,000 - $13,000 (assumes 10% probability that this would be required in any one year)	$35,000 approx. (50% reduction in probability that facility would need to be replaced due to coastal erosion)	2.7 – 3.9
	Beach nourishment to increase erosion buffer in this area (Pe2.4)	Medium term (5 – 20 years)	• Source sand for beach nourishment and place on the beach to build up dune and create buffer against storm erosion. Not likely to be feasible at this location.	• Would allow protection of the playground area against storm erosion by augmenting the existing dune • Would be aesthetically pleasing and would not detract from the beach amenity	• Pearl Beach sand is very coarse and suitable source of sand must also be coarse, may be difficult to find or inaccessible • Considerable study would be required to source sand and undertake environmental assessment • Pearl Beach planform is in equilibrium with the wave climate and beach nourishment unlikely to be effective without a control structure e.g. a groyne, to control outflow location from Green Point Creek and prevent sand from being lost from the system • Significant cost required as sand must be sourced from outside the Pearl Beach system.	$500,000 to $800,000	$1.2 – 1.8 million (assumes required every 10 years)	$70,000 approx. (reduction in damage potential)	0.05
	Develop entrance management guidelines for mechanical opening of Middle Creek (Pe2.5)	Short term	• Formulate an entrance management policy whereby Middle Creek entrance can be opened at a defined trigger water level and at a defined location on the beach berm to prevent scour in	• Would reduce erosion due to scour across the beach berm and along the dune adjacent to the properties along the southern end of the beach and hence reduce the risk of wave runup onto existing properties • Would reduce the risk of catchment based flooding to areas adjacent to the creek.	• Would require regular deployment of equipment to put the strategy in place and monitoring to assess whether trigger conditions have been reached.	$3,000	N/A	N/A	"No regrets" option to be implemented

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050 years)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
			front of the dunes						
	Long term removal and relocation of playground should erosion escarpment move landward in future (Pe2.6)	Long term (>20 years)	• Find an alternative location for the playground at such time as it is damaged by erosion from a future storm event and cannot be reinstated in the same location	• No capital cost required at this time, status quo is maintained	• Suitable location needs to be found for playground • Character and amenity of the beachfront area would change if playground moved to a different location	$30,000 to $50,000	$30,000 - $50,000 plus potential economic cost of loss of visitors from this location	$12,000 (reduction in damage potential if relocated in 20 years' time)	0.25 – 0.4
Future risk of erosion to Pearl Parade and associated services	Future installation of erosion protection works once erosion escarpment reaches set trigger distance from road edge (Pe2.7)	Long term (> 20 years)	• Design erosion protection works to protect Pearl Parade and properties on the landward side from future erosion risk, could be implemented once erosion escarpment reaches set trigger distance from edge of road. Likely not to be required for several years	• Would protect Pearl Parade, properties on landward side and associated services from damage in a future storm event • Would allow current access arrangements to the properties on Pearl Parade to be maintained • Likely not to be required for many years into the future	• Cost to design, construct and maintain works • Potential for increased erosion impacts after a large storm in front of and on either side of the works due to wave reflections • Potential for future loss of access along the beach in front of structure • Potential for erosion protection works to interrupt longshore transport and impact on coastal processes in the future	$2.0 to $3.0 million	$2.3 – 3.4 million	Approx. $4.5 million (retention of access to Pearl Parade properties and cost of replacement of road)	Approx. 1.5
	Future closure of road and installation of alternative access (e.g. rear lane access to properties along Pearl Parade) (Pe2.8)	Long term (>20 years)	• Once erosion begins to impact on Pearl Parade, investigate provision of alternative access arrangements to Pearl Parade properties.	• No action likely to be required for many years • Access provisions for properties along Pearl Parade are secured into the future without the need for terminal protection works, allowing the properties to remain viable	• Significant cost to purchase an easement behind the properties to allow access • Agreement of landholders required	$200,000 to $250,000 plus purchase costs	$300,000 if done in 2034 (assumes $100,000 compensation to each landowner for resumption of easement in 2034)	$140,000 approx. (based on 1% risk p.a. of loss of access to six homes and loss of land value of $1 million per lot after 2034)	0.5
	Repair and restoration of Pearl Parade should it be damaged by a future storm (Pe2.9)	Long term (>20 years)	• Repair and restore Pearl Parade roadway using damage resistant pavements following a large erosion event. Not likely to be required for many years.	• No action likely to be required for many years • Access provisions for properties along Pearl Parade are secured into the future without the need for terminal protection works, allowing the properties to remain viable • Use of damage resistant pavements would	• Cost to repair the road will be a recurrent cost into the future that will escalate once erosion begins to impact the road.	$200,000 to $250,000	$12,000 (assumes 2% risk p.a. of repair required after 2034)	$140,000 approx. (based on 1% risk p.a. of loss of access to six homes and loss of land value of $1	11.7

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050 years)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
				reduce future maintenance costs				million per lot after 2034)	
	Landward relocation of water supply and electricity should it be damaged by future erosion (Pe2.10)	Long term (>20 years)	• Landward relocation of services should they be located in the erosion hazard area in the future	• Would avoid damage to the services by moving out of the erosion hazard area	• Pearl Parade will have been impacted by erosion and access to the properties will have been lost, option would need to be implemented in conjunction with installation of alternative access to Pearl Beach properties.	$200,000 to $300,000	$70,000 if done in 20 years' time	$140,000 approx. (based on 1% risk p.a. of loss of access to six homes and loss of land value of $1 million per lot after 2034)	2.0
	Development controls as per existing DCP i.e. defined building line (e.g. existing building line or 2050 Zone of Slope Adjustment) with new buildings to be founded into 2100 Stable foundation Zone (Pe2.11)	Short term	• Can be based upon existing DCP	• Can be easily implemented within existing DCP as existing controls already in place – no need to adjust existing controls.	• None	N/A	None (all properties landward of 2050 ZRFC)	None until after 2050	"No regrets" option
Immediate erosion risk to dune	Encourage and assist Dunecare group to maintain and revegetate dune after a storm (Pe3.1)	Ongoing	• Continue providing support to local Dunecare groups and local residents to maintain dune as required and repair after a storm	• Would maintain existing beach amenity at this location • Social benefit of community participation in bush regeneration • No additional cost	• None	$15,000 - $25,000 p.a.	N/A	N/A	"No regrets" option to be implemented
	Post storm beach scraping to assist natural recovery of the dune and repair scour caused by breakout from Pearl Beach Lagoon and Middle Creek (Pe3.2)	After storm events as required	• Build up sand from the beach berm into a dune and vegetate as per standard dune management practice in accordance with the Coastal Dune Management Manual (DLWC 2001). • Repair of scour on the beach berm caused by lagoon breakout	• Would provide additional buffer of sand for the existing dune against storm erosion • Would be aesthetically pleasing and would not detract from the beach amenity • Would assist the natural post-storm recovery of the beach • Would improve post-breakout amenity in the area in front of the lagoon entrance and reduce risk of inundation from wave runup onto Coral Crescent	• Would require environmental assessment • Cost of environmental assessment and planning activities. • Potential conflict between dune maintenance and preservation of beach views • Disruption to beach users during works. • Benefit may be limited at this location	$7,000 to $10,000	#13,000 if done every 10 years on average	$88,000 (based on 50% reduction in probability of damage to the road, reduction in road maintenance costs, loss of access to six homes and loss of land value of $1 million per lot	6.8

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050 years)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
								after 2034)	
	Formalise entrance management guidelines for mechanical opening of Middle and Pearl Beach Lagoon entrances(Pe3.3)	Short term	• Formulate an entrance management policy whereby lagoon entrance can be opened at a defined trigger water level and at a defined location on the beach berm to prevent scour in front of the dunes. Needs to be consistent with requirements in Pearl Beach Lagoon CZMP.	• Would reduce erosion due to scour across the beach berm and along the dune adjacent to the properties along the southern end of the beach and hence reduce the risk of wave runup onto existing properties • May reduce the risk of catchment based flooding to areas adjacent to the lagoon.	• Would require regular deployment of equipment to put the strategy in place and monitoring to assess whether trigger conditions have been reached.	$3,000	N/A	N/A	"No regrets" option to be implemented
	Monitor effectiveness of concrete wall on northern bank of outlet (Pe3.4)	Short term	• Monitor the existing concrete wall following a breakout event to assess any damage or movement	• Remedial action could be put into place should any movement occur in the concrete block wall	• None	N/A	N/A	N/A	"No regrets" option to be implemented
Immediate and future erosion risk to Coral Crescent properties	Development controls as per existing DCP i.e. defined building line (e.g. existing building line or 2050 Zone of Slope Adjustment) with new buildings to be founded into 2100 Stable foundation Zone (Pe4.1)	Short term	• Can be based upon existing DCP. This would be similar to the provisions of the existing DCP. The clause that development not give rise to any increased hazard could be applied to prevent building re-development from being allowed to move seaward of the existing location	• Can be easily implemented within existing DCP as existing controls already in place – no need to adjust existing controls. • If planning control is based on existing DCP, would not increase the coastal hazard risk compared with existing situation • Benefit is individual value of properties protected by being on piled foundations by 2050	• Risk would increase beyond 2050	N/A	$1.332 million (assumes 2% risk p.a. of $50,000 damage to minor structures per property affected by immediate coastal erosion hazard)	$56 million (value of buildings within Immediate Zone of Reduced Foundation Capacity benefiting from being constructed on piled foundations)	42
	Allowing development landward of the 2100 Zone of Slope Adjustment with piled foundations into the 2100 Stable Foundation Zone (Pe4.2).	Short term	• This would be more restrictive than the existing DCP, with 11 dwellings currently having a portion slightly seaward of this line	• If planning control is adjusted to allow development landward of the 2100 Zone of Slope Adjustment with piled foundations into the 2100 Stable Foundation Zone, would improve the long term risk to development in the precinct compared with existing i.e. between 2050 and 2100	• Loss of development potential for 11 properties could lead to a decline in local property values	N/A	$4.9 million (assumes 2% risk p.a. of $50,000 damage to minor structures per	$56 million (value of buildings within Immediate Zone of Reduced Foundation	11.4

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050 years)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
							property affected by immediate coastal erosion hazard, plus 10% property value loss for 11 properties that would have reduced development potential)	Capacity benefiting from being constructed on piled foundations)	
	Post storm beach scraping to assist natural recovery of dune (Pe4.3)	After storm events as required	• Build up sand from the beach berm to provide toe protection to the erosion escarpment and assist natural recovery of the beach	• Would provide additional buffer of sand for the existing dune against storm erosion • Would be aesthetically pleasing and would not detract from the beach amenity • Would assist the natural post-storm recovery of the beach • Opportunity to build up dune crest level to prevent coastal inundation due to wave runup	• Ongoing cost for deployment of equipment. • Loss of views to residences if dune level built up higher than existing.	$30,000 to $50,000	$0.9 million ($50,000 cost undertaken bi-annually until 2050)	up to $6 million (based on 50% reduced risk of minor structure damage to at-risk properties plus 50% reduced risk of damage to buildings caused by reduced foundation capacity by 2050)	6.67
	Terminal protection once erosion escarpment reaches trigger distance from defined building line (Pe4.4)	Long term (> 20 years)	• Design erosion protection works to properties from future erosion risk, could be implemented once erosion escarpment reaches set trigger distance from building line. Likely not to be required for several years • Coordinated buried terminal protection	• Would protect Coral Crescent properties from future erosion events • Likely not to be required for many years into the future • Can be buried to minimise visual impact	• Cost to design, construct and maintain works and source of funding to be secured • All beachfront property owners would need to agree to the proposal • Potential for increased erosion impacts after a large storm in front of and on either side of the works due to wave reflections • Potential for future loss of access along the beach in front of structure • Potential for erosion protection works to impact on coastal processes in the future	$5.0 million	$6.8 million ($5 million design and construction plus 1% maintenance p.a. to 2050)	$24 million (reduction in risk to properties based on 1% annual risk of 50% property damage by 2050, buildings valued at $2 million each,	3.5

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050 years)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
			funded jointly by residents, Council and State Government through Coastal program					plus reduction in risk to minor assets).	
	Voluntary purchase of individual properties once erosion escarpment reaches set trigger distance from defined building line (Pe4.5)	Long term (> 20 years)	• Once appropriate trigger is reached e.g. erosion escarpment reaches set trigger distance e.g. 5m from building line and redevelopment in accordance with the DCP no longer feasible. Funded by State Government or jointly with Council at market value	• Council/State Government can offer to purchase the building through voluntary means once trigger distance is reached via negotiations with the individual owners. • Likely not required for many years • Would remove the erosion hazard from the dwellings • Restoration of natural dune environment over time	• Cost of property purchase would be prohibitive • Social impact on Pearl Beach community • Loss of rate income	>$100 million including loss of rate income	>$106 million (purchase of up to 32 properties where dwellings are partially seaward of 2050 Zone of Reduced Foundation Capacity, not including those landward of the 2050 Zone of Slope Adjustment already constructed on piles) and including $6 million net present value of loss of rate income	$23 million (reduction in risk to properties based on 1% annual risk of 50% property damage by 2050, buildings valued at $2 million each). Intangible environmental benefit difficult to quantify.	<0.22
	Trigger limited consents (Pe4.6)	Short term	• Introduce trigger limited consents for coastal development based on distance from erosion escarpment or time	• Would progressively remove the risk from the beachfront • Restoration of natural dune environment over time	• Loss of property values • Cost of legal action by property owners due to loss of development potential • Social impact on Pearl Beach community • Loss of rate income	None	= $21 million (based on 1% probability of trigger distance being reached p.a causing total loss of property value; 10% loss of property value	$2.3 million (based on 50% reduction in 1% p.a. damage risk to properties worth $1 million each)	0.1

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050 years)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
							assumed due to loss of development potential; 10% loss of rate income.)		
	Encourage and assist Dunecare group to maintain and revegetate dune after a storm (Pe4.7)	Ongoing	• Provide support and education to local Dunecare groups and local residents to maintain dune as required and repair after a storm	• Would improve existing beach amenity at this location by adoption of standard dune management approach in accordance with the Coastal Dune Management Manual (DLWC 2001) along entire beachfront • Social benefit of community participation in bush regeneration • No additional cost	• None	$15,000 - $25,000 p.a.	N/A	N/A	"No regrets" option to be implemented
	Beach nourishment to increase buffer against storm erosion (Pe4.8)	Medium term (5 – 20 years)	• Source sand for beach nourishment and place on the beach to build up dune and create buffer against storm erosion. Not likely to be feasible at this location.	• Would improve protection of the beachfront properties, especially minor structures against storm erosion by augmenting the existing dune • Would be aesthetically pleasing and would not detract from the beach amenity	• Pearl Beach sand is very coarse and suitable source of sand must also be coarse, may be difficult to find or inaccessible • Considerable study would be required to source sand and undertake environmental assessment • Pearl Beach planform is in equilibrium with the wave climate and beach nourishment unlikely to be effective without a control structure e.g. a groyne, to prevent sand from being lost from the system due to longshore drift. Such a control structure may cause adverse impacts elsewhere along Pearl Beach. • Significant cost required as sand must be sourced from outside the Pearl Beach system	$2,000,000 to $2,500,000	$4.6 – 5.7 million	up to $6 million (based on 50% reduced risk of minor structure damage to at-risk properties plus 50% reduced risk of damage to buildings caused by reduced foundation capacity by 2050)	1.2
Immediate and future inundation risk to Coral Crescent properties	Beach scraping to maintain crest level of dune above wave runup level (Pe4.9)	After storm events as required	• Build up sand from the beach berm to provide toe protection to the erosion escarpment and assist natural recovery of the beach. Build this high enough to provide	• Would provide additional buffer of sand for the existing dune against storm erosion • Would be aesthetically pleasing and would not detract from the beach amenity • Would assist the natural post-storm recovery of the beach • Opportunity to build up dune crest level to	• Ongoing cost for deployment of equipment. • Loss of views to residences if dune level built up higher than existing. • Insufficient sand may be available to build the dune to the required level. • Cost of environmental assessment and planning activities.	$30,000 to $50,000	$0.9 million ($50,000 cost undertaken bi-annually until 2050)	up to $6 million (based on 50% reduced risk of minor structure damage to at-risk properties	6.67

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050 years)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
			protection against wave inundation.	prevent coastal inundation due to wave runup	• Disruption to beach users during works.			plus 50% reduced risk of damage to buildings caused by reduced foundation capacity by 2050)	
	Encourage beachfront residents to maintain crest level of dune and vegetate dune on private property in accordance with dune management practice (e.g. community education, provision of free plants) (Pe4.10)	Short term, ongoing	• Provide support to local beachfront residents to assist them to maintain the dune in front of their properties	• Would improve existing beach amenity at this location by adoption of standard dune management approach in accordance with the Coastal Dune Management Manual (DLWC 2001) along entire beachfront • Low cost	• May not provide sufficient protection against wave inundation. • Potential conflict between dune maintenance and preservation of beach views	N/A	N/A	N/A	"No regrets" option to be implemented
	Development controls as per existing DCP i.e. requirement for floor levels to be above wave runup level and be compatible with inundation hazard (Pe4.11)	Short term	• Can be based upon existing DCP	• Can be easily implemented within existing DCP as existing controls already in place – no need to adjust existing controls.	• None	N/A	N/A	N/A	"No regrets" option already in place
All issues	Emergency Management (Pe4.12)	As required	• Undertake pre, during and post storm actions as described in Section 7.8 when trigger for action is reached	• Public safety	• N/A	N/A	N/A	N/A	"No regrets" option

8.6 Ocean/Umina Beach

8.6.1 Issues and Options

The major coastal hazards identified at Ocean/Umina Beach are:

- **Coastal inundation** due to wave runup affecting two beachfront residences at Berrima Crescent at the southern end of the beach;
- **Coastal erosion** having the potential to impact on one beachfront residence at Berrima Crescent and the dune all along the beachfront, as well as the carpark at Ocean Beach surf club and at the eastern end of Ocean Beach at Ettalong Point;
- **Slope Instability** having the potential to result in reduced foundation capacity for two beachfront lots along Berrima Crescent;
- **Dune vegetation management** in the Berrima Crescent area and in general along entire beachfront;
- **Erosion associated with estuary entrance instability** at Ettalong Creek; and
- **Scour associated with stormwater drainage** at Ocean Beach Surf Club.

The consequences of these coastal hazards being realised include:

- Present day potential for overfloor inundation of houses by wave runup, causing damage to existing buildings and services supplying those buildings;
- Present day threat of erosion damage to one building at Berrima Crescent identified as being within the Present Day *Zone of Slope Adjustment*, to the dune and Ocean Beach surf club carpark;
- Threat of erosion damage to stormwater infrastructure at Ocean Beach surf club;
- Major scour of the beach in front of the stormwater structure at Ocean Beach surf club leading to the potential for a rip to form at this location in a large storm;
- Future increased potential for overfloor inundation of houses by wave runup, and also inundation due to increased tailwater levels due to future sea level rise at the entrance to Ettalong Creek.

Coastal management issues identified at Ocean/Umina Beach are identified in Figure 58.

Ocean/Umina Beach was initially divided into two precincts, considering particular characteristics within each precinct, namely:

- **Precinct 1** – Southern end of the beach south from the entrance to Ettalong Creek (Berrima Crescent);
- **Precinct 2** – Between Ettalong Creek (at the Caravan Park) and Ettalong Point.

Based on community feedback, Ocean/Umina Beach has been divided into four separate precincts, namely:

- **Precinct 1** – Southern end of the beach south from the entrance to Ettalong Creek (Berrima Crescent);
- **Precinct 2** – Between Ettalong Creek (at the Caravan Park) and Umina Beach Surf Club.
- **Precinct 3** – Between Umina and Ocean Beach Surf Clubs
- **Precinct 4** – Between Ocean Beach Surf Club and Ettalong Point

Potential management actions that are relevant in addressing the identified coastal hazards for Ocean/Umina Beach include:

- **Development controls** to ensure new developments within the coastal hazard areas are unlikely to be damaged within a chosen planning period by coastal erosion and inundation (i.e. founded into the local stable foundation zone and located with a floor level 0.5m above the maximum wave runup level, allowing for future sea level rise);
- **Relocation** of existing buildings landward following re-development (this is feasible for the one building at Berrima Crescent impacted by coastal erosion hazard);
- Undertake or allow residents to undertake **erosion protection works** to protect the residences and property access at the southern end of the beach along the seaward boundaries of residences along Berrima Crescent;
- Undertake post-storm **beach scraping** at the foreshore adjacent to Berrima Crescent and the carpark at Ocean Beach Surf Club to accelerate beach recovery following erosion by changing the slope of the beach, periodically, to allow the energy of the sea to bring additional sand onshore;
- Undertake periodic beach nourishment to provide a buffer against erosion at the southern end of the beach;
- Entrance management guidelines for opening Ettalong Creek - provide defined opening line/s and angles which will minimise bank erosion, cliff instability and minimise damage to the beach front, and include the opening guidelines within Council's Lagoon Opening Policy and Procedure;
- Partial training of Ettalong Creek entrance to prevent it meandering across seaward side of Berrima Crescent properties and exacerbating erosion;
- Monitor the performance and assess the effectiveness of the existing concrete wall already in place at the Ocean Beach surf club carpark;
- Improve **maintenance of dune vegetation**, planting and fencing along entire length of beach;
- Improve stormwater management at the outlet at Ocean Beach surf club to reduce scour due to stormwater runoff;

- **Relocation of infrastructure** subject to potential damage due to coastal erosion e.g. services, amenities, carparking;
- **Maintenance of the dune crest** above the level of wave runup to prevent wave runup reaching the beachfront buildings.
- **Maintain status quo –** keep existing planning regime and existing coastal management measures.

A suite of 17 specific management options have been developed to address the coastal hazards identified at each of the two precincts in Ocean/Umina Beach for consideration. Each option has been provided with an identifier (O1.1 to O2.7) as illustrated in Table 20. A more detailed summary of these main options for coastal zone management including advantages and disadvantages, timeframe for adoption and indicative costs is provided in Table 21.

8.6.2 Landuse and Development

At Ocean/Umina Beach, the most recent coastal hazard assessment indicates that there are three private lots at the southern end of the beach (i.e. south of Ettalong Creek) subject to coastal erosion or reduced foundation capacity hazard by 2100. The provisions of the existing DCP are therefore adequate to address this hazard.

Potential strategies to deal with the erosion hazard risk in this area include:

- Modifying the existing DCP to allow for the erosion and inundation hazard and reduced foundation capacity risk;
- Terminal protection works funded by landowners in this precinct;
- Voluntary purchase of the properties or portion of the properties at risk.

It is considered that there is only one dwelling within the coastal erosion zone and that there is scope for re-development to be sited landward of the erosion hazard within that lot. The existing DCP could therefore be modified to allow development landward of the 2100 *Zone of Slope Adjustment* with piled foundations into the 2100 *Stable Foundation Zone*. Under the most recent coastal hazard assessment, only one property would be directly affected by the DCP.

Alternatively, terminal protection could be provided along the ocean frontage – however, the direct benefit would only be to a single property and access road, with future benefits provided to three properties. Funding could be provided by local property owners through a contribution payment toward the construction costs, with commissioning of the design and construction undertaken through funding from the NSW Coastal Management Program and part funding from Council. Maintenance would then be the responsibility of the local landowners, which could be undertaken by Council but funded by the residents.

Another alternative may be the purchase of the portion of 8 Berrima Crescent Umina seaward of the erosion hazard area, through negotiation with the landowner. This would provide an opportunity for the recreational amenity and environmental values of this land to be improved, and provide public space.

Table 20 – Management Options for Ocean/Umina Beach

Precinct	Issue	Management Option
Precinct 1 – Southern end of the beach south from Ettalong Creek entrance	Immediate and future risk of erosion and reduced foundation capacity to four properties and estuary entrance instability	Erosion Protection works to be allowed for four properties south of Ettalong Creek entrance (funded by residents) (O1.1)
		Monitor performance of existing training wall works along northern side of Ettalong Creek entrance (O1.2)
		Future relocation of residence on No.8 Berrima Crescent landward of immediate hazard area within same lot on redevelopment (O1.3)
		Beach nourishment (O1.4)
		Beach scraping to build dune in front of residences at Berrima Crescent (O1.5)
		Encourage and assist Dunecare group to improve dune vegetation management and consolidation of beach access at southern end of beach (O1.6)
		Develop entrance management guidelines for mechanical opening of Ettalong Creek (O1.7)
		Voluntary purchase of at risk property (O1.8)
		Voluntary purchase of portion of at risk property (O1.9)
		Development controls on redevelopment of properties within hazard area (O1.10)
		Construct “tripper” structure to control opening location of creek (O1.11)
	Coastal inundation of lots south of Ettalong Creek entrance	Development controls for residences to be above inundation levels on redevelopment of properties (O1.10)
		Develop entrance management guidelines for mechanical opening of Ettalong Creek (O1.7)
		Beach scraping to build dune crest level to minimise wave overtopping in front of residences (O1.5)
Precinct 2 – Ocean/Umina Beach north from Ettalong Creek entrance to Ettalong Point	Immediate and future risk of erosion to dunes, Ettalong Point and surf club carpark	Monitor existing erosion protection works in front of Ocean Beach surf club (O2.1)
		Repair of beach accessways and revegetation of dune following erosion in a large storm event (O2.2)
		Beach scraping following storm event to build dune crest level and revegetation (O2.3)
		Encourage and assist Dunecare group to maintain and revegetate dune after a storm (O2.2)
	Windblown dune erosion	Encourage and assist Dunecare group to undergo ongoing dune vegetation management (O2.2)
	Scour due to stormwater outlet at Ocean Beach Surf Club	Investigate installation of stormwater energy dissipation to reduce discharge velocities at outlet (O2.4)
		Post storm beach scraping to assist natural recovery of the dune and repair scour caused by stormwater discharge (O2.5)
All precincts	All issues	Emergency Management (O2.6)

1. Ettalong Creek meandering along beach berm in front of properties at southern end of beach, 3 April 2014

2. Ad-hoc erosion protection and embankment erosion along Berrima Crescent properties, south end of beach, 3 April 2014

3. Informal/overgrown beach access at south end of Umina Beach, 3 April 2014

4. Erosion escarpment north end of Ocean Beach, 16 September 2010

5. Training wall at Ettalong Creek entrance, 3 April 2014

6. Scour at stormwater outlet, Umina SLSC 3 April 2014

7. Dunes with scant vegetation cover, Umina Beach 3 April 2014

8. Umina Beach Surf Club seawall, 3 April 2014

Figure 58 – Coastal Management Issues identified at Ocean/Umina Beach

Table 21 – Management Options Description for Ocean/Umina Beach

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
Immediate and future risk of erosion and reduced foundation capacity to four properties and estuary entrance instability	Erosion Protection works to be allowed for four properties and carpark south of Ettalong Creek entrance (funded by Council and/or residents) (O1.1)	Short to medium term (0 – 20 years)	• Coordinated terminal protection constructed along existing embankment funded by residents • Council funded portion to protect carpark • Works may comprise engineered revetment placed along existing eroded embankment on seaward side of properties	• Would provide protection for the properties in a design storm and from erosion caused by creek flow. • Works would not adversely affect existing beach amenity if well designed. • Benefit is individual value of properties protected	• Cost to design, construct and maintain works • Potential for increased erosion impacts after a large storm in front of and on either side of the works due to wave reflections • Need for all properties to agree to construct works so that works do not impact on adjacent properties	$600,000 to $800,000	$1.088 million ($800,000 design/construction cost plus 1% maintenance p.a. to 2050)	$1.2 million ($4.5 million value of portion of property at risk, 2% chance of loss of existing house and portion of land at risk from erosion p.a. to 2050)	1.1
	Monitor performance of existing training wall works along northern side of Ettalong Creek entrance (O1.2)	As required	• Monitor effectiveness of existing works in a future storm or flood event	• No capital outlay • Would provide information on the effectiveness and impact of the existing works	• None	N/A	N/A	N/A	"No regrets" option to be implemented
	Future relocation of residence on No.8 Berrima Crescent landward of immediate hazard area within same lot on redevelopment (O1.3)	On redevelopment as per DCP	• On redevelopment, building to be located landward of hazard zone • Property currently has application in place for seawall protection with NSW Coastal Panel which would negate the need for relocation	• Would remove the erosion risk to the property • Consistent with existing requirements as per Gosford DCP	• None when compared with existing scenario	$200,000 to $400,000	$200,000 to $400,000 plus loss of subdivision potential	$140,000	Around 0.5
	Beach nourishment (O1.4)	Long term (>20 years)	• Import of sand into this portion of the beach to increase buffer against beach erosion	• Would provide buffer against storm erosion demand	• Suitable source of sand has not been identified, possibly shoals at Patonga Creek entrance? Extensive studies required to identify source of sand and undertake environmental assessment • Nourishment works would require a control structure (e.g. a groyne) to enable the sand to remain on the beach at this location • Training works would be required to the creek to prevent loss of the nourished sand	$300,000 to $500,000	$700,000 approx.	$1.2 million ($4.5 million value of portion of property at risk, 2% chance of loss of existing house and portion of land at risk from	1.7

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
					due to entrance instability at Berrima Crescent			erosion p.a. to 2050)	
	Beach scraping to build dune in front of residences at Berrima Crescent (O1.5)	Short term and as required (0-5 years)	• Build up sand from the beach berm into a dune and vegetate as per standard dune management practice in accordance with the Coastal Dune Management Manual (DLWC 2001).	• Would improve protection of the residences against storm erosion and inundation due to wave runup by augmenting the existing dune • Would be aesthetically pleasing and would not detract from the beach amenity	• Would be difficult to maintain a dune at this location because of scour caused by meandering of Ettalong Creek onto beach berm. Could be more effective if implemented in conjunction with entrance 'tripper' structure. • Potential conflict between dune maintenance and preservation of beach views • Cost of environmental assessment and planning activities. • Disruption to beach users during works.	$4,000 to $7,000	$90,000 - $160,000 (assumes annual frequency)	$200,000 approx. (probability decrease of loss of houses to erosion)	1.25 – 2.0 approx.
	Encourage and assist Dunecare group to improve dune vegetation management and consolidation of beach access at southern end of beach (O1.6)	Short term (0-5 years)	• Build up sand from the beach berm into a dune and vegetate as per standard dune management practice in accordance with the Coastal Dune Management Manual (DLWC 2001). Remove weeds and install native vegetation. Provide support to local Dunecare groups and local residents to maintain dune as required and repair after a storm	• Would provide an improved buffer of sand for the residences against storm erosion and inundation by creating a dune • Would improve the dune ecology in this area • Would be aesthetically pleasing and would not detract from the beach amenity • Would assist the natural post-storm recovery of the beach • Social benefit of community participation in bush regeneration	• Potential loss of views if dune is constructed too high or tall vegetation is planted.	$15,000 - $25,000 p.a.	N/A	N/A	"No regrets" option to be implemented
	Develop entrance management guidelines for mechanical opening of Ettalong Creek (O1.7)	Short term (0-5 years)	• Specify entrance management guidelines for opening of Ettalong Creek to encourage the creek to open in a direction away from the residences at Berrima Crescent	• Would reduce erosion due to scour across the beach berm and along the dune adjacent to the properties along the southern end of the beach • May reduce the risk of catchment based flooding to properties adjacent to the creek	• Would require regular deployment of equipment to put the strategy in place and monitoring to assess whether trigger conditions have been reached.	$3,000	N/A	N/A	"No regrets" option

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
	Voluntary purchase of at risk property (O1.8)	Medium term	• Offer to purchase property at No. 8 Berrima Crescent and return area to public ownership/create public reserve. All or part of the property could be purchased. Funded by State Government or jointly with Council at market value • Property currently has application in place for seawall protection with NSW Coastal Panel which would negate the need for purchase	• Would remove the risk to the existing house and property • Opportunity to improve local amenity by provision of additional community space	• Cost would be very high • Voluntary purchase may not be taken up by the property owners • Social and impact on property owner • Probably not required as property has enough available area to allow redevelopment landward of the hazard zone. • Loss of rate income	$2.0 million including loss of rate income	$2.1 million (estimated purchase price based on www.onthehouse.com.au) + loss of rate income	$720,000 ($1 million value of portion of property at risk, 2% chance of loss of existing house and portion of land at risk from erosion p.a. to 2050). Social and environmental benefit of returning land to open space for community use eg. parkland	0.34
	Voluntary purchase of portion of at risk property (O1.9)	Short – medium term	• Purchase of portion of 8 Berrima Crescent seaward of hazard zone, coupled with DCP to require development to be landward of coastal hazard zone. Resume at-risk portion of land with fair compensation to be negotiated with landowner. Future development on remainder of block to be located landward of the coastal hazard area and floor levels above inundation level as per DCP. Return resumed portion of land to public	• Would reduce the coastal hazard to the property • Would improve the recreational amenity of this location • Allows local landowner to retain usable plot of land	• Cost of purchase of land	$1 million	$1.05 million (estimate) including loss of 50% rate income	$720,000 ($1 million value of portion of property at risk, 2% chance of loss of existing house and portion of land at risk from erosion p.a. to 2050). Social and environmental benefit of returning land to open space for community use eg. parkland or	0.69

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
			space e.g. parkland, carparking, beach dune • Property currently has application in place for seawall protection with NSW Coastal Panel which would negate the need for purchase					restore dune.	
	Development controls on redevelopment of properties within hazard area (O1.10)	Short term	• As per existing Gosford DCP. Future development to be located landward of the coastal hazard area and floor levels above inundation level	• These requirements are already within the DCP i.e. no change to status quo • Would reduce the coastal hazard risk to the property in the longer term	• None when compared with existing requirements • Coastal risk to property remains until property is redeveloped.	N/A	None	$720,000 ($1 million value of portion of property at risk, 2% chance of loss of existing house and portion of land at risk from erosion p.a. to 2050).	"No regrets" option
	Construct "tripper" structure to control opening location of creek (O1.11)	Short term	• Construct a short buried training wall using reno mattresses to prevent creek from meandering in front of properties at southern end of beach	• Relatively low cost measure with minimal aesthetic impact as would be buried most of the time • Minimal ecological impact to the creek as would allow macrophytes to grow in the creek entrance and allow creek to close at times of low flow • Would prevent erosion caused by creek flow in front of the residences, by controlling location of the creek opening and reducing the need for mechanical intervention at the entrance	• Buried reno mattress may become a danger to beachgoers if damaged due to exposed wire and rock	$100,000 to $150,000	$110,000 - $170,000	$200,000 approx. (probability decrease of loss of houses to erosion)	1.2 – 1.8
Coastal inundation of lots south of Ettalong Creek entrance	Development controls for residences to be above inundation levels on redevelopment of properties (O1.12)	Short term	• Can be added to or based upon existing DCP	• These requirements are already within the DCP i.e. no change to status quo	• None when compared with existing requirements	N/A	N/A	N/A	"No regrets" option already implemented
Immediate and future risk of	Monitor existing erosion protection works in front of Ocean Beach surf	Short term and following storms as	• Monitor effectiveness of existing works in a future	• No capital outlay • Would provide information on the	• None	N/A	N/A	N/A	"No regrets"

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
erosion to dunes, Ettalong Point and surf club carpark; Windblown dune erosion	club (O2.1)	required	storm or flood event	effectiveness and impact of the existing works					option
	Repair of beach accessways and revegetation of dune following erosion in a large storm event (O2.2)	Short term and following storms as required	• Undertake dune management as per standard dune management practice in accordance with the Coastal Dune Management Manual (DLWC 2001). Remove weeds and install native vegetation. Provide support to local Dunecare groups and local residents to maintain dune as required and repair after a storm • Consider consolidation of beach accessways along Umina Beach	• Would improve public safety and assist natural recovery of dune following a storm event • Would reduce losses of sand due to wind erosion • Social benefit of community participation in bush regeneration	• None	$200,000 to $500,000	N/A	N/A	"No regrets" option to be implemented as required.
	Beach scraping following storm event to build dune crest level and revegetation (O2.3)	After storm events as required	• Push sand from the beach berm to the toe of the dune escarpment	• Would assist the natural post-storm recovery of the beach • Would improve public safety on the beach by reducing likelihood of embankment collapse	• Environmental assessment would be required; • Cost of environmental assessment and planning activities. • Disruption to beach users during works. • Effectiveness not yet well established for this beach	$130,000 to $160,000	$700,000	$200,000 approx. (probability decrease of loss of houses to erosion)	0.3 approx.
Scour due to stormwater outlet at Ocean Beach Surf Club	Investigate installation of stormwater energy dissipation to reduce discharge velocities at outlet (O2.4)	Short term (0 – 5 years)	• Dissipate energy in front of stormwater outlet by installing energy dissipation blocks, rock apron, or by other method to reduce velocity of outflows from stormwater outlet	• Would reduce scour on the beach berm from stormwater discharge • Would improve public safety during rainfall events • Would allow buildup of dune in this location which would enhance the sand buffer in front of the surf club carpark	• Needs to be designed well to not exacerbate flooding in the upstream catchment area • Cost to design, construct and maintain. • May be limited technical scope to improve existing scour potential.	$50,000	N/A	N/A	"No regrets" option to investigate technical feasibility.

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
	Post storm beach scraping to assist natural recovery of the dune and repair scour caused by stormwater discharge (O2.5)	As required	• Undertake beach scraping to repair the scour hole caused by stormwater discharge in the area in front of the surf club	• Would improve public safety and beach amenity following rainfall events • Would enhance the sand buffer in front of the surf club carpark.	• Cost of environmental assessment • Disruption to beach users during works	$10,000 to $20,000	$130,000	Intangible benefit of improved beach amenity and public safety..	Not known
All issues	Emergency Management (O2.6)	As required	• Undertake pre, during and post storm actions as described in Section 7.8 when trigger for action is reached	• Public safety	• N/A	N/A	N/A	N/A	"No regrets" option

8.7 Putty-Killcare

8.7.1 Issues and Options

The major coastal hazards identified at Putty-Killcare Beach are:

- **Coastal inundation** due to wave runup affecting the Surf Club at the southern end of the beach;
- **Coastal erosion** having the potential to impact on the Surf Club at the southern end of the beach, and future erosion affecting public infrastructure including services, the campground and carparks as well as the revegetated dune within Putty-Killcare Beach reserve; and
- **Scour associated with stormwater drainage** at Killcare Beach Surf Club.

The main management issues identified at Putty-Killcare Beach are illustrated in Figure 59.

The consequences of these coastal hazards being realised include:

- Present day potential for overfloor inundation of the Surf Club by wave runup, causing damage to the existing building and services supplying the building;
- Scour of the beach in front of the stormwater structure at the surf club exacerbating the erosion at this location in a large storm.

Putty-Killcare Beach has retained a largely natural setting, with virtually no urban development along the frontal dune area, except for the Surf Club. The Putty-Killcare Beach nature reserve was created following sandmining in the 1970's.

Potential management actions that are relevant in addressing the identified coastal hazards for Putty-Killcare Beach include:

- **Redevelopment of the Surf Club on deep piled foundations** to ensure that the building would be unlikely to be damaged by coastal erosion in a future storm (i.e. founded into the local stable foundation zone and located with a floor level 0.5m above the maximum wave runup level, allowing for future sea level rise);
- **Future Relocation** of the surf club landward of the hazard area (there is land available adjacent to the existing main carpark area that may be a feasible site for relocation of the Surf Club);
- **Erosion protection works** to protect the surf club and carpark at the southern end of the beach;
- Undertake periodic beach nourishment to provide a buffer against erosion at the southern end of the beach;

- Improve **maintenance of dune vegetation**, planting and fencing along the stretch of beach fronting the Surf Club;
- Improve stormwater management at the outlet at Killcare SLSC to reduce scour due to stormwater runoff;
- **Relocation of infrastructure** subject to potential damage due to coastal erosion e.g. services, amenities, carparking;
- **Maintenance of the dune crest** in front of the surf club above the level of wave runup to prevent wave runup reaching the surf club building.

A suite of 13 specific management options have been developed to address the coastal hazards identified at Putty-Killcare Beach for consideration. The options address coastal management concerns at the southern end of the beach. Each option has been provided with an identifier (K1 to K13) as illustrated in Table 22. A more detailed summary of these main options for coastal zone management including advantages and disadvantages, timeframe for adoption and indicative costs is provided in Table 23.

8.7.2 Landuse and Development

At Putty-Killcare Beach, the most recent coastal hazard assessment indicates that there is only one private lot at the southern end of the beach subject to reduced foundation capacity hazard by 2100. In addition to this lot, the Surf Club and adjacent carpark has been assessed as being at risk of erosion in the immediate timeframe.

Potential strategies to deal with the erosion hazard risk in this area include:

- Modifying the existing DCP to allow development landward of the *2100 Zone of Slope Adjustment* with piled foundations into the *2100 Stable Foundation Zone*.
- Terminal protection works fronting the carpark and surf club which could also provide benefit to the single property at risk of reduced foundation capacity by 2100;
- Re-location of the surf club to an area outside the erosion hazard zone.

It is considered that the surf club and adjacent carpark is the property most at risk in this area and that any long term strategy to deal with the coastal hazard in this area needs to consider the surf club. Requiring piled foundations for development into the *2100 Stable Foundation Zone* is considered to be feasible and would not restrict the development potential of the lot affected.

Should terminal protection be the preferred strategy along the surf club frontage, funding for construction and maintenance could be provided by the Surf Club with commissioning of the design and construction undertaken through funding from the NSW Coastal Management Program and part funding from Council.

Table 22 – Management Options for Putty-Killcare Beach

Issue/Hazard	Management Option
Immediate risk of erosion and inundation damage to surf club and carpark	Erosion Protection works at surf club (K1)
	Repair damage to surf club carpark should storm erosion occur (K2)
	Beach nourishment in front of surf club (K3)
	Beach scraping to build vegetated dune in front of surf club (K4)
	Future relocation of surf club and associated infrastructure to an area landward of the coastal hazard area (K5)
	Build a dune in front of surf club above the wave runup level with vegetation and/or fencing (K6)
	Redevelop surf club on deep piled foundations and geotechnical investigation of surf club area (K7)
	Maintain status quo (K8)
Future risk of erosion damage to main carpark	Move carpark landward in future (K9)
Stormwater erosion hazard	Improve stormwater outlet by installing energy dissipation to minimise scour and prevent sand ingress into outlet (K10)
Future erosion damage to Putty Beach camping area	Future relocation of camping area infrastructure landward of coastal erosion hazard zone (K11)
All issues	Emergency Management (K12)
	Monitor beach for erosion in front of surf club and camping area (K13)

1. Embankment in front of surf club, 3 April 2014

2. Stormwater outlet at surf club, 3 April 2014

3. Rock boulders within embankment in front of surf club, 3 April 2014

4. Stormwater outlet at surf club, 30 April 2011

5. Windblown dunes and small creek entrance, Putty Beach, 30 April 2011

Figure 59 – Putty-Killcare Beach – Coastal Management Issues

Table 23 - Management Options Description for Putty-Killcare Beach

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
Immediate risk of erosion and inundation damage to surf club and carpark	Erosion Protection works at surf club (K1)	Short to medium term (0 – 20 years)	• Works may comprise engineered revetment placed along existing embankment on seaward side of surf club	• Would provide protection for the surf club and carpark in a design storm. • Works would not adversely affect existing beach amenity if well designed. • Benefit is individual value of properties protected	• Cost to design, construct and maintain works • Potential for increased erosion impacts after a large storm in front of and on either side of the works due to wave reflections	$0.7 to $1.0 million	$1.36 million ($1 million design/construction cost plus 1% maintenance p.a. to 2050)	$1.44 million ($2 million value of portion of property at risk, 2% chance of loss of existing building and carpark at risk from erosion p.a. to 2050)	1.06
	Repair damage to surf club carpark should storm erosion occur (K2)	As required	• Restore carpark using damage resistant pavement should it be damaged in a future storm event	• No initial capital outlay • Use of damage resistant pavement would reduce future maintenance costs	• Risk of damage to carpark and surf club remains, although there is existing rock remaining from previous storms • Cost of repair	$65,000 to $130,000	$34,000 (assumes 2% risk p.a. of damage to carpark to 2050)	$34,000 (assumes 2% p.a. reduced maintenance cost due to damage resistant pavement)	1.0
	Beach nourishment in front of surf club (K3)	Short to medium term (0 – 20 years)	• Import of sand into this portion of the beach to increase buffer against beach erosion	• Would provide buffer against storm erosion demand to help protect surf club	• Suitable source of sand has not been identified, possibly from mobile dunes further north along the beach. Extensive studies required to identify source of sand and undertake environmental assessment • Nourishment works would likely not remain on the beach at this location	$0.7 to $1.0 million	$1.6 – 2.3 million (assumes nourishment required every 10 years)	$140,000 (based on reduced risk of damage to surf club)	<0.1
	Beach scraping to build vegetated dune in front of surf club (K4)	Short term (0-5 years)	• Scrape sand to build a dune in front of the surf club and vegetate as per standard dune management practice in accordance with the Coastal Dune Management Manual	• Would improve protection of the surf club and carpark against storm erosion and inundation by providing a buffer of sand • Would be aesthetically pleasing and would not detract from the beach amenity	• Not likely to provide sufficient protection against future storm event • Dune would be damaged by future storm events and would require maintenance • Cost of environmental assessment and planning activities. • Disruption to beach users during works.	$5,000 to $8,000	$70,000 - $110,000 (assumes required annually)	$70,000 (based on reduced risk of damage to surf club)	0.7 – 1.0

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
			(DLWC 2001).						
	Future relocation of surf club and associated infrastructure to an area landward of the coastal hazard area (K5)	Short to medium term (0 – 20 years)	• Relocate surf club to an area outside the erosion hazard zone e.g. adjacent to the main carpark • Offer to purchase surf club and provide new site, funded by State Government or jointly with Council at market value	• Would remove the immediate erosion risk to the surf club • Opportunity to improve local amenity by provision of additional community space • Land swap deal may be cost-neutral	• Cost to reconstruct surf club on piled foundations and potential cost to purchase land for placement of new surf club • Possible loss of carparking spaces	$1.5 to $2.0 million	$1 million (estimated cost to reconstruct surf club building on alternative site not including land purchase costs)	$1.44 million ($2 million value of portion of property at risk, 2% chance of loss of existing building and carpark at risk from erosion p.a. to 2050)	1.44
	Build a dune in front of surf club above the wave runup level with vegetation and/or fencing (K6)	Short term (0-5 years)	• Build up sand from the beach berm into a dune and vegetate as per standard dune management practice in accordance with the Coastal Dune Management Manual (DLWC 2001). Remove weeds and install native vegetation. Provide support to local Dunecare groups and local residents to maintain dune as required and repair after a storm	• Would improve protection of the surf club and carpark against storm erosion and inundation by providing a buffer of sand • Would be aesthetically pleasing and would not detract from the beach amenity	• Not likely to provide sufficient protection against future storm event • Dune would be damaged by future storm events and would require maintenance	$80,000 to $100,000	$180,000 - $230,000 (assumes required every 10 years)	$140,000 (based on reduced risk of damage to surf club)	0.6 – 0.8
	Redevelop surf club on deep piled foundations and undertake geotechnical investigation of surf club area (K7)	Long term (>20 years)	• On future redevelopment of surf club, reconstruct on deep piled foundations. Existing surf club foundations comprise of piles grout injected socketed into underlying bedrock.	• Would remove the risk of erosion damage to the surf club • Surf club can stay in its existing location	• Cost of reconstruction • Temporary loss of facility while reconstruction taking place	$1.0 million	$1.054 million (estimated cost to reconstruct surf club building and 1% p.a. risk that existing carpark would	$1.44 million ($2 million value of portion of property at risk, 2% chance of loss of existing building and	1.37

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
							need to be repaired due to storm damage)	carpark at risk from erosion p.a. to 2050)	
	Maintain status quo (K8)	Ongoing	• Surf club and carpark remain at existing location; emergency action to protect against storm erosion; undertake structural assessment of surf club building	• No capital outlay • Understanding structural risk to surf club may negate the need for expensive works	• Risk to surf club and carpark remains	N/A	$720,000 ($2 million value of portion of property at risk, 1% chance of loss of existing building and carpark at risk from erosion p.a. to 2050)	None	Very Low
Future risk of erosion damage to main carpark	Move carpark landward in future (K9)	Long term (>20 years)	• Move carpark landward as erosion threat increases in future	• No need for any action at present as carpark is outside the existing erosion hazard area	• Future potential for loss of carparking spaces	$150,000 to $200,000	$150,000 to $200,000	$70,000 (based on reduced risk of damage to carpark)	0.35 – 0.5
Stormwater erosion hazard	Improve stormwater outlet by installing energy dissipation to minimise scour and prevent sand ingress into outlet (K10)	Short term	• Install energy dissipation e.g. rocks at outlet to reduce scour caused by stormwater flow	• Would reduce scour on beach and potentially improve efficiency of stormwater outlet	• Needs to be designed well to not exacerbate flooding in the upstream catchment area • Cost to design, construct and maintain. • May be limited technical scope to improve existing scour potential.	$50,000	N/A	Intangible benefit of improved beach amenity and public safety	Not known
Future erosion damage to Putty Beach camping area	Future relocation of camping area infrastructure to an area landward of the coastal hazard area (K11)	Long term >20 years	• Relocate amenities and other camping area infrastructure to an area outside the erosion hazard	• Would remove the immediate erosion risk to the camping area infrastructure	• Future loss of amenity due to ongoing erosion	$50,000 - $70,000	$16,000 if done in 20 years time	Continued use of camping area	Not known
All issues	Emergency Management (K12)	As required	• Undertake pre, during and post storm actions as described in Section 7.8 when trigger for action is reached	• Public safety	• N/A	N/A	N/A	N/A	"No regrets" option

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
	Monitor beach for erosion in front of surf club and camping area (K13)	Short term, ongoing	• Undertake monitoring of the beach to establish erosion risk to surf club and camping infrastructure	• Public safety • Would provide early warning of actions required to protect surf club or caming infrastructure	• None	N/A	N/A	N/A	"No regrets" option to be implemented

8.8 MacMasters-Copacabana Beach

8.8.1 Issues and Options

The major coastal hazards identified at McMasters Beach are:

- **Coastal inundation** due to wave runup affecting the McMasters Beach Surf Club at the southern end of the beach and properties fronting the lagoon entrance;
- **Coastal erosion** having the potential to impact on the Surf Club at the southern end of the beach, as well as the carpark along Marine Parade, seaward portion of properties along Tudibaring Parade and future erosion affecting Copacabana Surf Club, Del Monte Place and properties along Del Monte Place;
- **Slope Instability** having the potential to result in future reduced foundation capacity for several lots along Marine Parade, Tudibaring Parade and Del Monte Place;
- **Estuary Entrance Instability** associated with the entrance to Cockrone Lagoon;
- **Scour associated with stormwater drainage** at Copacabana and MacMasters Beach Surf Club.

The consequences of these coastal hazards being realised include:

- Present day potential for overfloor inundation of MacMasters Beach surf club by wave runup, causing damage;
- Present day threat of erosion damage to MacMasters Beach Surf Club and parts of Marine Parade identified as being within the Present Day *Zone of Slope Adjustment*;
- Present day threat of erosion damage to fencing, private gardens and minor structures on the seaward side of Tudibaring Parade;
- Future loss of access to surf club and properties along Marine Parade due to erosion damage to Marine Parade;
- Future threat of erosion damage to dwellings along the seaward side of Tudibaring Parade and Del Monte Place;
- Future loss of access to properties due to erosion damage to Del Monte Place;
- Reduced foundation capacity to dwellings on seaward side of Tudibaring Parade and future risk of reduced foundation capacity for dwellings on Marine Parade;
- Damage to services including water supply and sewerage infrastructure caused by future erosion;
- Loss of sand from the beach due to wind erosion caused by lack of vegetation on the beach dunes;

- Increased threat of erosion and inundation of properties near the lagoon entrance with sea level rise due to climate change and depending on the stability of the entrance, unauthorised lagoon openings, and entrance management regime adopted.

MacMasters Beach has been divided into a number of precincts moving from south to north, considering particular characteristics within each precinct, namely:

- **Precinct 1** – Southern end of the beach between MacMasters Surf Club and the bluff;
- **Precinct 2** – Between the bluff and entrance to Cockrone Lagoon;
- **Precinct 3** – North from Cockrone Lagoon outlet (Copacabana).

Potential management actions that are relevant in addressing the identified coastal hazards for MacMasters Beach include:

- **Development controls** to ensure new developments within the coastal hazard areas are unlikely to be damaged within a chosen planning period by coastal erosion and inundation (i.e. founded into the local 2050 or 2100 stable foundation zone and located with a floor level 0.5m above the maximum wave runup level, allowing for future sea level rise);

- **Relocation** of existing buildings landward following re-development (e.g. the surf clubs, residences);

- Undertake or allow residents to undertake **erosion protection works** to protect the residences on the seaward side of Tudibaring Parade, carpark at Marine Parade, surf clubs, Del Monte Place and water and sewage infrastructure;

- Undertake post-storm **beach scraping** at the foreshore adjacent to the stormwater outlets to repair scour that has occurred following large storm events and reduce landward penetration of storm waves;

- Undertake beach nourishment to provide a buffer against erosion and improve beach amenity in the long term;

- Update the entrance management guidelines for Cockrone Lagoon Entrance in accordance with the updated Gosford Lagoons Coastal Zone Management Study and Plan, to help manage the lagoon entrance frontage erosion threat;

- Improve **maintenance of dune vegetation**, planting and fencing along length of beach, in areas under both private and public control;

- Improve stormwater management at the outlets adjacent to Copacabana Surf Club and MacMasters Beach Surf Club to prevent/reduce erosion caused by scour due to stormwater runoff;

- Undertake geotechnical investigations of the southern end of MacMasters Beach presumed to be underlain by bluff material, and the northern end of Copacabana Beach to determine the extent of reduced foundation capacity affecting properties landward of Marine Parade and Del Monte Place;

- **Relocation of infrastructure** subject to potential damage due to coastal erosion e.g. services, amenities, carparking.

The major coastal management issues identified at MacMasters/Copacabana Beach are illustrated in Figure 60.

A suite of 39 specific management options have been developed to address the coastal hazards identified at each of the three precincts in Copacabana/Macmasters Beach for consideration. Each option has been provided with an identifier (M1.1 to M3.15) as illustrated in Table 24. A more detailed summary of these main options for coastal zone management including advantages and disadvantages, timeframe for adoption and indicative costs is provided in Table 25.

Further to the management options below, Copacabana and MacMasters Beach has been named as an "Authorised Location" for placement of temporary protection works in the Code of Practice under the *Coastal Protection Act 1979* (OEH 2013). Under the Code of Practice, landowners may place temporary protection works comprising either:

- sand filled geotextile containers each of maximum 0.75m^3 filled volume stacked in a single layer up to 1.5m high (at a slope flatter than 34° from the horizontal, that is flatter than 1:1.5 vertical:horizontal); or,
- clean sand placed up to the crest on the seaward side of an eroding escarpment (under the Code of Practice, this is not permitted to be sourced from the beach on which the works are to be placed).

It is emphasised that landowners must act well (generally months) in advance of a storm to consider implementing these works. It should also be noted that landowners are not permitted to install coastal protective works without following the procedures outlined in the Code of Practice (OEH 2013), and severe penalties may apply if they are not followed.

8.8.2 Landuse and Development

At MacMasters/Copacabana Beach, building is not currently permitted seaward of the 2045 erosion line except under special circumstances as discussed in the Gosford DCP (refer Section 3.1 of this report). Management options to address landuse and development issues at this beach are discussed below.

8.8.2.1 Southern End of MacMasters Beach

The most recent coastal hazard assessment has identified that there are 14 lots and 8 dwellings on Marine Parade at the southern end of the beach which are largely seaward of the 2100 *Zone of Slope Adjustment.* Note that the previous coastline Hazard Lines for the study area did not make any allowance for reduced foundation capacity as required now by the Guidelines for Preparing Coastal Zone Management Plans (Office of Environment and Heritage 2013).

Landward movement of buildings within these lots is not feasible. However, most of these lots and all the buildings (except for the surf club) are landward of the 2050 *Zone of Slope Adjustment.* During the site visit, hard pan material was observed along this area and the erosion hazard may be overstated, given that the hazard assessment has assumed that the underlying material is unconsolidated sand.

Access to these properties is via Marine Parade, which is itself partially within the *Present Day Zone of Slope Adjustment*. Should the roadway be damaged by coastal erosion, access to the properties along the landward side of Marine Parade as well as the Surf Club would be lost, and alternative access would be difficult to provide. Loss of access to the properties presents a major risk for this area, even if the properties themselves are not at direct risk from coastal erosion.

Realistic management options for this area therefore include:

- Refine the coastal hazard assessment for the Marine Parade area by undertaking geotechnical investigations to ascertain the risk to the roadway;
- Undertake geotechnical investigations to refine the risk of reduced foundation capacity for the properties on the landward side of Marine Parade;
- Investigate the feasibility of provision of alternative access to the properties on the landward side of Marine Parade i.e. via MacMasters Parade;
- Investigate the provision of terminal protection works for the Surf Club and Marine Parade;
- Planned retreat from this area, including the voluntary purchase/relocation of the surf club, properties that would lose their access should Marine Parade be damaged by future erosion and closure of Marine Parade. The most recent sales data for these lots (www.onthehouse.com.au) indicate property values of approximately $1 million for each of these lots.

8.8.2.2 Tudibaring Parade Area

On the seaward side of Tudibaring Parade, there are 14 lots and dwellings with a portion seaward of the *2100 Zone of Slope Adjustment*. Six of these lots have been subdivided, which has exposed the seaward portion of the lots to coastal erosion hazard. For these lots, landward relocation of development is not feasible and re-development of some of these lots, even landward of the 2050 *Zone of Slope Adjustment*, is problematic due to the lack of available area for development within these lots. For eight of the lots, it would be feasible to require redevelopment to be landward of the 2050 *Zone of Slope Adjustment*, with foundations piled into the *2100 Stable Foundation Zone*.

Options for the coastal management of this area therefore include:

- Not allowing further subdivisions to occur in the lots along this coastal frontage;
- Applying the provisions of the Gosford DCP to this area to require redevelopment to be landward of the *2050 Zone of Slope Adjustment*, with foundations piled into the *2100 Stable Foundation Zone*;

- Voluntary purchase of the six subdivided lots where redevelopment landward of the *2050 Zone of Slope Adjustment* line is not feasible. Market value for these properties is expected to be around $3 million each based on data provided by www.onthehouse.com.au;
- Provision of terminal protection for this area to be implemented at such time that the erosion escarpment reaches a set trigger distance from the seaward edge of the properties.

It should be noted that there are no public assets at risk in this area, and that any terminal protection in this area would benefit the property owners directly. To prevent ad-hoc protection works being constructed at individual properties, a terminal protection scheme would need to be agreed to by all the property owners in the precinct. Such a scheme would need to be subject to a detailed design and environmental assessment. Consent for such a structure would be contingent on the structure meeting the requirements in Section 55M of the *Coastal Protection Act 1979*. Funding could be provided by local property owners through a contribution payment toward the construction costs, with commissioning of the design and construction undertaken through funding from the NSW Coastal Management Program and part funding from Council. Maintenance would then be the responsibility of the local landowners, which could be undertaken by Council but funded by the residents.

8.8.2.3 Copacabana Beach

The most recent coastal hazard assessment has identified the following:

- Ten lots at the northern end of the beach where the 2100 *Zone of Slope Adjustment* extends into the lot;
- A further 11 lots south of the Surf Club where the 2100 *Zone of Slope Adjustment* extends into the lot;
- Two lots which extend partially into the 2050 *Zone of Slope Adjustment*;
- Parts of Del Monte Place which extend into the 2050 *Zone of Slope Adjustment*.

It is considered that the existing DCP can be feasibly modified in this area to allow re-development landward of the 2050 *Zone of Slope Adjustment*, with deep piled foundations into the 2100 *Stable Foundation Zone.*

In the longer term, once Del Monte Place becomes at risk from coastal erosion, terminal protection could be provided or the roadway narrowed to accommodate future erosion as part of a long-term retreat strategy. Alternative access to the local shops and properties could be planned for once the erosion hazard increases, which may be required by 2050. In the short-term, localised works can be carried out at the stormwater outlet in the area north of the Copacabana Surf Club to prevent undermining of the dune caused by the northward meandering of the stormwater outlet in this area and thus reduce the erosion hazard.

Voluntary purchase could be offered in the future for the three properties at 235 – 239 Del Monte Place once the coastal erosion risk becomes too high to allow re-development to be feasible, although this is not expected to occur prior to 2050.

It is noted that a Cliff line Hazard Definition Study was conducted for Tudibaring Headland (Shirley Consulting Engineers, 1996). That study considered that all the existing lots adjoining the headland are suitable for residential building purposes, provided that suitable building restrictions are implemented.

1. Rock protection installed at base of Norfolk Pine tree, south end of beach, 5 October 2010

2. Ad-hoc erosion protection and embankment erosion along beachfront at MacMasters Beach Surf Club, 5 October 2010

3. Scour at stormwater drain and weed growth over embankment, Marine Parade MacMasters Beach, 3 April 2014

4. Dune and development on seaward side of Tudibaring Parade, 5 October 2010

5. Erosion along northern bank of Cockrone Lagoon entrance, 5 October 2010

6. Windblown dune near northern end of Cockrone Lagoon entrance, 5 October 2010

7. Scour at stormwater drain and creek entrance, near Copacabana surf club, 5 October 2010

8. Scour at stormwater drain and creek entrance, near Copacabana surf club, 3 April 2014

Figure 60 – Main issues identified at MacMasters/Copacabana Beach

Table 24 – Coastline Management Options for MacMasters/Copacabana Beach

Precinct	Management Issue	Management Option
Precinct 1 – Southern end of the beach between MacMasters Surf Club and the bluff	Immediate and future risk of erosion and reduced foundation capacity to surf club and Marine Parade	Erosion Protection works for MacMasters Beach Surf Club (M1.1)
		Monitor performance of existing erosion works around base of Norfolk Island Pine trees and at surf club at southern end of beach (M1.2)
		Erosion protection works for Marine Parade (M1.3)
		Improve stormwater outlet (M1.4)
		Beach nourishment in front of surf club and Marine Parade (M1.5)
		Beach scraping to build dune in front of Surf Club, eroded pine tree roots and Marine Parade (M1.6)
		Dune vegetation management at southern end of beach (M1.7)
		Undertake geotechnical investigation of area behind Marine Parade (M1.8)
		Future relocation of surf club landward on redevelopment (M1.9)
		Development controls for residences to be on piled foundations on redevelopment of properties within 2050 or 2100 hazard area (M1.10)
		Landward relocation of sewer infrastructure along Marine Parade (M1.11)
		Repair damage to Marine Parade should it be damaged by future erosion (M1.12)
		Long term narrowing, removal and relocation or provision of alternative access for Marine Parade (M1.13)
		Planned retreat from this area, including the voluntary purchase/relocation of the surf club, properties that would lose their access should Marine Parade be damaged by future erosion and closure of Marine Parade (M1.14)
		Do nothing (M1.15)
	Scour due to stormwater outflow	Improve stormwater outlet to reduce scour (M1.16)
		Periodic beach scraping to repair damage caused by scour from stormwater outlet (M1.17)
	Dune vegetation management/beach amenity	Beach scraping to create dune in front of Marine Parade and Surf Club; remove weeds and encourage maintenance by Dunecare groups (M1.18)
		Improve pedestrian access onto beach from carpark (M1.19)
Precinct 2 – Between the bluff and entrance to Cockrone Lagoon	Immediate and future risk of erosion and reduced foundation capacity to properties along seaward side of Tudibaring Parade	Development controls for residences on Tudibaring Parade to be on piled foundations on redevelopment of properties within 2050 or 2100 hazard area (M2.1)
		Not allowing further subdivision of properties on seaward side of Tudibaring Parade (M2.2)
		Future voluntary purchase of properties offered when erosion scarp reaches set trigger distance from buildings (M2.3)
		Terminal protection structure for properties along seaward side of Tudibaring Parade (M2.4)
		Beach nourishment to increase erosion buffer in this area (M2.5)
		Encourage and assist Dunecare group and local residents to maintain and revegetate dune after a storm through provision of free plants and public education material (M2.6)
	Risk of erosion due to lagoon entrance instability	Seaward extension of existing training wall along southern side of entrance (M2.7)
		Undertake review of entrance management procedure as recommended by Gosford Coastal Lagoons CZMP. Implement management actions as required (M2.8)

Precinct	Management Issue	Management Option
Precinct 3 – North from Cockrone Lagoon outlet (Copacabana)	Windblown erosion of dune	Encourage and assist Dunecare group and local residents to maintain and revegetate dune after a storm through provision of free plants and public education material (M3.1)
	Risk of future erosion damage to Del Monte Place, services/utilities and Copacabana surf club	Erosion Protection works for Copacabana Beach Surf Club (M3.2)
		Erosion protection works for Del Monte Place to be installed once erosion escarpment reaches set trigger distance from edge of road (M3.3)
		Landward relocation of sewer and water infrastructure along Del Monte Place (M3.4)
		Beach nourishment in front of surf club and Del Monte Place (M3.5)
		Repair damage to Del Monte Place should it be damaged by future erosion (M3.6)
		Long term narrowing, removal and relocation or provision of alternative access for Del Monte Place (M3.7)
		Future relocation of surf club landward on redevelopment (M3.8)
		Voluntary purchase of properties affected by coastal hazards (M3.9)
		Development controls for residences and commercial premises to be on piled foundations on redevelopment of properties within 2050 or 2100 hazard area (M3.10)
		Geotechnical investigation around surf club area to confirm level of bedrock and reduced foundation capacity hazard (M3.11)
	Scour and water quality issues due to stormwater management near Copacabana surf club	Improve energy dissipation at stormwater outlet (M3.12)
		Construct “training” or “tripper” control structure to prevent stormwater outlet from scouring base of dune along Del Monte Place (M3.13)
	Dune vegetation management	Dune vegetation management to remove weeds and encourage dune growth (M3.14)
All precincts	All issues	Emergency Management (M3.15)

Table 25 – Coastline Management Options Description for Copacabana/MacMasters Beach

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
Immediate and future risk of erosion and reduced foundation capacity to surf club and Marine Parade	Erosion Protection works for MacMasters Beach Surf Club (M1.1)	Short term (0 – 5 years)	• Works may comprise engineered rock revetment works constructed along face of existing embankment in front of surf club	• Would provide protection for the surf club in a design storm. • Would prevent undermining of the large Norfolk Island Pine trees due to erosion. • Works would not adversely affect beach amenity if well designed. • Works would not increase erosion impacts in front of and on either side when compared with the existing situation, as surf club already fronted by dumped rock and hard-pan material in the embankment.	• Cost to design, construct and maintain works	$0.7 to $1.0 million	$1.36 million ($1 million design and construction plus 1 maintenance p.a. to 2050)	$720,000 ($2 million value of portion of property at risk, 1% chance of loss of existing building and carpark at risk from erosion p.a. to 2050)	0.53
	Monitor performance of existing erosion works around base of Norfolk Island Pine trees and at surf club at southern end of beach (M1.2)	Ongoing	• Monitor effectiveness of existing works in a future storm event	• No capital outlay • Would provide information on the effectiveness of the works in preventing undermining of the Norfolk Island Pine trees in a large storm	• None	N/A	N/A	N/A	"No regrets" option to be implemented
	Erosion protection works for Marine Parade (M1.3)	Short term (0 – 5 years)	• Works may comprise engineered rock revetment works constructed along face of existing embankment at Marine Parade and could be a continuation of a revetment provided at the Surf Club. Could be implemented as an emergency or temporary measure.	• Would provide protection against storm erosion damage to the sewer line, carparking and roadway of Marine Parade • Works would not adversely affect amenity if well designed, and may offer the opportunity to improve pedestrian beach access.	• Cost to design, construct and maintain works • Would require the removal of mature Banksia trees and other coastal dune vegetation.	$2.0 to $3.0 million	$4.08 million ($3 million design and construct cost plus 1% p.a. maintenance to 2050)	$745,000 ($2 million value of portion of surf club building at risk, 1% chance of loss of existing building and cost of repair of Marine Parade roadway should it be damaged in a storm event)	0.18
	Improve stormwater outlet (M1.4)	Short term (0 – 5 years)	• Two stormwater outlets – one at Marine Parade Carpark and one draining the reserve at the corner of Marine Parade and Gerda Road – provide energy dissipation to	• Would reduce the effect of scour on the beach caused by flows from the stormwater outlets. • Potential to improve stormwater water quality.	• Needs to be designed well to not exacerbate flooding in the upstream catchment area • Cost to design, construct and maintain. • May be limited technical scope to improve existing scour potential.	$50,000 - $100,000	$50,000 - $100,000	$75,000 (assumes 10% reduction in probability of erosion damage to	1.0

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
			reduce impact of scour on beach					Marine Parade, damage to surf club and loss of access to Marine Parade properties.) Improved beach amenity and public safety – not possible to quantify	
	Beach nourishment in front of surf club and Marine Parade (M1.5)	Medium term (5 – 20 years)	• Source sand for beach nourishment and place on the beach to build up dune and create buffer against storm erosion	• Would allow protection of the sewer, trees, Marine Parade and surf club against storm erosion by providing a buffer of sand against storm erosion • Embayment is largely closed to longshore sediment transport and sand would likely stay within beach compartment – i.e. nourishment likely to be effective • Would be aesthetically pleasing and would not detract from the beach amenity • Feasibility studies and investigations on nourishment for this beach have already been carried out so costs and sand sources well understood.	• Considerable cost in sand extraction and placement • Nourishment would likely need to be repeated in the future	$1,600,000 to $2,000,000	$3.7 – 4.6 million (assume required every 10 years)	$700,000 (approx.) includes risk of damage to surf club, carpark and road and loss of access for properties	0.15 – 0.2
	Beach scraping to build dune in front of Surf Club, eroded pine tree roots and Marine Parade (M1.6)	After storm events as required	• Build up sand from the beach berm into a dune and vegetate as per standard dune management practice in accordance with the Coastal Dune Management Manual (DLWC 2001).	• Would provide some buffer of sand for the sewer, Marine Parade roadway and surf club against storm erosion • Would be aesthetically pleasing and would not detract from the beach amenity • Would assist the natural post-storm recovery of the beach	• May not be very effective due to limited sand supply • Environmental assessment required. • Cost of environmental assessment and planning activities. • Disruption to beach users during works.	$20,000 to $25,000	$280,000 - $350,000 (assumes required annually)	$350,000 (approx.) includes risk of damage to surf club, carpark and road and loss of access for properties	1.0
	Dune vegetation management at southern end of beach (M1.7)	Ongoing	• Provide support to local Dunecare groups to maintain dune as required, remove weeds	• Would improve existing beach amenity at this location • Social benefit of community participation in bush regeneration	• Insufficient availability of sand to enable viable dune vegetation to be established	$15,000 - $25,000 p.a.	N/A	N/A	"No regrets" option to be implemented

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
			and plant native dune vegetation						
	Undertake geotechnical investigation of area behind Marine Parade (M1.8)	Short term (0 – 5 years)	• Undertake geotechnical drilling to determine the nature of the material behind Marine Parade, to determine whether buildings landward of Marine Parade would be subject to reduced foundation capacity	• Would help determine foundation requirements for buildings landward of Marine Parade and what degree of erosion and reduced foundation capacity hazard, if any, this area is subject to • Would help determine the degree of risk to the roadway • Would inform future policy and development controls for this area of MacMasters Beach	• None	$30,000	N/A	N/A	"No regrets" option
	Future relocation of surf club landward on redevelopment (M1.9)	Medium term (5 – 20 years)	• Upon redevelopment of the surf club, move building further landward (i.e. as far landward as practicable) – potentially to the existing reserve on the landward side of Marine Parade	• Would reduce the erosion hazard to the building • Opportunity to return the area where the surf club is located to public open space, vegetate with native vegetation and improve local amenity.	• There is limited available scope to move the building landward within the existing lot as most of the lot is within the Immediate Zone of Slope Adjustment. • Moving the building into the reserve could lead to a loss of public space – also cost to purchase new site	$1.5 to $2.0 million	$1.5 to $2.0 million	$280,000 (assumed 2% risk of $1 million damage p.a.)	0.14 – 0.19
	Development controls for residences to be on piled foundations on redevelopment of properties within 2050 or 2100 hazard area (i.e. maintain status quo) (M1.10)	Short term (0 – 5 years)	• As per existing Gosford DCP. Geotechnical investigation could ascertain whether properties on the landward side of Marine Parade need development controls also. The clause that development not give rise to any increased hazard could be applied to prevent building re-development from being allowed to move seaward of the existing location	• Would not increase the coastal hazard risk compared with existing situation • Would be consistent with existing DCP. • Benefit is individual value of properties protected by being on piled foundations by 2050	• Additional properties may need to be added to the DCP which could affect development potential. • Risk would increase beyond 2050 • Does not address the risk of erosion to the road and temporary loss of access	N/A	$25,000 (assumes 1% risk p.a. of $70,000 damage to Marine Parade roadway)	$3 million (value of buildings within 2050 Zone of Reduced Foundation Capacity benefiting from being constructed on piled foundations)	120
	Landward relocation of sewer infrastructure along Marine Parade	Short term (0 – 5 years)	• Reconstruct sewer line on landward side of	• Would reduce the erosion risk to the sewer line	• May not be technically feasible	$100,000 to $200,000	$100,000 to $200,000	$180,000 - $200,000	0.9 – 2.0

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
	(M1.11)		Immediate Zone of Slope Adjustment line					(assumes 2% risk of damage p.a. plus implications of loss of sewer infrastructure)	
	Repair damage to Marine Parade should it be damaged by future erosion (M1.12)	As required	• Repair damage to the road using damage resistant pavements should it be impacted by erosion (i.e. accept existing risk) • Undertake repairs to the road as a post-storm emergency measure	• No initial cost outlay • No action required unless damage occurs • Use of damage-resistant pavement would reduce future maintenance costs	• Cost of road repair should it be required • Risk to public safety should design storm occur and road is damaged • Risk of temporary loss of access to properties and surf club, social and economic impact • Recurrent cost of repair should coastal erosion risk increase in the future	$150,000 to $200,000	$745,000 ($2 million value of portion of surf club building at risk, 1% chance of loss of existing building and cost of repair of Marine Parade roadway should it be damaged in a storm event)	$300,000 (estimated reduction in road maintenance costs using erosion resistant pavement)	0.40
	Long term narrowing, removal and relocation or provision of alternative access for Marine Parade (M1.13)	Medium to long term (> 5 years)	• Long term narrowing of Marine Parade to a single lane, relocation of servicers, followed by purchase of an alternative access easement at the rear of the properties for provision of access to properties along Marine Parade	• Risk of loss of road due to erosion is reduced over time	• Landowners would need to agree to purchase of access easement • Prohibitive cost • Technically difficult to implement due to steepness of terrain • Reduced ease of public access to beachfront and surf club over time	$200,000 to $250,000 not including purchase costs	$200,000 to $250,000 not including purchase costs	$3 million approx. (based on 2% risk p.a. of loss of access to homes and loss of land value of $1 million per lot)	12 - 15
	Planned retreat from this area, including the voluntary purchase/relocation of the surf club, properties that would lose their access should Marine Parade be damaged by future erosion and closure of Marine Parade. (M1.14)	Long term (> 20 years)	• Voluntary purchase to be offered for properties that may lose their access over time	• Would remove the risk to the surf club and in long term, need to repair road • Opportunity to improve local amenity by provision of additional community space	• Very high cost • Low take-up rate of voluntary purchase scheme • roadway will need to be maintained until all properties purchased • Social impact on community • Loss of rate income	$10 million (estimate) including loss of rate income	$10 million (estimate)	$745,000 ($2 million value of portion of surf club building at risk, 1% chance of loss of existing	0.07

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
								building and cost of repair of Marine Parade roadway should it be damaged in a storm event)	
	Do nothing (M1.15)	Short term	• Maintain status quo • Do not replace road access if lost to erosion	• No capital outlay • No intensification of development in coastal hazard area	• Loss of property value and development potential for beachfront blocks • Increase in coastal hazard risk over time for existing beachfront development • Loss of rate revenue • Loss of access to properties and property viability	N/A	$10 million (estimate) based on loss of access to properties and surf club	None	0.0
Scour due to stormwater outflow	Improve stormwater outlet to reduce scour (M1.16)	Short term (0 – 5 years)	• Two stormwater outlets – one at Marine Parade Carpark and one draining the reserve at the corner of Marine Parade and Gerda Road – provide energy dissipation to reduce impact of scour on beach	• Would reduce the effect of scour on the beach caused by flows from the stormwater outlets. • Potential to improve stormwater water quality.	• Needs to be designed well to not exacerbate flooding in the upstream catchment area • Cost to design, construct and maintain. • May be limited technical scope to improve existing scour potential.	$50,000 - $100,000	$50,000 - $100,000	$75,000 (assumes 10% reduction in probability of erosion damage to Marine Parade, damage to surf club and loss of access to Marine Parade properties.) Improved beach amenity and public safety – not possible to quantify	1.0
	Periodic beach scraping to repair damage caused by scour from stormwater outlet (M1.17)	After storm events as required	• Scrape sand from beach berm to repair areas scoured by stormwater outflow	• Would improve public safety and erosion risk by repairing scoured areas • Would be aesthetically pleasing and would not detract from the beach amenity • Would assist the natural post-storm recovery of the beach	• Would need to be repeated frequently • Difficult to deploy equipment during a storm • Cost of environmental assessment and planning activities. • Disruption to beach users during works.	$10,000 to $20,000	$50,000 - $100,000 if done every 2 years on average	$75,000 (assumes 10% reduction in probability of erosion damage to	1.0

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
								Marine Parade, damage to surf club and loss of access to Marine Parade properties.) Improved beach amenity and public safety – not possible to quantify	
Dune vegetation management/ beach amenity	Beach scraping to create dune in front of Marine Parade and Surf Club; remove weeds and encourage maintenance by Dunecare groups (M1.18)	Short term	• Build up sand from the beach berm into a dune and vegetate as per standard dune management practice in accordance with the Coastal Dune Management Manual (DLWC 2001).	• Would provide some buffer of sand for the sewer, Marine Parade roadway and surf club against storm erosion • Would be aesthetically pleasing and would not detract from the beach amenity • Would assist the natural post-storm recovery of the beach • Social benefit of community participation in bush regeneration	• May not be very effective due to limited sand supply • Environmental assessment required. • Cost of environmental assessment and planning activities. • Disruption to beach users during works.	$20,000 to $25,000	$280,000 - $350,000 (assumes required annually)	$350,000 (approx.) includes risk of damage to surf club, carpark and road and loss of access for properties	1.0
	Improve pedestrian access onto beach from carpark (M1.19)	Short term (0 – 5 years)	• Improve pedestrian access onto beach by constructing in accordance with relevant Australian Standard	• Would reduce scour caused by runoff onto beach • Would improve public safety and therefore beach amenity • Would provide improved access onto the beach • Potential to provide disabled access to beach	• Cost	$10,000 to $20,000	$10,000 - $20,000	Improved beach amenity, difficult to quantify	Not known
Immediate and future risk of erosion and reduced foundation capacity to properties along seaward side of Tudibaring	Development controls for residences on Tudibaring Parade to be on piled foundations on redevelopment of properties within 2050 or 2100 hazard area (M2.1)	Short term (0 – 5 years)	• As per existing Gosford DCP. The clause that development not give rise to any increased hazard could be applied to prevent building re-development from being allowed to move seaward of the existing location.	• Would be consistent with existing policy and Gosford DCP • Risk to properties would be reduced in the long term • Benefit is individual value of properties protected by being on piled foundations by 2050	• None when compared with existing situation • Risk would increase beyond 2050 • Six properties already subdivided have no redevelopment potential	N/A	$234,000 (assumes 1% risk p.a. of $50,000 damage to minor structures per property affected by immediate	$9 million (value of buildings within 2050 Zone of Reduced Foundation Capacity benefiting from being constructed on	38

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
Parade							coastal erosion hazard)	piled foundtaions)	
	Not allowing further subdivision of properties on seaward side of Tudibaring Parade (M2.2)	Short term	• Not allow further subdivision of properties on the seaward side of Tudibaring Parade as the seaward side of these lots is subject to unacceptable coastal risk	• Reduces potential to increase coastal hazard risk due to development intensification	• Opportunity cost of loss of subdivision land and associated income	N/A	None. Opportunity cost only of around $10 million divided amongst landowners of unsubdivided lots	$2.88 million (assumes 1% risk p.a. of $1,000,000 damage to properties affected by coastal erosion hazard) and prevention of loss of development potential for existing homes	N/A
	Future voluntary purchase of properties offered when erosion scarp reaches set trigger distance from buildings (M2.3)	Medium – long term (> 5 years)	• Offer purchase of individual properties when erosion escarpment reaches set trigger distance from building at fair market value. Offer to purchase six properties that cannot be redeveloped under existing DCP provisions	• Would progressively remove the risk from the property • Opportunity to improve local amenity by provision of additional community space • Opportunity to improve environmental values of dune	• Very high cost of purchase • Social and community economic impact due to loss of property values over time • Voluntary purchase schemes have traditionally low take-up rates • Loss of rate income	$18 million including loss of rate income	$18 million (based on $3 million purchase price estimate per property)	$2.16 million (assumes 1% risk p.a. of $1,000,000 damage to properties affected by coastal erosion hazard)	0.12
	Terminal protection structure for properties along seaward side of Tudibaring Parade (M2.4)	Medium term (5 – 20 years)	• Engineered buried terminal protection structure to be implemented in the future once dwellings are subject to immediate erosion hazard risk, to be funded by residents	• Would allow protection of the properties from coastal erosion into the future • Dune may be able to be maintained in front of terminal protection structure so little visual impact in the short term	• High cost to design and construct • Political question as to who will bear the cost • Would need full environmental assessment • All landholders would need to agree • Potential impact of erosion on adjacent land and in front of the structure once exposed • There is currently scope for many of these properties to be redeveloped landward of the 2050 or 2100 hazard zone.	$3.0 to $4.0 million	$5.44 million (based on $4 million construction/design cost plus 1% maintenance p.a.)	$2.88 million (assumes 1% risk p.a. of $1,000,000 damage to properties affected by coastal erosion hazard)	0.53
	Beach nourishment to increase erosion buffer in this area (M2.5)	Medium term (5 – 20 years)	• Source sand for beach nourishment and place	• Would allow future protection of the properties against storm erosion by	• Considerable cost in sand extraction and placement	$2.0 to $2.5	$4.6 - $5.7	$2.88 million	0.5 – 0.6

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
			on the beach to build up dune and create buffer against storm erosion	providing a buffer of sand • Embayment is largely closed to longshore sediment transport and sand would likely stay within beach compartment – i.e. nourishment likely to be effective • Would be aesthetically pleasing and would not detract from the beach amenity • Feasibility studies and investigations on nourishment for this beach have already been carried out so costs and sand sources well understood.	• Nourishment would likely need to be repeated in the future	million	million (assumes required every 10 years)	(assumes 1% risk p.a. of $1,000,000 damage to properties affected by coastal erosion hazard) and prevention of loss of development potential for existing homes	
	Encourage and assist Dunecare group and local residents to maintain and revegetate dune after a storm through provision of free plants and public education material (M2.6)	Short term (0 – 5 years)	• Provide community education program to encourage residents to maintain dune in front of their properties with the assistance of local Dunecare group	• Low cost • Would help protect against wind erosion and assist natural dune building process improving the buffer of sand in front of the properties • Social benefit of community participation in bush regeneration	• Minimal impact as dune already in reasonable condition here • Does not offer sufficient protection against storm erosion demand.	$15,000 - $25,000 p.a.	N/A	N/A	"No regrets" option to be implemented
Risk of erosion due to lagoon entrance instability	Seaward extension of existing training wall along southern side of entrance (M2.7)	Medium term (5 - 20 years)	• Extend existing training wall along southern side of entrance to prevent erosion of toe of dune at southern end of entrance	• Would improve erosion protection for the dune at the southern side of the entrance caused by estuary entrance instability	• Cost to design, construct and maintain works • Potential for changes to ecology of the lagoon entrance due to hydrodynamic influence of training wall • Erosion potential for dune is low as dune is currently very high • Potential for future loss of access along the beach in front of structure • Potential for erosion protection works to interrupt longshore transport and impact on coastal processes in the future	$400,000 to $500,000	$450,000 - $560,000	$700,000 (assumes 1% p.a. risk of $1 million damage to 5 properties)	1.25 – 1.5
	Undertake review of entrance management procedure as recommended by Gosford Coastal Lagoons CZMP. Implement management actions as required (M2.8)	Short term (0 - 5 years)	• Updated CZMP for Gosford Lagoons includes specific entrance management measures relating to Cockrone Lagoon	• Entrance management measures should reduce the impact of erosion at the entrance and balance ecological needs of the lagoon	• Possible impacts on lagoon ecology	$5,000 for review, $12,000 p.a. ongoing lagoon opening cost	$170,000	$350,000 (assumes 1% p.a. risk of $500,000 damage to 5 properties)	2.0

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
Windblown erosion of dune	Encourage and assist Dunecare group and local residents to maintain and revegetate dune after a storm through provision of free plants and public education material (M3.1)	Short term (0 – 5 years)	• Provide community education program to encourage residents to maintain dune in front of their properties with the assistance of local Dunecare group	• Low cost • Would help protect against wind erosion and assist natural dune building process improving the buffer of sand in front of the properties • Social benefit of community participation in bush regeneration	• Ongoing maintenance required.	$15,000 - $25,000 p.a.	N/A	N/A	"No regrets" option to be implemented
Risk of future erosion damage to Del Monte Place, services/ utilities and Copacabana surf club	Erosion Protection works for Copacabana Beach Surf Club (M3.2)	Medium term (5 - 20 years)	• Terminal protection for Copacabana surf club	• Would improve existing erosion protection at the surf club	• Cost to design and construct works • Potential impact of works on adjacent beach dunes • Surf club has been recently redeveloped and reconstructed on piles so terminal protection would not improve erosion protection for the building itself	$600,000 to $800,000	$680,000 - $900,000	$280,000 (2% risk of $1million damage p.a.)	0.3 – 0.4
	Erosion protection works for Del Monte Place to be installed once erosion escarpment reaches set trigger distance from edge of road (M3.3)	Long term (> 20years)	• Not likely to be required for several years as road not within Immediate Zone of Slope Adjustment • Engineered buried terminal protection structure to be implemented in the future once roadway subject to immediate erosion hazard risk, or piled seawall on seaward side of road similar to that at Terrigal, to be funded jointly by Council/State Government and directly affected residents	• Would provide future certainty of protection of the Del Monte roadway and access to properties and Copacabana commercial centre • May not detract from the local beach amenity if well designed as works could provide for urban amenity e.g. Terrigal • Dune may be able to be maintained in front of terminal protection structure so little visual impact in the short term • Little visual impact as structure could blend in with natural toe protection at base of dune east from Copacabana Surf Club in form of natural boulder scree slope	• Cost of construction and implementation • Impact of works on dune vegetation and coastal values at Copacabana • Impact of works on adjacent areas of the beach due to effect on coastal processes.	$7.0 to $9.0 million	$12.24 million (based on $9 million construction/design cost plus 1% maintenance p.a.)	$1.224 million (assumes 1% risk p.a. of $1,000,000 damage to properties affected by coastal erosion hazard plus 1% risk that $400,000 damage would occur to Del Monte Place)	0.10
	Landward relocation of sewer and water infrastructure along Del Monte Place (M3.4)	Long term (> 20years)	• Not likely to be required for several years as services not within Immediate Zone of Slope Adjustment	• Would remove the infrastructure from coastal erosion risk	• Cost of moving infrastructure and temporary disruption to community	$200,000 to $300,000	$200,000 to $300,000	$20,000 to $30,000	0.1
	Beach nourishment in front of surf club and Del Monte Place (M3.5)	Long term (> 20 years)	• Source sand for beach nourishment and place	• Would allow future protection of the properties and road against storm erosion	• Considerable cost in sand extraction and placement	$5.0 to $6.0 million	$11.5 - $13.8 million	$1.224 million (assumes 1%	0.1

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
			on the beach to build up dune and create buffer against storm erosion	by providing a buffer of sand • Embayment is largely closed to longshore sediment transport and sand would likely stay within beach compartment – i.e. nourishment likely to be effective • Would be aesthetically pleasing and would not detract from the beach amenity • Feasibility studies and investigations on nourishment for this beach have already been carried out so costs and sand sources well understood. • Not likely to be required for many years as currently sufficient sand available on beach to cater for immediate storm erosion demand	• Nourishment would likely need to be repeated in the future • High cost • Loss of sand possible due to scour from stormwater/creek entrance at northern side of Surf Club		(assumes nourishment required every 10 years)	risk p.a. of $1,000,000 damage to properties affected by coastal erosion hazard plus 1% risk that $400,000 damage would occur to Del Monte Place)	
	Repair damage to Del Monte Place should it be damaged by future erosion (M3.6)	Medium term and as required (> 5 years)	• Undertake repairs to the road using damage-resistant pavements as a post-storm emergency measure	• No initial cost outlay • No action required unless damage occurs • Not likely to occur for many years • Use of damage-resistant pavement would reduce future maintenance costs	• Cost of road repair should it be required • Risk to public safety should design storm occur and road is damaged • Risk of temporary loss of access to properties and surf club, social and economic impact • Recurrent cost of repair should coastal erosion risk increase in the future	$300,000 to $400,000 per event	$80,000 - $110,000 (based on risk of damage)	$40,000 - $55,000 (based on reduced maintenance costs)	0.5
	Long term narrowing, removal and relocation or provision of alternative access for Del Monte Place (M3.7)	Long term (> 20 years)	• Long term narrowing of Del Monte Place to a single lane, relocation of servicers, followed by purchase of an alternative access easement at the rear of the properties for provision of access to properties along Del Monte Place	• Risk of loss of road due to erosion is reduced over time	• High traffic area not suitable for single lane traffic • Landowners would need to agree to purchase of access easement • Prohibitive cost • Reduced ease of public access to beachfront and surf club over time	$2 - $3 million	$2 - $3 million	$1.224 million (assumes 1% risk p.a. of $1,000,000 damage to properties affected by coastal erosion hazard plus 1% risk that $400,000 damage would occur to Del Monte Place)	0.5
	Future relocation of surf club landward on redevelopment (M3.8)	Long term (>20 years)	• Move surf club landward onto an alternative site as	• Would remove the hazard risk	• Not required at present as erosion risk for club already managed by club being	$1.0 to $1.5	$1.0 to $1.5	$280,000 (2%	0.2 – 0.3

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
			erosion hazard increases when surf club is due to be redeveloped		constructed on piles • Cost to purchase new site • Pedestrian safety due to club being landward of del Monte Place • Disruption to the community	million	million	risk of $1million damage p.a.)	
	Voluntary purchase of properties affected by coastal hazards (M3.9)	Long term (>20 years)	• Provision of alternative road access at rear of homes and businesses, voluntary purchase of three properties on seaward side of Del Monte Place to be offered once erosion escarpment reaches trigger distance from buildings.	• Would remove the risk to these properties over time • Opportunity to improve local amenity by provision of additional community space • Opportunity to improve environmental values of dune	• Very high cost • Low take-up rate of voluntary purchase scheme • Social and economic impact on locality • Loss of rate income	$11.4 million including loss of rate income	$11.4 million (based on $3 million purchase price estmate for three properties, $100,000 compensation for 10 properties for provision of rear access, purchase of an additional property at $1 million, plus $400,000 construction cost)	$1.224 million (assumes 1% risk p.a. of $1,000,000 damage to properties affected by coastal erosion hazard plus 1% risk that $400,000 damage would occur to Del Monte Place)	0.11
	Development controls for residences and commercial premises to be on piled foundations on redevelopment of properties within 2050 or 2100 hazard area; i.e. status quo (M3.10)	Short term (0 – 5 years)	• As per existing DCP. The clause that development not give rise to any increased hazard could be applied to prevent building re-development from being allowed to move seaward of the existing location. Repair of the road will be required should it be impacted by erosion	• Can be easily implemented within existing DCP as existing controls already in place – no need to adjust existing controls. • Geotechnical investigations can be carried out to assess the extent of reduced foundation capacity issues for properties along Copacabana Beach • Benefit is individual value of properties protected by being on piled foundations by 2050 or 2100	• Disruption to the community should services and Del Monte Place require reconstruction in the future. • Recurrent cost of repairing the road will increase in the future	N/A	$162,000 (assumes 1% risk p.a. of $50,000 damage to properties affected by coastal erosion hazard plus 1% risk that $400,000 damage would occur to Del	$1.08 million (value of buildings within 2050 Zone of Reduced Foundation Capacity benefiting from being constructed on piled foundations)	6.67

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
							Monte Place)		
	Geotechnical investigation around surf club area to confirm level of bedrock and reduced foundation capacity hazard (M3.11)	Short term (0 – 5 years)	• Undertake geotechnical drilling to determine the nature of the material under the beach near Copacabana Surf Club, to determine whether buildings landward of Del Monte Place would be subject to reduced foundation capacity	• Would help determine foundation requirements for buildings landward of Del Monte Place and the Surf Club and what degree of erosion and reduced foundation capacity hazard this area is subject to • Would inform future policy and development controls for this area of Copacabana Beach	• None	$30,000	N/A	N/A	"No regrets" option
Scour and water quality issues due to stormwater management near Copacabana surf club	Improve energy dissipation at stormwater outlet (M3.12)	Short tern (0 – 5 years)	• Major stormwater outlet adjacent to surf club	• Would reduce the effect of scour on the beach caused by flows from the stormwater outlets. • Potential to improve stormwater water quality.	• Needs to be designed well to not exacerbate flooding in the upstream catchment area • Cost to design, construct and maintain. • May be limited technical scope to improve existing scour potential.	$50,000	$50,000	$27,000 (assumes 10% reduction in 1% p.a. risk of damage to surf club building valued at $2 million). Unquantified benefit of improved beach amenity	0.54
	Construct "training" or "tripper" control structure to prevent stormwater outlet from scouring base of dune along Del Monte Place (M3.13)	Short term (0 – 5 years)	• Construct a short buried training wall using rock, reno mattresses or geotextile bags to prevent stormwater/creek flows from meandering in front of dune at northern end of beach	• Relatively low cost measure with minimal aesthetic impact as would be buried most of the time • Minimal ecological impact to the creek as would allow macrophytes to grow in the creek entrance • Would prevent erosion caused by creek flow in front of dune at the northern end of the beach, by preventing creek flows undermining the existing dune and reducing the need for mechanical intervention at the entrance	• Buried control structure materials may become a danger to beachgoers if damaged • May reduce beach access during periods when the structure is exposed	$10,000 to $20,000	$10,000 - $20,000	$27,000 (assumes 10% reduction in 1% p.a. risk of damage to surf club building valued at $2 million).	1.35 – 2.7
Dune vegetation management	Dune vegetation management to remove weeds and encourage dune growth (M3.14)	Ongoing	• Provide support and education to local Dunecare groups and local residents to	• Would improve existing beach amenity at this location by adoption of standard dune management approach in accordance with the Coastal Dune Management Manual	• Ongoing management required.	$15,000 to $25,000	N/A	N/A	"No regrets" option to be implemented

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
			maintain dune as required and repair after a storm. Would need to be combined with weed control in the creek channel adjacent to Del Rio Drive and catchment.	(DLWC 2001) along entire beachfront • Dune and creek channel currently overrun by weeds • Social benefit of community participation in bush regeneration • No additional cost					
All issues	Emergency Management (M3.15)	As required	• Undertake pre, during and post storm actions as described in Section 7.8 when trigger for action is reached	• Public safety	• N/A	N/A	N/A	N/A	"No regrets" option

8.9 Avoca Beach

8.9.1 Issues and Options

The major coastal hazards identified at Avoca Beach are:

- **Coastal inundation** of houses and carparks by wave runup and at the lagoon entrance, causing damage to existing buildings and services and a risk to public safety;
- **Coastal erosion** having the potential to impact on the beachfront residences, carpark, café, surf viewing tower, public facilities, fencing, signage and services including stormwater, sewer. such as dune fencing, viewing platform and accessways;
- **Slope Instability** having the potential to result in reduced foundation capacity for up to 71 lots, with this number increasing to 114 lots by 2100;
- **Future coastal erosion** and recession affecting up to 90 m length of Bareena Avenue, 220 m length of North Avoca Drive and ends of View Street, Ocean Street and Lake Street and
- **Erosion associated with estuary entrance instability** at Avoca Lake.

The consequences of these coastal hazards being realized include:

- Present day potential for overfloor inundation of houses by wave runup, causing damage to existing buildings and services supplying those buildings;
- Present day threat of erosion damage to the beachfront buildings identified as being within the Present Day *Zone of Slope Adjustment*;
- Present day threat of erosion damage to carpark, surf viewing tower, café, fencing, signage and beach accessways and associated loss of beach amenity;
- Present day threat of erosion damage to stormwater, sewer and power services at Tarun Road, Avoca Drive and near the SLSC.
- Future erosion risk to properties is expected to increase, increasing the risk of damage to private property due to erosion and reduced foundation capacity, as well as risk to public safety increasing with time;
- Future increased potential for overfloor inundation of houses by wave runup, and also inundation due to increased tailwater levels due to future sea level rise at the entrances to Avoca Lake.

Avoca Beach has been divided into a number of precincts moving from south to north, considering particular characteristics within each precinct, namely:

- **Precinct 1** – Avoca Beach, South of Austral Avenue and **Precinct 2** – Avoca Beach, Austral Avenue to Ficus Avenue (options A1.1 – A1.18);

- **Precinct 3** – Avoca Lake Entrance (options A3.1 – A3.3); and
- **Precinct 4 & 5** – Avoca Beach, North of Avoca Lake Entrance (options A4.1 – A4.23).

Potential management actions that are relevant in addressing the identified coastal hazards for Avoca Beach include:

- Undertake **erosion protection works** to protect properties, houses and infrastructures along Avoca Beach;
- **Development controls** to ensure new developments are located with a floor level 0.5m above the maximum wave runup level or 100 year ARI flood level (whichever is higher), allowing for future sea level rise;
- **Development controls** to ensure new developments within the coastal hazard areas are unlikely to be damaged within a chosen planning period by coastal erosion and inundation (i.e. founded into the local 2050 or 2100 stable foundation zone and located with a floor level 0.5m above the maximum wave runup level, allowing for future sea level rise);
- **Relocation of existing buildings and infrastructure** subject to potential damage due to coastal erosion e.g. residences and services;
- Undertake or allow residents to undertake **erosion protection works** to protect the residences near the Avoca Lake entrance;
- Entrance management guidelines for opening Avoca Lake - provide defined opening line/s and angles which will minimise bank erosion, cliff instability and minimise damage to the beach front, and include the opening guidelines within Council's Lagoon Opening Policy and Procedure;
- **Placement of sand** on the beach in front of the properties to increase the buffer of sand available and provide some protection against storm erosion;
- Undertake periodic beach nourishment to provide a buffer against erosion;
- **Maintenance of the dune crest** above the level of wave runup to prevent wave runup reaching the buildings;
- Improve **maintenance of dune vegetation**, planting and fencing along length of beach, in areas under both private and public control; and
- Improve stormwater management at the stormwater outlets to prevent scour due to stormwater runoff.

A suite of 36 specific management options for actions that could be undertaken by Council have been developed to address the coastal hazards identified at Avoca Beach for consideration. Each option has been provided with an identifier (A1.1 to A4.11) as illustrated in Table 26. A more detailed summary of these main options for coastal zone management including advantages and disadvantages, timeframe for adoption and indicative costs is provided in Table 27.

Further to the management options below, Avoca (North and South) Beach has been named as an "Authorised Location" for placement of temporary protection works in the Code of Practice under the Coastal Protection Act 1979 (OEH 2013). Under the Code of Practice, landowners may place temporary protection works comprising either:

- sand filled geotextile containers each of maximum 0.75m^3 filled volume stacked in a single layer up to 1.5m high (at a slope flatter than 34° from the horizontal, that is flatter than 1:1.5 vertical:horizontal); or,
- clean sand placed up to the crest on the seaward side of an eroding escarpment (under the Code of Practice, this is not permitted to be sourced from the beach on which the works are to be placed).

It is emphasised that landowners must act well (generally months) in advance of a storm to consider implementing these works. It should also be noted that landowners are not permitted to install coastal protective works without following the procedures outlined in the Code of Practice (OEH 2013), and severe penalties may apply if they are not followed.

8.9.2 Landuse and Development

At Avoca Beach, building is not currently permitted seaward of the 2045 erosion line except under special circumstances. Management options to address landuse and development issues at this beach are discussed below.

8.9.2.1 South Avoca Beach

The most recent coastal hazard assessment has identified that there are 34 lots and 17 dwellings on Avoca Drive south of the entrance to Avoca Lagoon which are partially seaward of the 2050 *Zone of Slope Adjustment.* The 2100 *Zone of Slope Adjustment* impacts on 45 lots and 35 dwellings. All of the beachfront lots seaward of Avoca Drive are affected by coastal inundation. Note that the previous coastline Hazard Lines for the study area did not make any allowance for reduced foundation capacity as required now by the Guidelines for Preparing Coastal Zone Management Plans (Office of Environment and Heritage 2013).

For some of these lots, landward movement of buildings within these lots is not feasible. Many of the buildings are strata titled apartments. However, for many of the lots, should the existing buildings be redeveloped, it would be feasible to redevelop the buildings on piles landward of the 2050 *Zone of Slope Adjustment*, with deep-piled foundations into the 2100 *Stable Foundation Zone*.

Some of the properties in this area were observed to have installed coastal protection works, and there was rock protection observed for the Surf Club, adjacent carpark, and at the base of the large Norfolk Island pine trees adjacent to local stormwater outlets.

Realistic management options to address the landuse and development issues for this area include:

- Applying the provisions of the Gosford DCP to this area to require redevelopment to be landward of the 2050 *Zone of Slope Adjustment*, with foundations piled into the 2100 *Stable Foundation Zone*;
- Investigating the effectiveness of the existing rock protection works provided at the Surf Club and adjacent carpark through monitoring, ground penetrating radar, etc. and upgrade the works if required to the required engineering standard;
- Investigate the effectiveness of the existing rock protection works installed along the lagoon frontage at Ficus Avenue and upgrade the works if required to the required engineering standard;
- Investigate what existing ad hoc protection works have been implemented along the beachfront properties and establish their effectiveness against a potential storm;
- Investigate the future provision of terminal protection works for the private properties along Avoca Drive, to be implemented at a future date;
- Beach scraping to assist the natural buildup of sand on the beach and provide a dune that would help to reduce the risk of inundation due to wave runup and improve the buffer of sand available to protect against storm erosion;
- Planned retreat from this area in the future, including the voluntary purchase/relocation of the surf club, and individual properties once they are located seaward of the *Immediate Zone of Slope Adjustment*. The most recent sales data for these lots (www.onthehouse.com.au) indicate property values of approximately $1 million for a typical apartment within the strata titled lots, with property values for individual dwellings of up to $4 million (no. 93 Avoca Drive sold for $4.35 million in February 2011).

To prevent ad-hoc protection works being constructed at individual properties, a terminal protection scheme would need to be agreed to by all the property owners in the precinct. Such a scheme would need to be subject to a detailed design and environmental assessment. Funding could be provided by local property owners through a contribution payment toward the construction costs, with commissioning of the design and construction undertaken through funding from the NSW Coastal Management Program and part funding from Council. Maintenance would then be the responsibility of the local landowners, which could be undertaken by Council but funded by the residents.

8.9.2.2 North Avoca Beach

At North Avoca Beach, there are 27 lots and 6 dwellings with a portion seaward of the *Immediate Zone of Slope Adjustment*. There are 44 lots and 37 dwellings with a portion seaward of the *2050 Zone of Slope Adjustment.* For some of these lots, landward relocation of development is not feasible and re-development of some of these lots, even landward of the 2050 *Zone of Slope Adjustment*, is problematic due to the lack of available area for development within these lots. For the precinct between View Street and Kiana Street, it is considered feasible to apply development controls as per the existing Gosford DCP, as most of the dwellings on these lots are landward of the 2050 *Zone of*

Slope Adjustment, or there is sufficient area available within the lot landward of this zone to allow the blocks to be reasonably developed.

For the lots north of and including the Surf Club, application of the existing policy in the DCP would not allow these lots to be redeveloped as the available area landward of the 2050 *Zone of Slope Adjustment* within these lots is too small. For approximately 12 of the beachfront lots south of View Street, the 2050 *Zone of Slope Adjustment* is also located relatively landward within these lots to allow the lots to be redeveloped, although the dwellings within these lots are landward of the *Immediate Zone of Slope Adjustment.*

Options for the coastal management of this area therefore include:

- Applying the provisions of the Gosford DCP to this area to require redevelopment to be landward of the *2050 Zone of Slope Adjustment*, with foundations piled into the *2100 Stable Foundation Zone* – this could reasonably be applied to the beachfront lots in the area between View Street and the Surf Club;
- Modifying the Gosford DCP for the precinct south from View Street to allow for redevelopment to occur landward of a determined building line between the Immediate and *2050 Zone of Slope Adjustment* and piled into the *2100 Stable Foundation Zone*;
- Voluntary or compulsory purchase of the six lots north of the Surf Club where development landward of the *2050 Zone of Slope Adjustment* is not feasible – market value for these properties is expected to be around $3.5 million each based on data provided by www.onthehouse.com.au;
- Future voluntary purchase of the properties south from View Street where development landward of the *2050 Zone of Slope Adjustment* is not feasible.
- Investigate what existing ad hoc protection works have been implemented along the beachfront properties and establish their effectiveness against a potential storm;
- Provision of terminal protection works for the section of beach north of and including the surf club - the degree of coastal hazard in this area is such that protection would be of immediate benefit.
- Investigation of terminal protection works to be implemented along the entire beachfront in the future should the coastal hazard risk increase with time.

It should be noted that there are no public assets at risk in the area north of the Surf Club, and that any terminal protection in this area would benefit the property owners directly. To prevent ad-hoc protection works being constructed at individual properties, a terminal protection scheme would need to be agreed to by all the property owners in the precinct. Such a scheme would need to be subject to a detailed design and environmental assessment. Consent for such a structure would be contingent on the structure meeting the requirements in Section 55M of the *Coastal Protection Act 1979*. Funding could be provided by local property owners through a contribution payment toward the construction costs, with commissioning of the design and construction undertaken through funding from the NSW Coastal Management Program and part funding from Council. Maintenance would then be the responsibility of the local landowners, which could be undertaken by Council but funded by the residents.

Table 26 – Coastline Management Options for Avoca Beach

Precinct	Issue/Hazard	Management Option
Precinct 1 – Avoca Beach, South of Austral Avenue; and **Precinct 2 –** Avoca Beach, Austral Avenue to Ficus Avenue	Immediate risk of inundation to surf club	Survey floor levels to determine degree of inundation hazard (A1.1)
	Immediate and future risk of erosion and inundation damage to the surf club carpark	Repair damage to carpark and other infrastructure should storm erosion occur (A1.2)
		Beach nourishment in front of carpark (A1.3)
		Beach scraping to build vegetated dune in front of carpark (A1.4)
		Future relocation of carpark to an area land ward of the coastal hazard area (A1.5)
		Monitor performance of existing rock works in front of surf club and carpark following a large storm (A1.6)
	Immediate and future risk of erosion risk to properties	Development controls as per existing DCP i.e. defined building line (e.g. defined building line or 2050 Zone of Slope Adjustment) with new buildings to be founded into 2100 Stable foundation Zone (A1.7)
		Development controls based on 2100 Zone of Slope Adjustment with new buildings to be founded into 2100 Stable foundation Zone (A1.8)
		Erosion protection works to be allowed for properties for emergency protection (funded by residents) (A1.9)
		Terminal seawall protection for the properties (A1.10)
		Voluntary purchase of individual properties where buildings are seaward of 2050 Zone of Slope Adjustment. (A1.11)
		Relocate sewer infrastructure further landwards (A1.12)
		Beach nourishment to increase erosion buffer in this area (A1.13)
		Beach scraping to build dune in front of residences (A1.14)
		Encourage and assist Dunecare group to maintain and revegetate dune after a storm (A1.15)
	Immediate and future risk of inundation risk to properties	Development controls for residences to be above inundation levels on redevelopment of properties (A1.16)
	Erosion risk to stormwater outlets on Avoca Drive	Erosion protection works in front and around the stormwater outlet should storm erosion occur (A1.17)
		Relocate stormwater outlets (A1.18)
	Inundation and erosion risk to Ficus Avenue carpark	Repair damage to carpark and other infrastructure should storm erosion occur (A1.19)
		Beach scraping to build dune in front of carpark and properties 165 Avoca Drive to 1 Ficus Avenue (A1.20)
Precinct 3 – Avoca Lake Entrance	Immediate and future erosion and inundation risk to properties and infrastructure	Development controls for residences to be above inundation levels on redevelopment of properties (A3.1)
		Review entrance management guidelines for mechanical opening of Avoca Lake (A3.2)
		Allow lagoon frontage properties to self-protect (A3.3)
Precinct 4 – North Avoca Beach, North of Avoca Lake Entrance **Precinct 5 –** North Avoca Beach	Immediate and future risk of erosion risk to properties	Allowing development landward of the 2050 Zone of Slope Adjustment with piled foundations into the 2100 Stable Foundation Zone (A4.1)
		Allowing development landward of a specially defined building line with piled foundations into the 2100 Stable Foundation Zone (i.e. similar to existing DCP, status quo, A4.2)
		Allowing development landward of the 2100 Zone of Slope Adjustment with piled foundations into the 2100 Stable Foundation Zone (A4.3)
		Erosion protection works to be allowed for properties for emergency protection (funded by residents) (A4.4)
		Terminal seawall protection for all the properties (A4.5)
		Terminal seawall protection for the properties north from the Surf Club only (A4.6)
		Planned retreat from this area, including the voluntary purchase of properties where buildings are seaward of 2050 Zone of Slope Adjustment (A4.7)

Precinct	Issue/Hazard	Management Option
		Voluntary purchase of properties where buildings are seaward of Immediate Zone of Slope Adjustment (A4.8)
		Relocate sewer infrastructure further landwards (A4.9)
		Beach nourishment to increase erosion buffer in this area (A4.10)
		Encourage and assist Dunecare group to maintain and revegetate dune after a storm (A4.11)
	Immediate and future risk of inundation risk to properties	Development controls for residences to be above inundation levels on redevelopment of properties (A4.12)
	Scour erosion due to stormwater outlet	Scour protection in front of stormwater outlet (A4.13)
	Immediate and future risk of erosion and inundation risk to the surf club and carpark	Erosion protection works at surf club (A4.14)
		Repair damage to surf club and carpark should storm erosion occur (A4.15)
		Beach nourishment in front of surf club and carpark (A4.16)
		Beach scraping to build vegetated dune in front of surf club and carpark (A4.17)
		Future relocation of surf club and associated infrastructure to an area landward of the coastal hazard area (A4.18)
		Build and maintain a dune in front of surf club above the wave runup level with vegetation and/or fencing (A4.19)
		Redevelop surf club on deep piled foundations (A4.20)
All precincts	All areas	Emergency Management (A4.21)

Table 27 – Detailed Summary of Management Options for Avoca Beach

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
Immediate risk of inundation to Avoca Beach SLSC	Survey floor levels to determine degree of inundation hazard (A1.1)	Short term	• Undertake survey of existing floor levels – raising buildings could be examined as an action	• Would allow assessment of damage during inundation	• None	$3,000 to $5,000	N/A	N/A	"No regrets" option
Immediate and future risk of erosion and inundation damage to the surf club carpark	Repair damage to carpark and other infrastructure should storm erosion occur (A1.2)	As required	• Restore carpark using damage-resistant pavements should it be damaged in a future storm event	• No initial capital outlay • Use of damage-resistant pavement would reduce future maintenance requirements	• Risk of damage to carpark and surf club remains, although there is existing rock remaining from previous storms • Cost of repair	$150,000 to $180,000	$150,000 to $180,000	$120,000 - $140,000 (assumes 5% risk p.a. of damage)	0.8
	Beach nourishment in front of carpark (A1.3)	Short to medium term (0 – 20 years)	• Import of sand into this portion of the beach to increase buffer against beach erosion	• Would provide buffer against storm erosion demand to help protect the surf club and carpark	• Suitable source of sand has not been identified, possibly from mobile dunes further north along the beach. Extensive studies required to identify source of sand and undertake environmental assessment • Nourishment works would likely not remain on the beach at this location	$500,000 to $700,000	$1.15 – 1.6 million	$420,000 (risk of erosion and inundation damage to club and carpark)	0.25
	Beach scraping to build vegetated dune in front of carpark (A1.4)	Short term (0-5 years)	• Scrape sand to build a dune in front of the carpark and vegetate as per standard dune management practice in accordance with the Coastal Dune Management Manual (DLWC 2001).	• Would improve protection of the surf club and carpark against storm erosion and inundation by providing a buffer of sand • Would be aesthetically pleasing and would not detract from the beach amenity	• Not likely to provide sufficient protection against future storm event • Dune would be damaged by future storm events and would require maintenance • Cost of environmental assessment and planning activities. • Disruption to beach users during works.	$3,000 to $5,000	Up to $66,000 if done annually	$60,000 (if 50% reduction in inundation damage of carpark is achieved)	1.0
	Future relocation of carpark to an area landward of the coastal hazard area (A1.5)	Short to medium term (0 – 20 years)	• Relocate carpark to an area outside the erosion hazard zone eg. futher landward	• Would remove the immediate erosion risk to the carpark	• Cost to reconstruct carpark and potential cost to purchase land for placement of new carpark • Possible loss of carparking spaces	$180,000 to $200,000 (not including resumption costs)	$180,000 to $200,000 (not including resumption costs)	$120,000 - $140,000 (assumes 5% risk p.a. of damage)	0.7
	Monitor performance of existing rock works in front of surf club and carpark following a large storm (A1.6)	Short term and as required	• Assess post-storm damage to existing rock protection at Surf Club and carpark to determine	• Would provide information on performance and effectiveness of the existing erosion protection to assess in more detail level of risk to surf club and	• None	N/A	N/A	N/A	"No regrets" option to be implemented

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
			level of protection provided and design upgrade if necessary	carpark area					
Immediate and future risk of erosion to properties on Avoca Drive	Development controls as per existing DCP i.e. defined building line (e.g. defined building line, or 2050 Zone of Slope Adjustment) with new buildings to be founded into 2100 Stable foundation Zone (A1.7)	Short term	• Can be added to or based upon existing DCP. Allowing development landward of the 2050 Zone of Slope Adjustment with piled foundations into the 2100 Stable Foundation Zone (i.e. similar to existing DCP, status quo). The clause that development not give rise to any increased hazard could be applied to prevent building re-development from being allowed to move seaward of the existing location. No subdivision of properties seaward of Avoca Drive to be allowed.	• Can be easily implemented within existing DCP as existing controls already in place – no need to adjust existing controls. • Would not increase the coastal hazard risk compared with existing situation • Would be consistent with existing DCP. • Benefit is individual value of properties protected by being on piled foundations by 2050 or 2100	• Additional controls may place additional impost onto beachfront property owners and could affect property resale values • Inundation still a risk for many properties • Risk still remains for existing properties until they are redeveloped • Erosion risk to Norfolk Pine trees still remains	N/A	$1.224 million (assumes 1% p.a. risk of $50,000 erosion/inundation damage to public infrastructure and 34 private lots, plus 1% risk p.a. for lots with buildings seaward of 2050 Zone of Slope Adjustment)	$9.72 million (assumes 1% risk p.a. of $1,000,000 damage to private properties seaward of 2050 Zone of Reduced Foundation Capacity)	7.9
	Development controls based on 2100 Zone of Slope Adjustment with new buildings to be founded into 2100 Stable foundation Zone (A1.8)	Short term	• Allowing development landward of the 2100 Zone of Slope Adjustment with piled foundations into the 2100 Stable Foundation Zone. This would be more restrictive than the existing DCP, with 35 dwellings currently having a portion slightly seaward of this line	• Would improve the long term risk to development in the precinct compared with existing i.e. between 2050 and 2100	• Loss of development potential for 35 properties could lead to a decline in local property values, although the potential decline is difficult to estimate	N/A	$14.63 million (assumes 1% risk p.a. of $50,000 damage to minor structures per property affected by coastal erosion hazard, plus 10% property value loss for 35 properties that would have	$9.72 million (assumes 1% risk p.a. of $1,000,000 damage to private properties seaward of 2050 Zone of Reduced Foundation Capacity)	0.66

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
							reduced development potential)		
	Erosion protection works to be allowed for properties for emergency protection (funded by residents) (A1.9)	Short to medium term, some of these properties already have protection installed	• Works may comprise similar design to existing adjacent works	• Would provide protection for the properties in a design storm. • Would be consistent with works already installed at adjacent properties. • Would protect services against future erosion risk • Works would not adversely affect amenity if well designed, as per existing works.	• Cost to design, construct and maintain works • Potential for increased erosion impacts after a large storm in front of and on either side of the works due to wave reflections • Potential for future loss of access along the beach in front of structure • Potential for erosion protection works to interrupt longshore transport and impact on coastal processes in the future	$250,000 per propertyl	$92,500 per property (assumes 1% probability p.a. that works will be required to 2050)	$67,000 per property (assumes 50% reduction of 1% risk p.a. of $1,000,000 damage to 28 properties affected by 2050 coastal erosion/reduced foundation capacity hazard)	0.72
	Terminal seawall protection for the properties (A1.10)	Short to medium term	• Works may comprise a buried armour seawall protection for Avoca Drive properties. Structure to be implemented in the future once properties subject to immediate erosion hazard risk, to include works at Surf Club and adjacent carpark, to be funded jointly by Council/State Government and directly affected residents	• Would provide protection for the properties in a design storm. • Would protect services against future erosion risk • Works would not adversely affect amenity if well designed, as per existing works. • Works could be designed to benefit surf club and carpark as well as private infrastructure • Impact would be low as many properties currently have ad-hoc or emergency protection works currently in place, including at the Surf Club • Would manage inundation risk from wave runup	• Cost to design, construct and maintain works • Potential for increased erosion impacts after a large storm in front of and on either side of the works due to wave reflections • Potential for future loss of access along the beach in front of structure • Potential for erosion protection works to interrupt longshore transport and impact on coastal processes in the future • Requires beach nourishment	$6.0 to $7.0 million	$9.52 million (based on $7 million construction/design cost plus 1% maintenance p.a.)	$10.08 million (assumes 1% risk p.a. of $1,000,000 damage to 28 properties affected by 2050 coastal erosion/reduced foundation capacity hazard)	1.06
	Voluntary purchase of individual properties where buildings are seaward of 2050 Zone of Slope Adjustment. (A1.11)	Medium – long term	• Voluntary purchase to be offered for 17 properties where buildings are seaward of the 2050 Zone of Slope Adjustment (i.e. limited	• Would remove the erosion hazard from the properties • Opportunity to improve local amenity by provision of additional community space • Opportunity to improve environmental values of dune	• Very high cost of purchase • Voluntary purchase may not be taken up by the property owners • Social and economic impact on locality • Loss of rate income	$68 million including loss of rate income	$72 million (based on $4 million average purchase price per property for 17 properties)	$6.12 million (assumes 1% risk p.a. of $1,000,000 damage to properties	0.08

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
			development potential under existing DCP) or once appropriate trigger is reached e.g. erosion escarpment reaches set trigger distance e.g. 5m from edge of building • Council/State Government can offer to purchase the building through voluntary means once trigger distance is reached via negotiations with the owners.				including $4million net present value of loss of rate income to 2050	affected by erosion hazard)	
	Relocate sewer infrastructure further landwards (A1.12)	Short term (0 – 5 years)	• Sewer currently located at the seaward end of the properties – this option would involve investigating the feasibility of moving the sewer landward out of the hazard area	• Would protect sewer against damage by erosion in future storms	• Could be technically difficult or not feasible to move sewer landward due to the topography of the area.	$250,000 to $400,000	$250,000 to $400,000	$70,000 - $110,000	0.2 – 0.3
	Beach nourishment to increase erosion buffer in this area (A1.13)	Short term	• Source sand for beach nourishment and place on the beach to build up dune and create buffer against storm erosion	• Would provide some protection for properties and infrastructures against storm erosion and inundation by augmenting the existing dune • Would be aesthetically pleasing and would not detract from the beach amenity	• Considerable study would be required to source sand and undertake environmental assessment • Avoca Beach planform is in equilibrium with the wave climate and beach nourishment unlikely to be effective as sand would be lost from the system. Groyne as a control structure was assessed to have little beneficial effect as there is low net alongshore drift (PWD, 1985b) • Significant cost required as sand must be sourced from outside the beach system. • Recommended sand source not able to be legally accessed at this time	$3.0 to $4.0 million	$6.9 – 9.2 million	$10.08 million (assumes 1% risk p.a. of $1,000,000 damage to 28 properties affected by 2050 coastal erosion/reduced foundation capacity hazard)	1.1 – 1.4
	Beach scraping to build dune in front	Short term (0 - 5	• Build up sand from the	• Would provide additional buffer of sand	• Ongoing cost for deployment of	$50,000	$0.9 million	up to $5.5	6.11

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
	of residences (A1.14)	years, ongoing)	beach berm into a dune and vegetate as per standard dune management practice in accordance with the Coastal Dune Management Manual (DLWC 2001).	for the existing dune against storm erosion • Would be aesthetically pleasing and would not detract from the beach amenity • Would assist the natural post-storm recovery of the beach • Opportunity to build up dune crest level to prevent coastal inundation due to wave runup	equipment. • Loss of views to residences if dune level built up higher than existing.		($50,000 cost undertaken bi-annually until 2050)	million (based on 50% reduced risk of minor structure damage to at-risk properties plus 50% reduced risk of damage to buildings caused by reduced foundation capacity by 2050)	
	Repair of beach accessways and revegetation of dune following erosion in a large storm event (A1.15)	Short term and following storms as required	• Undertake dune management as per standard dune management practice in accordance with the Coastal Dune Management Manual (DLWC 2001). Remove weeds and install native vegetation. Provide support to local Dunecare groups and local residents to maintain dune as required and repair after a storm	• Would improve public safety and assist natural recovery of dune following a storm event • Would reduce losses of sand due to wind erosion • Social benefit of community participation in bush regeneration	• None	$30,000 - $40,000	N/A	N/A	"No regrets" option to be implemented
Immediate and future risk of inundation risk to properties (south of Austral Avenue)	Development controls for residences to be above inundation levels on redevelopment of properties (A1.16)	Short term	• Can be added to or based upon existing DCP	• Protects new development against inundation due to wave runup • Can be easily implemented within existing DCP as existing controls already in place – no need to adjust existing controls.	• Additional controls may place additional impost onto beachfront property owners and could affect property resale values	$50,000 per residence on redevelopment	$50,000 per residence on redevelopment	$14,000 per residence (reduction in inundation damage, assumes 15% damage to housing with 1m average	0.28 (not including public safety benefit)

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
								overfloor depth and probability of occurrence of 1% p.a.)	
	Terminal seawall protection for the properties (A1.10)	Short to medium term	• Works may comprise a buried armour seawall protection for Avoca Drive properties. Structure to be implemented in the future once properties subject to immediate erosion hazard risk, to include works at Surf Club and adjacent carpark, to be funded jointly by Council/State Government and directly affected residents	• Would provide protection for the properties in a design storm. • Would protect services against future erosion risk • Works would not adversely affect amenity if well designed, as per existing works. • Works could be designed to benefit surf club and carpark as well as private infrastructure • Impact would be low as many properties currently have ad-hoc or emergency protection works currently in place, including at the Surf Club • Would manage inundation risk from wave runup	• Cost to design, construct and maintain works • Potential for increased erosion impacts after a large storm in front of and on either side of the works due to wave reflections • Potential for future loss of access along the beach in front of structure • Potential for erosion protection works to interrupt longshore transport and impact on coastal processes in the future • Requires beach nourishment	$6.0 to $7.0 million	$9.52 million (based on $7 million construction/design cost plus 1% maintenance p.a.)	$10.08 million (assumes 1% risk p.a. of $1,000,000 damage to 28 properties affected by 2050 coastal erosion/reduced foundation capacity hazard)	1.06
Erosion risk to stormwater outlets	Erosion protection works in front and around the stormwater outlet should storm erosion occur (A1.17)	Short term	• Work may comprise a suitable apron or rock protection in front of the outlet	• Would protect stormwater outlet against damage by erosion in future storms	• Potential for minor future loss of access along the beach in front of outlet structure • Needs to be designed well to not exacerbate flooding in the upstream catchment area • Cost to design, construct and maintain. • May be limited technical scope to improve existing scour potential.	$100,000	$100,000	Difficult to quantify improvement in beach amenity	Not known
	Relocate stormwater outlets (A1.18)	Short term	• This option would involve investigating the feasibility of moving the stormwater outlet landward	• Would protect stormwater outlet against damage by erosion in future storms	• Could be technically difficult or not feasible to move the stormwater outlet landward due to the topography of the area	$100,000	$100,000	Difficult to quantify improvement in beach amenity	Not known
Inundation and erosion risk to Ficus Avenue	Repair damage to carpark and other infrastructure should storm erosion	As required	• Restore carpark using damage-resistant	• No initial capital outlay • Use of damage-resistant pavement would reduce future maintenance	• Risk of damage to carpark and surf club remains • Cost of repair	$150,000 to $180,000	$150,000 to $180,000	$42,000 to $50,000 (based	0.2 – 0.3

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
carpark	occur (A1.19)		pavements should it be damaged in a future storm event	requirements				on 2% risk of damage p.a.)	
	Beach scraping to build dune in front of carpark and properties 165 Avoca Drive to 1 Ficus Avenue (A1.20)	Short term (0 - 5 years)	• Build up sand from the beach berm into a dune and vegetate as per standard dune management practice in accordance with the Coastal Dune Management Manual (DLWC 2001).	• Would provide additional buffer of sand for the carpark against storm erosion • Would be aesthetically pleasing and would not detract from the beach amenity • Would assist the natural post-storm recovery of the beach • Opportunity to build up dune crest level to prevent coastal inundation due to wave runup	• Ongoing cost for deployment of equipment.	$50,000 every two years	$0.9 million ($50,000 cost undertaken bi-annually until 2050)	up to $0.7 million (based on $50,000 reduction of maintenance cost for pavement p.a. to 2050)	0.78
Immediate and future erosion and inundation risk to properties and infrastructures at Avoca Lake Entrance	Development controls for residences to be above inundation levels on redevelopment of properties (A3.1)	Short term	• Can be added to or based upon existing DCP	• Protects new development against inundation due to wave runup • Can be easily implemented within existing DCP as existing controls already in place – no need to adjust existing controls.	• Additional controls may place additional impost onto beachfront property owners and could affect property resale values	$50,000 per residence on redevelopment	$50,000 per residence on redevelopment	$14,000 per residence (reduction in inundation damage, assumes 15% damage to housing with 1m average overfloor depth and probability of occurrence of 1% p.a.)	0.28
	Review entrance management guidelines for mechanical opening of Avoca Lake (A3.2)	Short term	• The entrance management policy and procedure for Avoca Lake is to be reviewed as identified in the Gosford Lagoons planning process	• Would reduce erosion due to scour across the beach berm and along the dune adjacent to the properties north of the lagoon entrance • Would reduce the risk of catchment based flooding to properties adjacent to the creek.	• Would require regular deployment of equipment to put the strategy in place and monitoring to assess whether trigger conditions have been reached.	$5,000 for review + $12,000 p.a. average lagoon opening cost	N/A	N/A	"No regrets" option
	Allow lagoon frontage properties to self-protect (A3.3)	Short term	• Allow property owners to self-protect when erosion escarpment reaches trigger distance from	• Would provide protection against erosion damage to properties.	• Cost to design, construct and maintain works; • May adversely impact on coastal hazard at adjacent properties • Potential for increased erosion impacts	$250,000 per property	$93,000 per property, assuming 1% probability p.a.	$93,000 per residence (reduction in erosion damage	1.0

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
			defined building line		after a large storm in front of and on either side of the works due to wave reflections • Potential for future loss of access along the beach in front of structure		that protection would be required	of $250,000 per property, probability of occurrence of 1% p.a.)	
Immediate and future risk of erosion risk to properties at North Avoca Beach	Allowing development landward of the 2050 Zone of Slope Adjustment with piled foundations into the 2100 Stable Foundation Zone (A4.1)	Short term	• This would be similar to the provisions of the existing DCP, although the hazard now affects more properties than previous assessment. The clause that development not give rise to any increased hazard could be applied to prevent building re-development from being allowed to move seaward of the existing location. within coastal hazard area to be allowed	• Would not increase the coastal hazard risk compared with existing situation • Would be consistent with existing DCP. • Benefit is individual value of a proportion of properties protected by being on piled foundations by 2050 or 2100	• Inundation still a risk for many properties • Development potential for up to 10 properties lost when compared with existing • Risk still remains for existing properties until they are redeveloped • There will still be 37 buildings at risk of damage prior to 2050 due to erosion within the future Immediate wave impact zone.	N/A	$5.62 million approx. (assumes 1% risk p.a. of $50,000 damage to minor structures per property affected by coastal erosion hazard by 2050, plus 1% risk p.a.of $100,000 for 37 buildings with a portion seaward of the 2050 Zone of Slope Adjustment, plus 10% loss in property value for up to 10 properties where development potential is impacted compared with existing)	$15.12 million (assumes 1% risk p.a. of $1,000,000 damage to 42 private properties seaward of 2050 Zone of Reduced Foundation Capacity)	2.7
	Allowing development landward of a specially defined building line with piled foundations into the 2100 Stable Foundation Zone (i.e. similar to existing DCP, status quo, A4.2)	Short term	• This would be similar to the provisions of the existing DCP. The clause that development not give rise to any increased	• Would not increase the coastal hazard risk compared with existing situation • Would be consistent with existing DCP. • Benefit is individual value of properties protected by being on piled foundations	• Inundation still a risk for many properties • Risk still remains for existing properties until they are redeveloped • Risk due to buildings in immediate impact zone increasing with time	N/A	$2.34 million approx. (assumes 1% risk p.a. of $50,000	$15.12 million (assumes 1% risk p.a. of $1,000,000 damage to 42	6.5

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
			hazard could be applied to prevent building re-development from being allowed to move seaward of the existing location. within coastal hazard area to be allowed.	by 2050 or 2100 • No loss of development potential when compared with existing DCP	• There will still be 37 buildings at risk of damage prior to 2050 due to erosion within the future Immediate wave impact zone.		damage to minor structures per property affected by coastal erosion hazard by 2050, plus 1% risk p.a. of $100,000 for 31 buildings with a portion seaward of the 2050 Zone of Slope Adjustment, plus 2% risk p.a. for damage of $100,000 for up to 6 buildings in the Immediate Zone of Slope Adjustment)	private properties seaward of 2050 Zone of Reduced Foundation Capacity)	
	Allowing development landward of the 2100 Zone of Slope Adjustment with piled foundations into the 2100 Stable Foundation Zone (A4.3)	Short term	• This would be more restrictive than the existing DCP, with 49 dwellings currently having a portion seaward of this line	• Would improve the long term risk to development in the precinct compared with existing i.e. between 2050 and 2100	• Loss of development potential for 49 properties could lead to a decline in local property values, although the potential decline is difficult to estimate • These properties would not remain viable in the future and may need to be purchased after 2050	N/A	$24 million approx. (assumes 1% risk p.a. of $50,000 damage to minor structures per property affected by coastal erosion hazard by 2050, plus 10% property value loss for 67 properties that would have reduced	$15.12 million (assumes 1% risk p.a. of $1,000,000 damage to 42 private properties seaward of 2050 Zone of Reduced Foundation Capacity)	0.63

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
							development potential)		
	Erosion protection works to be allowed for properties for emergency protection (funded by residents) (A4.4)	Short to medium term, some of these properties already have protection installed	• Works may comprise similar design to existing adjacent works	• Would provide protection for the properties in a design storm. • Would be consistent with works already installed at adjacent properties. • Would protect services against future erosion risk • Works would not adversely affect amenity if well designed, as per existing works.	• Cost to design, construct and maintain works • Potential for increased erosion impacts after a large storm in front of and on either side of the works due to wave reflections • Potential for future loss of access along the beach in front of structure • Potential for erosion protection works to interrupt longshore transport and impact on coastal processes in the future	$250,000 per property	$92,500 per property (assumes 1% probability p.a. that works will be required to 2050)	$67,000 per property (assumes 50% reduction of 1% risk p.a. of $1,000,000 damage to 28 properties affected by 2050 coastal erosion/reduced foundation capacity hazard)	0.72
	Terminal seawall protection for all the properties (A4.5)	Short to medium term	• Works may comprise a buried armour seawall protection for all the properties along North Avoca beachfront. • Engineered buried terminal protection structure to be implemented in the future once properties subject to immediate erosion hazard risk. • Could be funded jointly by State, Federal Government and directly affected residents or by residents only.	• Would provide protection for the properties in a design storm. • Would protect services against future erosion risk • Works would not adversely affect amenity if well designed, as per existing works.	• Cost to design, construct and maintain works • Potential for increased erosion impacts after a large storm in front of and on either side of the works due to wave reflections • Potential for future loss of access along the beach in front of structure • Potential for erosion protection works to interrupt longshore transport and impact on coastal processes in the future • Requires beach nourishment	$9.0 to $10.0 million	$13.6 million (based on $10 million construction/design cost plus 1% maintenance p.a.)	$16.2 million (assumes 1% risk p.a. of $1,000,000 damage to 45 properties affected by 2050 coastal erosion/reduced foundation capacity hazard)	1.42
	Terminal seawall protection for the properties north from the Surf Club only (A4.6)	Short – medium term (0 – 20 years)	• Engineered buried terminal protection structure to be implemented • Could be funded jointly	• Would provide protection for the properties and surf club in a design storm. • Would protect services against future erosion risk • Works would not adversely affect	• Cost to design, construct and maintain works • Potential for increased erosion impacts after a large storm in front of and on either side of the works due to wave reflections	$1.2 million	$1.63 million (based on $1.2 million construction/design cost for 120	$3.6 million (assumes 2% risk p.a. of $1,000,000 damage to 5	2.21

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
			by State, Federal Government and directly affected residents or by residents only.	amenity if well designed	• Potential for future loss of access along the beach in front of structure • Potential for erosion protection works to interrupt longshore transport and impact on coastal processes in the future • Requires beach nourishment		m long structure plus 1% maintenance p.a.)	properties affected by erosion hazard)	
	Planned retreat from this area, including the voluntary purchase of properties where buildings are seaward of 2050 Zone of Slope Adjustment (A4.7)	Medium – long term	• Voluntary purchase to be offered for 37 properties where buildings are seaward of the 2050 Zone of Slope Adjustment	• Would remove the risk to these properties over time • Opportunity to improve local amenity by provision of additional community space • Opportunity to improve environmental values of dune	• Very high cost • Low take-up rate of voluntary purchase scheme • Social and economic impact on locality • Loss of rate income	$129.5 million including loss of rate income	$137.5 million (based on $3.5 million average purchase price per property for 37 properties) including net present value of $8 million of loss of rate income	$13.32 million (assumes 1% risk p.a. of $1,000,000 damage to 37 properties affected by erosion hazard)	0.10
	Voluntary purchase of properties where buildings are seaward of Immediate Zone of Slope Adjustment (A4.8)	Medium term	• Voluntary purchase to be offered for 6 properties where buildings are seaward of the Immediate Zone of Slope Adjustment	• Would remove the risk to these properties • Opportunity to improve local amenity by provision of additional community space • Opportunity to improve environmental values of dune	• Very high cost • Low take-up rate of voluntary purchase scheme • Social and economic impact on locality	$21 million including loss of rate income	$22 million (based on $3.5 million average purchase price per property for 6 properties) and including loss of rate income	$4.32 million (assumes 2% risk p.a. of $1,000,000 damage to 6 properties affected by erosion hazard)	0.20
	Relocate sewer infrastructure further landwards (A4.9)	Short term (0 – 5 years)	• Sewer currently located at the seaward end of the properties – this option would involve investigating the feasibility of moving the sewer landward out of the hazard area	• Would protect sewer and pumping station against damage by erosion in future storms	• Could be technically difficult or not feasible to move sewer landward due to the topography of the area.	$350,000 to $450,000	$350,000 to $450,000	$100,000 - $130,000	0.2 – 0.3
	Beach nourishment to increase erosion buffer in this area (A4.10)	Short term	• Source sand for beach nourishment and place on the beach to build up dune and create buffer	• Would provide some protection for properties and infrastructure against storm erosion and inundation by augmenting the existing dune	• Considerable study would be required to source sand and undertake environmental assessment • Avoca Beach planform is in equilibrium	$5.5 to $6.5 million	$6.2 – 7.3 million	$16.2 million (assumes 1% risk p.a. of $1,000,000	2.3

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
			against storm erosion	• Would be aesthetically pleasing and would not detract from the beach amenity	with the wave climate and beach nourishment unlikely to be effective as sand would be lost from the system. Groyne as a control structure was assessed to have little beneficial effect as there is low net alongshore drift (PWD, 1985b) • Significant cost required as sand must be sourced from outside the beach system. • Recommended sand source not able to be legally accessed at this time			damage to 45 properties affected by 2050 coastal erosion/reduced foundation capacity hazard)	
	Repair of beach accessways and revegetation of dune following erosion in a large storm event (A4.11)	Short term and following storms as required	• Undertake dune management as per standard dune management practice in accordance with the Coastal Dune Management Manual (DLWC 2001). Remove weeds and install native vegetation. Provide support to local Dunecare groups and local residents to maintain dune as required and repair after a storm	• Would improve public safety and assist natural recovery of dune following a storm event • Would reduce losses of sand due to wind erosion • Social benefit of community participation in bush regeneration	• None	$30,000 - $40,000	N/A	N/A	"No regrets" option to be implemented
Immediate and future risk of inundation risk to properties at North Avoca Beach	Development controls for residences to be above inundation levels on redevelopment of properties (A4.12)	Short term	• Can be added to or based upon existing DCP	• Protects new development against inundation due to wave runup • Can be easily implemented within existing DCP as existing controls already in place – no need to adjust existing controls.	• Additional controls may place additional impost onto beachfront property owners and could affect property resale values	$50,000 per residence on redevelopment	$50,000 per residence on redevelopment	$14,000 per residence (reduction in inundation damage, assumes 15% damage to housing with 1m average overfloor depth and probability of occurrence of	0.28

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
								1% p.a.)	
Scour erosion due to stormwater outlet	Scour protection in front of stormwater outlets (A4.13)	Short term	• Work may comprise a suitable apron or rock protection in front of the outlet	• Would reduce erosion due to scour across the beach berm	• Potential for minor future loss of access along the beach in front of outlet structure • May be limited technical scope to improve existing scour potential. • Needs to be designed well to not exacerbate flooding in the upstream catchment area • Cost to design, construct and maintain.	$100,000	$100,000	Difficult to quantify improvement in beach amenity	Not known
Immediate and future risk of erosion and inundation risk to the North Avoca SLSC and carpark	Erosion protection works at surf club (A4.14)	Short to medium term (0 – 20 years)	• Works may comprise engineered revetment placed along existing embankment on seaward side of surf club	• Would provide protection for the surf club and carpark in a design storm. • Works would not adversely affect existing beach amenity if well designed.	• Cost to design, construct and maintain works • Potential for increased erosion impacts after a large storm in front of and on either side of the works due to wave reflections	$600,000 to $800,000	$680,000 to $900,000	$280,000 (based on 2% risk p.a. of $1million damage)	0.3 – 0.4
	Repair damage to surf club carpark should storm erosion occur (A4.15)	As required	• Restore carpark using damage-resistant pavements should it be damaged in a future storm event	• No initial capital outlay • Use of damage-resistant pavements would reduce future maintenance costs	• Risk of damage to carpark and surf club remains, although there is existing rock remaining from previous storms • Cost of repair	$60,000 to $80,000	$60,000 to $80,000	$20,000 (reduced repair cost over time)	0.25 – 0.3
	Beach nourishment in front of surf club and carpark (A4.16)	Short to medium term (0 – 20 years)	• Import of sand into this portion of the beach to increase buffer against beach erosion	• Would provide buffer against storm erosion demand to help protect surf club	• Suitable source of sand has not been identified, possibly from mobile dunes further north along the beach. Extensive studies required to identify source of sand and undertake environmental assessment • Nourishment works would likely not remain on the beach at this location	$500,000 to $800,000	$1.1 - $1.8 million (based on renourishment required every 10 years)	$280,000 (based on 2% risk p.a. of $1million damage)	0.15 – 0.25
	Beach scraping to build vegetated dune in front of surf club and carpark (A4.17)	Short term (0-5 years)	• Scrape sand to build a dune in front of the surf club and vegetate as per standard dune management practice in accordance with the Coastal Dune	• Would improve protection of the surf club and carpark against storm erosion and inundation by providing a buffer of sand • Would be aesthetically pleasing and would not detract from the beach amenity	• Not likely to provide sufficient protection against future storm event • Dune would be damaged by future storm events and would require maintenance • Cost of environmental assessment and planning activities. • Disruption to beach users during works.	$4,000 to $7,000	Up to $130,000 if undertaken every two years	$130,000 (based on 50% reduction of 2% p.a. probability of $1 million damage)	1.0

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
			Management Manual (DLWC 2001).						
	Future relocation of surf club and associated infrastructure to an area landward of the coastal hazard area (A4.18)	Long term (> 20 years)	• Relocate surf club to an area outside the erosion hazard zone e.g. adjacent to the main carpark once asset is due for renewal. Would require identification and securing of appropriate land parcels for this purpose.	• Would remove the immediate erosion risk to the surf club	• Cost to reconstruct surf club on piled foundations and potential cost to purchase land for placement of new surf club • Possible loss of carparking spaces	$1.0 to $2.0 million not including land purchase cost	$1.0 to $2.0 million not including land purchase cost	$280,000 (based on 2% risk p.a. of $1million damage)	0.14 – 0.28
	Build and maintain a dune in front of surf club above the wave runup level with vegetation and/or fencing (A4.19)	Short term (0-5 years)	• Build up sand from the beach berm into a dune and vegetate as per standard dune management practice in accordance with the Coastal Dune Management Manual (DLWC 2001). Remove weeds and install native vegetation. Provide support to local Dunecare groups and local residents to maintain dune as required and repair after a storm	• Would improve protection of the surf club and carpark against storm erosion and inundation by providing a buffer of sand • Would be aesthetically pleasing and would not detract from the beach amenity • Social benefit of community participation in bush regeneration	• Not likely to provide sufficient protection against future storm event • Dune would be damaged by future storm events and would require maintenance	$100,000 to $150,000	$230,000 - $350,000 (assumes dune would need to be rebuilt every 10 years on average)	$140,000 (based on decreased risk of damage)	0.4 – 0.6
	Redevelop surf club on deep piled foundations (A4.20)	Medium term (5 – 20 years)	• On future redevelopment of surf club, reconstruct on deep piled foundations. Surf club likely to be underlain by rock – foundations can be piled into the rock	• Would remove the risk of erosion damage to the surf club • Surf club can stay in its existing location	• Cost of reconstruction • Temporary loss of facility while reconstruction taking place	$1.0 to $1.5 million	$1.0 to $1.5 million	$280,000 (based on 2% risk p.a. of $1million damage)	0.19 – 0.28
All issues	Emergency Management (A4.21)	As required	• Undertake pre, during and post storm actions as	• Public safety	• N/A	N/A	N/A	N/A	"No regrets" option

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
			described in Section 7.8 when trigger for action is reached						

8.10 Terrigal-Wamberal Beach

8.10.1 Issues and Options

The major coastal hazards identified at Terrigal and Wamberal Beach are:

- **Coastal inundation** due to wave runup affecting the Terrigal Surf Club, future impact on the Terrigal commercial zone due to overtopping of existing seawall and beachfront residences along Wamberal Beach;
- **Coastal erosion** having the potential to impact on the beachfront residences along Wamberal Beach and minor structures such as dune fencing, viewing platform and accessways;
- **Slope Instability** having the potential to result in reduced foundation capacity for up to 87 lots and services including stormwater, sewer and water along Wamberal Beach, with this number increasing to 126 lots by 2100;
- **Future coastal erosion** and recession affecting up to 100 length of Calais Road, 500 m length Ocean View Drive and 200 m length of Pacific Street by 2100, as well as dwellings, services including stormwater, sewer, water and power along the roads; and
- **Erosion associated with estuary entrance instability** at Terrigal and Wamberal Lagoon.

The consequences of these coastal hazards being realised include:

- Present day potential for overfloor inundation of houses by wave runup, causing damage to existing buildings and services supplying those buildings;
- Present day threat of erosion damage to the beachfront buildings along Wamberal Beach identified as being within the Present Day *Zone of Slope Adjustment*;
- Present day threat of erosion damage to dune fencing, viewing platforms and accessways;
- Future erosion risk to stormwater, sewer, water and power services along Calais Roads, Ocean View Drive, Pacific Street and at end of Dover Road;
- Future erosion risk to properties along Wamberal Beach is expected to increase, increasing the risk of damage to private property due to erosion and reduced foundation capacity, as well as risk to public safety increasing with time;
- Future increased potential for overfloor inundation of houses by wave runup, and also inundation due to increased tailwater levels due to future sea level rise at the entrances to Terrigal and Wamberal Lagoon.

Terrigal-Wamberal Beach has been divided into a number of precincts moving from south to north, considering particular characteristics within each precinct, namely:

- **Precinct 1** – Terrigal Haven

- **Precinct 2** – Terrigal Beach;
- **Precinct 3** – Terrigal Lagoon to Wamberal Beach;
- **Precinct 4** – Wamberal Beach;
- **Precinct 5** – Wamberal Lagoon; and
- **Precinct 6 –** North Wamberal Beach.

Potential management actions that are relevant in addressing the identified coastal hazards for Terrigal and Wamberal Beach include:

- Undertake **erosion protection works** to protect properties, houses and infrastructure along Wamberal Beach;
- **Monitoring** of existing erosion protection works at Terrigal and Terrigal haven to assess performance with respect to wave overtopping;
- **Development controls** to ensure new developments for Wamberal Beach are located with a floor level 0.5m above the maximum wave runup level or 100 year ARI flood level (whichever is higher), allowing for future sea level rise;
- **Development controls** to ensure new developments for Wamberal Beach within the coastal hazard areas are unlikely to be damaged within a chosen planning period by coastal erosion and inundation (i.e. founded into the local 2050 or 2100 stable foundation zone and located with a floor level 0.5m above the maximum wave runup level, allowing for future sea level rise);
- **Relocation of existing buildings and infrastructure** subject to potential damage due to coastal erosion e.g. residences and services;
- Undertake or allow residents to undertake **erosion protection works** to protect the residences near the Terrigal and Wamberal Lagoon entrance;
- **Maintenance of the dune crest** above the level of wave runup to prevent wave runup reaching the buildings;
- **Placement of sand** on the beach in front of the properties in the form of beach nourishment or beach scraping to increase the buffer of sand available and provide some protection against storm erosion;
- Undertake periodic beach nourishment to provide a buffer against erosion;
- Entrance management guidelines for opening Terrigal and Wamberal Lagoon - provide defined opening line/s and angles which will minimise bank erosion, cliff instability and minimise damage to the beach front, and include the opening guidelines within Council's Lagoon Opening Policy and Procedure.

A suite of 24 specific management options for actions that could be undertaken by Council have been developed to address the coastal hazards identified at Terrigal and Wamberal Beach for consideration. Each option has been provided with an identifier (TW2.1 to TW5.2) as illustrated in Table 28. A more detailed summary of these main options for coastal zone management including advantages and disadvantages, timeframe for adoption and indicative costs is provided in Table 29.

8.10.2 Landuse and Development

At Terrigal Beach, coastal protection works have been implemented in the form of vertical concrete block seawalls, for both the Terrigal Haven area and the main Terrigal Beach area. These structures have been designed to modern engineering standards and it has been assumed that they will be effective in a large storm event. The effectiveness of the existing structures should be monitored in a future large storm. North of the Surf Club, Terrigal Drive is underlain by a sandstone escarpment, the toe of which has been protected by large boulders. The effectiveness of these works should be assessed in a future storm event.

At Wamberal Beach, 73 properties have been assessed to be partially affected by the *Immediate Zone of Slope Adjustment* with 61 private buildings partially seaward of the *Immediate Zone of Slope Adjustment*. The coastal erosion and inundation hazards at Wamberal Beach have been documented in previous studies, including the Gosford Open Coast Beaches Coastal Management Plan (WBM, 1995). The erosion and inundation risks have been found to be increasing over time at Wamberal, as documented in the most recent Coastal Process and Hazard Definition Study (WorleyParsons 2014). Note that the previous coastline Hazard Lines for the study area did not make any allowance for reduced foundation capacity as required now by the Guidelines for Preparing Coastal Zone Management Plans (Office of Environment and Heritage 2013).

Development along Wamberal-Terrigal Beach has been threatened, damaged or destroyed by the action of coastal storms, particularly in the 1960's, 1974 and 1978 (WorleyParsons 2014). As a result, rock and other material has been placed at some locations in an attempt to prevent property damage. Specifically PWD (1985) noted that:

- major storms of May-June 1974 caused severe erosion of Central Coast beaches, and a house at the northern end of Wamberal-Terrigal Beach was severely damaged as its seaward brick foundation wall was undermined by dune erosion and,
- two houses (at 23a and 23b Ocean View Drive) collapsed due to undermining caused by dune erosion in June 1978.

PWD (1985) noted that virtually all beachfront development at Wamberal-Terrigal Beach was threatened from severe erosion in the 1974 storms, and that the State Emergency Service and Australian Army were called in and tipped rocks, sand bags and other materials seaward of the eroding dune face. Beachfront property owners also constructed a variety of structures in response, comprising rock rubble, corrugated iron, rubber tyres, besser blocks, concrete walls and gunite (cement, sand, and water applied through a pressure hose).

8.10.2.1 Terminal Protection Structure

A Terminal Protection Structure has been designed for the entire beach frontage north of the entrance to Terrigal Lagoon and south of the entrance to Wamberal Lagoon (WRL, 1998), based on the recommendations of the previous Coastal Zone Management Plan. The proposed structure consists of a buried Seabee armoured revetment.

An Environmental Assessment for two options, being the construction of a terminal protection structure coupled with periodic beach nourishment and large scale beach nourishment alone, was carried out (MHL, 2003). At this time, no suitable source for beach nourishment has been secured, with the most suitable identified source being located offshore. However, the offshore resources are currently not available for extraction due to the prohibition on offshore minerals extraction enforced in the *Offshore Minerals Act (1999)* (Withycombe *et al.*, 2009).

The existing Gosford DCP allows building seaward of the 2045 erosion line but at least 3 m landward (up to 7 m landward in some areas) of the proposed revetment, subject to special conditions. Therefore, under the existing policy, development has been allowed to occur on land seaward of the *Immediate Zone of Slope Adjustment* in the interim prior to a terminal protection structure being implemented.

The Wamberal Terminal Protection Structure is currently Council's preferred protective strategy for Wamberal Beach.

In July 2004 Council resolved to pursue the construction of a buried Terminal Protective Structure (TPS) along the length of Wamberal Beach extending from Terrigal Lagoon in the south to Wamberal SLSC in the north. The design of the TPS was completed in 1998 by the Water Research Laboratory and an Environmental Impact Statement was prepared in 2003 by Manly Hydraulics Laboratory.

On the 30 March 2006, the Mayor, the General Manager and Council's Principal Environmentalist met with the Minister Kelly along with his Policy Adviser on Emergency Services. At the meeting Council presented a detailed briefing paper. In summary, the briefing paper requested:

- Funding assistance of a one off request of $2.8 million from the State Government towards the construction of an $8.2 million terminal protection structure (seawall) along Wamberal Beach. Council is seeking a similar financial assistance from the Federal Government of $2.8 million and intends to seek the balance of $2.8 million from the 78 residential properties that front Wamberal Beach to cover the total project cost of $8.2 million. The estimated cost for the construction of the Wamberal TPS in 2014 would be approximately $10.5 million.
- In addition to the construction cost Council was seeking an ongoing commitment of approximately $380,000 towards periodic sand nourishment which is currently estimated at $760,000.

Council has since endeavoured to source grant funds through the State's Coastal Management Program and the Federal Government's Natural Disaster Mitigation Program. Council has also lobbied State and Federal governments, however, all efforts to secure financial assistance for the project have been unsuccessful.

A Strategy Policy Paper was developed (Gosford Council, 2004) specifically to consider a protection strategy for Wamberal Beach, which recommended that the Wamberal Terminal Protection Structure be endorsed as the preferred protective strategy for Wamberal Beach. The purpose of that report was to provide information on the protection of Wamberal Beach. That report contains the following:

- explanation of the coastal processes affecting Wamberal beach,
- responses by Council to address the coastal processes at Wamberal beach,
- overview of the key options investigated to protect Wamberal beach,
- results from community consultation, and
- a recommended strategy for the protection of Wamberal beach.

Council also commissioned a research study specifically considering Wamberal Beach (Beavis *et al.*, 2009). That study considered the environmental, economic and social implications of the following strategies for Wamberal Beach:

- do nothing;
- planned retreat;
- beach nourishment; and
- terminal protection structure.

The study found that the Terminal Protection Structure is the most viable option but that funding is a key obstacle. Funding for the project has yet to be secured – with Council seeking equal funding from affected beachfront owners, State Government and Federal Government.

It is noted that the option of funding the works entirely based on the contribution of beachfront property owners has not been explored to date.

8.10.2.2 EMERGENCY ACTION SUBPLAN

An Emergency Action Sub-plan has been developed for Wamberal Beach. The subplan identifies the extent of ad hoc protection works at the various private lots along the beachfront.

Wamberal Beach has been named as an "Authorised Location" for placement of temporary protection works in the Code of Practice under the *Coastal Protection Act 1979* (OEH 2013). Under the Code of Practice, landowners may place temporary protection works comprising either:

- sand filled geotextile containers each of maximum 0.75m^3 filled volume stacked in a single layer up to 1.5 m high (at a slope flatter than 34° from the horizontal, that is flatter than 1:1.5 vertical:horizontal); or,
- clean sand placed up to the crest on the seaward side of an eroding escarpment (under the Code of Practice, this is not permitted to be sourced from the beach on which the works are to be placed).

It is emphasised that landowners must act well (generally months) in advance of a storm to consider implementing these works. It should also be noted that landowners are not permitted to install coastal protective works without following the procedures outlined in the Code of Practice (OEH 2013), and severe penalties may apply if they are not followed.

Based on *State Environmental Planning Policy (Infrastructure) 2007*, landowners can consider the installation of emergency or long term coastal protective works of any form. As consent is required under *SEPP Infrastructure* for such works, Part 4 of the *Environmental Planning and Assessment Act 1979* applies. Therefore, before installing these general protective works it would be necessary for landowners to:

- undertake an environmental assessment, that is either a Statement of Environmental Effects or an Environmental Impact Statement (the latter if significant impacts were expected); and,
- lodge a Development Application (DA) with a consent authority.

Until a Coastal Zone Management Plan (CZMP) is in force on the land, the NSW Coastal Panel is the consent authority.

In January 2011, the then Minister administering the Coastal Protection Act 1979 directed Gosford City Council under section 55B of the Act to submit draft Emergency Action Subplan (EAS) for Wamberal-Terrigal Beach which was identified as an authorised location.

The minimum requirements of the EAS as set out in the NSW Government Guide Note are to describe:

- intended emergency actions to be carried out during periods of beach erosion, such as coastal protection works for property or asset protection, other than matters dealt with in any plan made under the State Emergency and Rescue Management Act 1989 relating to emergency response,
- any site-specific requirements for landowner emergency coastal protection works, and
- the consultation carried out with the owners of land affected by the subplan.

While the EAS for the Wamberal/Terrigal Beach was prepared in advance of the Coastal Zone Management Plan, it will later be incorporated into the Gosford's Open Coast & Broken Bay Beaches Coastal Zone Management Plan.

8.10.2.3 Options for Wamberal Beach

Given the degree of coastal hazard, realistic options for Wamberal Beach include:

- Reviewing the design and environmental assessment for the Wamberal Terminal Protection Structure, and securing funding for its construction;
- In the interim, prior to construction of the Terminal Protection Structure, modifying the Gosford DCP to not allow new development seaward of the *Immediate Zone of Slope Adjustment*, or defining a new foreshore building line landward of the *Immediate Zone of Slope Adjustment*, requiring that any new development be piled into the *2100 Stable Foundation Zone;*
- Should funding not be able to be secured or the TPS not go ahead, voluntary purchase of the individual properties where buildings are located seaward of the *Immediate Zone of Slope*

Adjustment could be offered – it is estimated based on data available at www.onthehouse.com.au that individual properties are valued at $4 million each. This could be coupled with application of the Gosford DCP on the same basis as what has been applied to the rest of the beaches in the LGA – i.e. locating new development landward of the *2050 Zone of Slope Adjustment*and requiring piling into the *2100 Stable Foundation Zone.* This would effectively disallow new development on the existing lots, thereby not increasing the value of properties currently at risk of erosion.

If voluntary purchase (i.e. planned retreat) were to be offered to individual property owners, it would need to be done as part of an overall strategy for the whole beachfront, as removal of properties on an individual *ad hoc* basis would not remove the coastal hazard risk from those properties that remain. Alternatively, voluntary purchase of those individual properties seaward of the *Immediate Zone of Slope Adjustment* and not recently re-developed and constructed on piles in accordance with the most recent Gosford DCP could be offered, as it is these homes that would be most at risk in a major coastal storm.

Funding for a Terminal Protection Structure could be provided by local property owners through a contribution payment toward the construction costs, with commissioning of the design and construction undertaken through funding from the NSW Coastal Management Program and part funding from Council. However, advice from OEH to Council is that the TPS at Wamberal would be a low priority for funding because it would mainly protect private property. Maintenance would then be the responsibility of the local landowners, which could be undertaken by Council but funded by the residents. It is noted also that, should a Terminal Protection Structure not be constructed, then there is a risk that access could be lost along Ocean View Drive in the vicinity of 25 Ocean View Drive sometime in the future, with breakthrough into the lagoon possible. Should this occur, access to this area could be restored through construction of a bridge, or be cut off from the south permanently.

It is noted that some of the individual residents (as identified in the Emergency Action Subplan) can place temporary protection works in accordance with the *Coastal Protection Act 1979* – however, these would be unlikely to provide sufficient protection against a very severe coastal storm. Until the updated Coastal Zone Management Plan is in force, placement of coastal protection works of any form by individual property owners could be considered based on *State Environmental Planning Policy (Infrastructure) 2007*, which would require an environmental assessment under Part 4 of the *Environmental Planning and Assessment Act 1979*, and a development application can be lodged with the NSW Coastal Panel. It is noted that a long term solution is preferred over emergency protection measures, due to the environmental impact on beach if emergency works are carried out in an ad-hoc manner.

Table 28 – Coastline Management Options for Terrigal-Wamberal Beach

Precinct	Issue/Hazard	Management Option
Precinct 1 – Terrigal Haven	Beach erosion/inundation impacting on recreational amenity	Monitor performance of existing seawall in addressing erosion and inundation (TW1.1)
		Monitor beach profile following significant storm events (TW1.2)
		Beach nourishment to increase buffer against storm erosion (TW1.3)
Precinct 2 – Terrigal Beach	Immediate and future inundation risk to Terrigal Surf Life Saving Club	Survey floor levels to determine degree of inundation hazard (TW2.1)
		Monitor performance of existing seawall against erosion and inundation (TW2.2)
Precinct 3 – Terrigal Lagoon	Immediate and future erosion and inundation risk to properties north of Terrigal Lagoon entrance	Review entrance management guidelines for mechanical opening of Terrigal Lagoon (TW3.1)
		Allow lagoon frontage properties at southern end of Pacific Street to self-protect (TW3.2)
		Beach scraping from lagoon entrance to reduce erosion and inundation risk to properties at southern end of Pacific Street (TW3.3)
Precinct 3&4 – Wamberal Beach	Immediate and future erosion and inundation risk to properties and infrastructures	Allowing development landward of the 2050 Zone of Slope Adjustment with piled foundations into the 2100 Stable Foundation Zone (TW4.1)
		Allowing development landward of a specially defined building line or Immediate Zone of Slope Adjustment with piled foundations into the 2100 Stable Foundation Zone (TW4.2)
		Allowing development as per existing DCP (i.e. 3 m or 7 m landward of revetment line depending on location) with piled foundations (i.e. status quo) (TW4.3)
		Allow residents to construct own permanent protection works combined with existing DCP controls (TW4.4)
		Terminal protection once erosion escarpment reaches trigger distance from defined building line (TW4.5)
		Planned retreat from this area, through voluntary purchase of properties where buildings are seaward of 2050 Zone of Slope Adjustment. (TW4.6)
		Voluntary purchase of properties where buildings are seaward of Immediate Zone of Slope Adjustment (i.e. 61 properties) (TW4.7)
		Continue dune vegetation management (TW4.8)
		Beach nourishment to increase buffer against storm erosion (TW4.9)
Precinct 5 – Wamberal Lagoon	Immediate and future erosion and inundation risk to properties south of the lagoon entrance	Review entrance management guidelines for mechanical opening of Wamberal Lagoon (TW5.1)
	Future erosion and immediate inundation risk to Wamberal Surf Life Saving Club	Repair damage to surf club carpark should storm erosion occur (TW5.2)
		Beach nourishment in front of carpark (TW5.3)
		Beach scraping to build vegetated dune in front of carpark (TW5.4)
		Future relocation of surf club and carpark to an area land ward of the coastal hazard area (TW5.5)
		Redevelop surf club on deep piled foundations (TW5.6)
All precincts	All issues	Emergency Management (TW5.7)

Table 29 – Detailed Summary of Management Options for Terrigal and Wamberal Beach

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
Beach erosion/inundation impacting on recreational amenity	Monitor performance of existing seawall in addressing erosion and inundation (TW1.1)	Short term, ongoing	• Monitor performance of existing seawall structure following storm events and inspect for signs of damage	• Would provide information on performance and effectiveness of the seawall to ensure properties and town centre are provided with continuing protection	• None	N/A	N/A	N/A	"No regrets" option to be implemented
	Monitor beach profile following significant storm events (TW1.2)	Short term, ongoing	• Monitor beach profile following storm events and inspect for signs of damage. Implement actions in Council's Beach Management Policy	• Would provide information on performance and effectiveness of the seawall to ensure properties and town centre are provided with continuing protection	• None	N/A	N/A	N/A	"No regrets" option to be implemented
	Beach nourishment to increase buffer against storm erosion (TW1.3)	Medium term	• Source sand for beach nourishment and place on the beach to build up dune and create buffer against storm erosion	• Would provide some protection to the public infrastructure against storm erosion and inundation • Would be aesthetically pleasing and enhance beach amenity	• Considerable study would be required to source sand and undertake environmental assessment • Significant cost required as sand must be sourced from outside the Wamberal Beach system. • Sand may be transported out of the area by littoral drift without the construction of a control structure such as a groyne. • Recommended sand source not currently able to be accessed under existing legislation.	$1 to $1.5 million	$2.3 – 3.4 million	Benefit of enhanced beach amenity	Not known
Immediate and future inundation risk to Terrigal Surf Life Saving Club and Terrigal commercial district	Survey floor levels to determine degree of inundation hazard (TW2.1)	Short term	• Undertake survey of existing floor levels – raising buildings could be examined as an action	• Would allow assessment of damage during inundation	• None	$3,000 to $5,000	N/A	N/A	"No regrets" option
	Monitor performance of existing seawall against erosion and inundation (TW2.2)	Short term/as required	• Monitor performance of existing seawall structure following storm events and inspect for signs of damage	• Would provide information on performance and effectiveness of the seawall to ensure properties and town centre are provided with continuing protection	• None	N/A	N/A	N/A	"No regrets" option to be implemented
Immediate and future erosion	Review entrance management guidelines for mechanical opening of	Short term	• The entrance management policy and	• Would reduce erosion due to scour across the beach berm and along the	• Would require regular deployment of equipment to put the strategy in place and	$5,000 for review +	N/A	N/A	"No regrets" option to be

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
and inundation risk to properties north of the Terrigal Lagoon entrance	Terrigal Lagoon (TW3.1)		procedure for Terrigal Lagoon is to be reviewed as identified in the Gosford Lagoons planning process.	dune adjacent to the properties north of the lagoon entrance • Would reduce the risk of catchment based flooding to properties adjacent to the creek.	monitoring to assess whether trigger conditions have been reached.	$64,500 p.a. for 12.9 average openings per year at $5,000 each.			implemented
	Allow lagoon frontage properties at southern end of Pacific Street to self-protect (TW3.2)	Short term	• Allow property owners to self-protect when erosion escarpment reaches trigger distance from defined building line	• Would provide protection against erosion damage to properties.	• Cost to design, construct and maintain works; • May adversely impact on coastal hazard at adjacent properties • May adversely impact on the ecology and hydrodynamics of the lagoon entrance • Potential for increased erosion impacts after a large storm in front of and on either side of the works due to wave reflections • Potential for future loss of access along the beach in front of structure	$250,000 per property	$93,000 per property, assuming 1% probability p.a. that protection would be required	$93,000 per residence (reduction in erosion damage of $250,000 per property, probability of occurrence of 1% p.a.)	1.0
	Beach scraping from lagoon entrance to reduce erosion and inundation risk to properties at southern end of Pacific Street (TW3.3)	Short term	• Beach scraping from Terrigal Lagoon entrance channel to beach in front of properties at southern end of Pacific Street as per current Council practice	• Reduction in erosion and inundation risk to properties at southern end of Pacific Street • Can be implemented in conjunction with entrance management activities	• Ongoing cost	$50,000 p.a.	$700,000	$280,000 (reduced risk of damage)	0.4
Immediate and future erosion and inundation risk to properties and infrastructures along Wamberal Beach	Allowing development landward of the 2050 Zone of Slope Adjustment with piled foundations into the 2100 Stable Foundation Zone (TW4.1)	Short term	• This would be similar to the provisions of the existing DCP at the remaining open coast beaches. However, this would impact the development potential of most of the properties on the beachfront. Could be implemented as an interim policy until TPS is constructed. Development controls to include an indemnity as	• Would improve the coastal hazard risk compared with existing situation • May be appropriate until TW4.5 and TW4.9 are carried out	• Development potential for up to 76 properties lost when compared with existing • Risk still remains for existing properties until they are redeveloped i.e. liability issues • There will still be 67 buildings at risk of damage prior to 2050 due to erosion within the future Immediate wave impact zone. • Risk that access to Wamberal Beach can be lost along Ocean View Drive if breakthrough into lagoon occurs.	N/A	$37 million approx. (assumes 2% risk p.a. of $150,000 damage per property affected by immediate coastal erosion hazard by 2050, plus 1% risk p.a.of $150,000 for 6 buildings	Up to $47.5 million (assumes 2% risk p.a. of $1,000,000 damage to 66 properties affected by immediate coastal erosion/reduced foundation capacity hazard)	1.28

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
			per existing DCP.				with a portion seaward of the 2050 Zone of Slope Adjustment, plus 10% loss in property value for up to 76 properties where development potential is impacted due to DCP compared with existing)		
	Allowing development landward of a specially defined building line or Immediate Zone of Slope Adjustment with piled foundations into the 2100 Stable Foundation Zone (TW4.2)	Short term	• This would be similar to but slightly more restrictive than the provisions of the existing DCP. The clause that development not give rise to any increased hazard could be applied to prevent building re-development from being allowed to move seaward of the existing location within coastal hazard area. Could be implemented as an interim policy until TPS is constructed. Development controls to include an indemnity as per existing DCP.	• Would not increase the coastal hazard risk compared with existing situation • Would be consistent with existing DCP. • Benefit is individual value of properties protected by being on piled foundations by 2050 or 2100 • Less loss of development potential when compared with adopting 2050 ZSA as building line • May be appropriate until TW4.5 and TW4.9 are carried out	• Inundation still a risk for many properties • Risk still remains for existing properties until they are redeveloped • Risk due to buildings in immediate impact zone increasing with time • There will still be 67 buildings at risk of damage prior to 2050 due to erosion within the future Immediate wave impact zone. • Risk that access to Wamberal Beach can be lost along Ocean View Drive if breakthrough into lagoon occurs.	N/A	$39.6 million approx. (assumes 2% risk p.a. of $200,000 damage per property affected by immediate coastal erosion hazard by 2050, plus 1% risk p.a.of $200,000 for 6 buildings with a portion seaward of the 2050 Zone of Slope Adjustment, plus 10% loss in property value for up to 76 properties	Up to $47.5 million (assumes 2% risk p.a. of $1,000,000 damage to 66 properties affected by immediate coastal erosion/reduced foundation capacity hazard)	1.20

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
							where development potential is impacted due to loss of land caused by erosion)		
	Allowing development as per existing DCP (i.e. 3 m or 7 m landward of revetment line depending on location) with piled foundations (i.e. status quo) (TW4.3)	Short term	• This would be similar to the provisions of the existing DCP. The clause that development not give rise to any increased hazard could be applied to prevent building re-development from being allowed to move seaward of the existing location within coastal hazard area. Could be implemented as an interim policy until TPS is constructed. Development controls to include an indemnity as per existing DCP.	• Would not increase the coastal hazard risk compared with existing situation • Would be consistent with existing DCP. • Benefit is individual value of properties protected by being on piled foundations by 2050 or 2100 • No loss of development potential when compared with existing • May be appropriate until TW4.5 and TW4.9 are carried out	• Inundation still a risk for many properties • Risk still remains for existing properties until they are redeveloped • Risk due to buildings in immediate impact zone increasing with time - i.e. liability issues • There will still be 67 buildings at risk of damage prior to 2050 due to erosion within the future Immediate wave impact zone. • Risk that access to Wamberal Beach can be lost along Ocean View Drive if breakthrough into lagoon occurs.	N/A	$41.8 million approx. (assumes 3% risk p.a. of $200,000 damage per building for 30 buildings within Immediate Wave Impact Zone, plus 2% risk p.a. of $200,000 damage per property affected by immediate coastal erosion hazard by 2050, plus 1% risk p.a.of $200,000 for 6 buildings with a portion seaward of the 2050 Zone of Slope Adjustment, plus 10% loss in property value for up to 76 properties	Up to $47.5 million (assumes 2% risk p.a. of $1,000,000 damage to 66 properties affected by immediate coastal erosion/reduced foundation capacity hazard)	1.14

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
							where development potential is impacted due to loss of land caused by erosion)		
	Allow residents to construct own permanent protection works combined with existing DCP controls (TW4.4)	Short term, ongoing	• Works must be designed by a coastal engineer • Allow works only for properties seaward of Immediate ZSA	• Would provide protection for individual properties • Cost would be entirely borne by landholder • May be appropriate until TW4.5 and TW4.9 are carried out	• Environmental impact on beach due to lack of coordinated approach • Impact on neighbouring unprotected properties if works carried out in ad-hoc manner • Lack of formal maintenance regime	$43 million (assumes half of properties take up protection, at a cost of $10,000/m for 12 m frontage)	$64.2 million (assume half of all properties would undertake protection, construction/design cost plus 1% maintenance p.a.), plus 5% risk p.a. of $1 million damage to 30 unprotected properties	up to $26 million (assumes 36 properties are protected - savings in potential damage = 2% risk p.a. of $1,000,000 damage to 36 properties)	0.40
	Terminal protection (TW4.5)	Short –medium term	• Works may consist of a buried armour seawall. Engineered buried terminal protection structure to be implemented in the future once properties subject to immediate erosion hazard risk to be funded either jointly by State, Federal Government and directly affected residents, by the residents only or by a special levy introduced onto affected lots	• Would provide protection against erosion damage to properties and infrastructure • Would protect services against future erosion risk • Works would not adversely affect amenity if well designed • A design has been already been prepared	• Cost to construct and maintain works • Potential for loss of recreational amenity through loss of access to foreshore • Probable need to undertake updated environmental assessment • Potential for increased erosion impacts in front of and on either side of the works due to wave reflections • Potential for future loss of access along the beach in front of structure • Requires sand nourishment	$13 to $15 million	$20.4 million (based on $15 million construction/design cost plus 1% maintenance p.a.)	Up to $47.5 million (assumes 2% risk p.a. of $1,000,000 damage to 66 properties affected by immediate coastal erosion/reduced foundation capacity hazard)	2.33

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
	Planned retreat from this area, through voluntary purchase of properties where buildings are seaward of 2050 Zone of Slope Adjustment. (TW4.6)	Medium – long term	• Voluntary purchase to be offered for 76 properties seaward of the 2050 Zone of Slope Adjustment • Council/State Government can offer to purchase the building through voluntary means via negotiations with the owners.	• Would remove the erosion hazard from the properties over time • Opportunity to improve local amenity by provision of additional community space • Opportunity to improve environmental values of dune	• Very high cost of purchase • Voluntary purchase may not be taken up by the property owners • Social and economic impact on locality • Loss of rate income • Cost is borne by the broader community and also by property owners due to loss of property value • Could lead to community decay and impact on investor confidence	$304 million including loss of rate income	$319 million (based on $4 million average purchase price per property for 76 properties) including $15 million loss of rate income (based on Council provided rate revenue discounted at 7% p.a. with 3% increase p.a. in rate)	Up to $47.5 million (assumes 2% risk p.a. of $1,000,000 damage to 66 properties affected by immediate coastal erosion/reduced foundation capacity hazard)	0.15
	Voluntary purchase of properties where buildings are seaward of Immediate Zone of Slope Adjustment (i.e. 61 properties) (TW4.7)	Medium term (5 - 20 years)	• Voluntary purchase to be offered for 61 properties where buildings are seaward of the Immediate Zone of Slope Adjustment	• Would remove the risk to these properties • Opportunity to improve local amenity by provision of additional community space • Opportunity to improve environmental values of dune	• Very high cost • Low take-up rate of voluntary purchase scheme • Social and economic impact on locality • Loss of rate income • Risk to remaining properties still exists • Risk that access to Wamberal Beach can be lost along Ocean View Drive if breakthrough into lagoon occurs.	$244 million (based on $4 million average purchase price per property for 61 properties) and including loss of rate income	$259 million (based on $4 million average purchase price per property for 61 properties) including $15 million loss of rate income (based on Council provided rate revenue discounted at 7% p.a. with 3% increase p.a. in rate)	Up to $44 million (assumes 2% risk p.a. of $1,000,000 damage to 61 properties affected by erosion hazard)	0.17
	Continue dune vegetation management (TW4.8)	Ongoing	• Continue providing support to local Dunecare groups and local	• Would maintain existing beach amenity at this location • Social benefit of community participation in bush regeneration	• May need to be carried out more frequently in the future	$15,000 - $25,000 p.a.	N/A	N/A	"No regrets" option to be implemented

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
			residents to maintain dune as required and repair after a storm	• No additional cost					
	Beach nourishment to increase buffer against storm erosion (TW4.9)	Short term	• Source sand for beach nourishment and place on the beach to build up dune and create buffer against storm erosion	• Would provide some protection for properties and infrastructure against storm erosion and inundation by augmenting the existing dune • Would be aesthetically pleasing and would not detract from the beach amenity	• Considerable study would be required to source sand and undertake environmental assessment • Significant cost required as sand must be sourced from outside the Wamberal Beach system. • Sand may be transported out of the area by littoral drift without the construction of a control structure such as a groyne. • Recommended sand source not currently able to be accessed under existing legislation.	$8.5 to $10.0 million	$19.5 – 23 million	Up to $47.5 million (assumes 2% risk p.a. of $1,000,000 damage to 66 properties affected by immediate coastal erosion/reduced foundation capacity hazard)	2.0
Immediate and future erosion and inundation risk to properties south of the Wamberal Lagoon entrance	Review entrance management guidelines for mechanical opening of Wamberal Lagoon (TW5.1)	Short term	• The entrance management policy & procedure for Wamberal Lagoon is to be reviewed as identified in the Gosford Lagoons planning process.	• Would reduce erosion due to scour across the beach berm and along the dune • Would reduce the risk of catchment based flooding to properties adjacent to the lagoon.	• Would require regular deployment of equipment to put the strategy in place and monitoring to assess whether trigger conditions have been reached.	$5,000 + $14,500 p.a. lagoon opening cost, $5,000 per opening at 2.9 openings p.a.	N/A	N/A	"No regrets" option to review policy
Future erosion and immediate inundation risk to Wamberal Surf Life Saving Club	Repair damage to surf club carpark should storm erosion occur (TW5.2)	As required	• Restore carpark using damage-resistant pavement should it be damaged in a future storm event	• No initial capital outlay	• Risk of damage to carpark and surf club remains, although there is existing rock remaining from previous storms • Cost of repair	$150,000 to $180,000	$150,000 to $180,000	$90,000 (reduced maintenance cost and reduced losses due to protection of car parking)	0.5 – 0.6
	Beach nourishment in front of carpark (TW5.3)	Short to medium term (0 – 20 years)	• Import of sand into this portion of the beach to increase buffer against	• Would provide buffer against storm erosion demand to help protect the surf club and carpark	• Suitable source of sand has not been identified, possibly from mobile dunes further north along the beach. Extensive	$0.8 to $1.0 million	$1.8 – 2.3 million	$90,000 (reduced maintenance	0.05

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
			beach erosion		studies required to identify source of sand and undertake environmental assessment • Nourishment works would likely not remain on the beach at this location • Recommended sand source not currently able to be accessed under existing legislation			cost and reduced losses due to protection of car parking)	
	Beach scraping to build vegetated dune in front of carpark (TW5.4)	Short term (0-5 years)	• Scrape sand to build a dune in front of the carpark and vegetate as per standard dune management practice in accordance with the Coastal Dune Management Manual (DLWC 2001).	• Would improve protection of the surf club and carpark against storm erosion and inundation by providing a buffer of sand • Would be aesthetically pleasing and would not detract from the beach amenity	• Not likely to provide sufficient protection against future storm event • Dune would be damaged by future storm events and would require maintenance. • Cost of environmental assessment and planning activities. • Disruption to beach users during works.	$8,000 to $10,000	$180,000 - $230,000	$90,000 (reduced maintenance cost and reduced losses due to protection of car parking)	0.4 – 0.5
	Future relocation of surf club and carpark to an area landward of the coastal hazard area (TW5.5)	Short to medium term (0 – 20 years)	• Relocate carpark to an area outside the erosion hazard zone eg. further landward	• Would remove the immediate erosion risk to the carpark	• Cost to reconstruct carpark and potential cost to purchase land for placement of new carpark • Possible loss of carparking spaces	$1.0 to $2.0 million	$1.0 to $2.0 million	$90,000 (reduced maintenance cost and reduced losses due to protection of car parking)	<0.1
	Redevelop surf club on deep piled foundations (TW5.6)	Medium term (5 – 20 years)	• On future redevelopment of surf club, reconstruct on deep piled foundations. May not be required if TPS is implemented.	• Would remove the risk of erosion damage to the surf club • Surf club can stay in its existing location	• Cost of reconstruction • Temporary loss of facility while reconstruction taking place	$1.0 to $1.5 million	$1.0 to $1.5 million	$90,000 (reduced maintenance cost and reduced losses due to protection of car parking)	<0.1
All issues	Emergency Management (TW5.7)	As required	• Undertake pre, during and post storm actions as described in Section 7.8 and Wamberal Emergency Action	• Public safety	• N/A	N/A	N/A	N/A	"No regrets" option.

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
			Subplan when trigger for action is reached						

8.11 Forresters Beach

8.11.1 Issues and Options

The major coastal hazards identified at Forresters Beach are:

- **Coastal erosion** having the potential to impact on four beachfront lots along Kalakau Ave, as well as services such as stormwater and the beach accessways and dune fencing; and
- **Slope Instability** may have the potential to result in reduced foundation capacity for buildings subject to determination of the geotechnical soil properties of the dune matrix.

The consequences of these coastal hazards being realized include:

- Present day potential damage to fencing, private gardens and minor structures within four beachfront lots along Kalakau Ave;
- Damage to stormwater outlet at end of Bluewave Cres;
- Damage to beach accessways and dune fencing; and
- Future erosion risk to services, private gardens and minor structures along Kalakau Ave is expected to increase, as well as risk to public safety increasing with time

Potential management actions that are relevant in addressing the identified coastal hazards for Forresters include:

- Review existing geotechnical information and undertaken additional **geotechnical investigation** if required to determine the *Zone of Reduced Foundation Capacity*;
- Undertake **erosion protection works** to protect properties under erosion threat;
- **Development controls** to ensure new developments within the coastal hazard areas are unlikely to be damaged within a chosen planning period by coastal erosion and inundation (i.e. founded into the local 2050 or 2100 stable foundation zone and located with a floor level 0.5m above the maximum wave runup level, allowing for future sea level rise);
- Undertake periodic beach nourishment to provide a buffer against erosion;
- Improve stormwater management at existing outlet; and
- Improve **maintenance of dune vegetation**, planting and fencing along length of beach, in areas under both private and public control.

The revised 2050 Hazard Line indicates the affected properties have houses that are outside the erosion hazard zone, therefore voluntary purchase have not been considered further in this report. The relocation of the existing stormwater outlet has already been undertaken.

A suite of 7 specific management options for actions that could be undertaken by Council have been developed to address the coastal hazards identified at Forresters Beach for consideration. Each option has been provided with an identifier (F1 to F7) as illustrated in Table 30. A more detailed summary of these main options for coastal zone management including advantages and disadvantages, timeframe for adoption and indicative costs is provided in Table 31.

Further to the management options below, Forresters Beach has been named as an “Authorised Location” for placement of temporary protection works in the Code of Practice under the Coastal Protection Act 1979 (OEH 2013). Under the Code of Practice, landowners may place temporary protection works comprising either:

- sand filled geotextile containers each of maximum 0.75m^3 filled volume stacked in a single layer up to 1.5m high (at a slope flatter than 34° from the horizontal, that is flatter than 1:1.5 vertical:horizontal); or,
- clean sand placed up to the crest on the seaward side of an eroding escarpment (under the Code of Practice, this is not permitted to be sourced from the beach on which the works are to be placed).

It is emphasised that landowners must act well (generally months) in advance of a storm to consider implementing these works. It should also be noted that landowners are not permitted to install coastal protective works without following the procedures outlined in the Code of Practice (OEH 2013), and severe penalties may apply if they are not followed.

8.11.2 Landuse and Development

At Forresters Beach, the re-assessed erosion hazard does not impact on any of the beachfront properties. However, there is uncertainty as to whether any properties would be impacted by reduced foundation capacity, as investigations into the underlying geology of the beach have shown that the dune is underlain by stiff clays in some areas.

For Forresters Beach, it is recommended that detailed geotechnical investigations be carried out to ascertain the degree of geotechnical slope stability hazard and inform Council as to whether any special requirements are needed for development applications. In the interim, vegetation on the steep foredune slopes should be protected, and stormwater discharges should be directed away from the toe of the slope, to prevent it from being undermined.

Table 30 – Coastline Management Options for Forresters Beach

Issue/Hazard	Management Option
Immediate risk of erosion damage to properties and minor structures	Geotechnical investigation to determine the Zone of Reduced Foundation Capacity (F1)
	Development controls (F2)
	Erosion protection works (F3)
	Placement of sand to provide buffer against storm erosion (F4)
	Stabilisation of dunes with vegetation and/or fencing (F5)
All issues	Emergency Management (F6)
	Beach monitoring (F7)

Table 31 – Detailed Summary of Management Options for Forresters Beach

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
Immediate risk of erosion damage to properties and minor structures	Geotechnical investigation to determine the Zone of Reduced Foundation Capacity (F1)	Short term	• Investigation to determine the Zone of Reduced Foundation Capacity	• Would provide greater certainty of the hazard to properties	• Access for the geotechnical investigation could be result in damage to the dune.	$30,000	N/A	N/A	"No regrets" option
	Development controls – status quo (F2)	Short term	• Can be added to or based upon existing DCP	• Can be easily implemented within existing DCP as existing controls already in place – no need to adjust existing controls.	• Additional controls may place additional impost onto beachfront property owners and could affect property resale values	N/A	N/A	N/A	"No regrets" option already in place
	Erosion protection works (F3)	Short term	• Works may consist of a rock toe drainage/retaining structure	• Could improve the stability of the embankment, subject to geotechnical investigation.	• Cost to design, construct and maintain works • Potential for loss of recreational amenity through loss of access to foreshore • Potential for increased erosion impacts in front of and on either side of the works due to wave reflections • Potential for future loss of access along the beach in front of structure • Requires sand nourishment	$6.0 to $7.0 million	$6.8 – 7.9 million	Not known	Not known, subject to geotechnical investigation
	Placement of sand to provide buffer against storm erosion (F4)	Medium term	• Medium - long term, then repeat as required	• Sand would provide buffer against storm erosion should beach dune become depleted over time which could prevent damage to properties and minor structures.	• Approvals and detailed studies required to access the sand source for placement • Sand would rapidly re-distribute itself along the beach and buffer protection would be limited without construction of a retaining structure such as a groyne (which would add significantly to the cost) • Potential for sand drift problem if sand is not stabilised by vegetation and fencing • Works would need to be undertaken periodically and there would be a recurrent cost associated with this.	$3.0 to $4.0 million	$6.9 – 9.2 million	Not known	Not known
	Continue dune vegetation management (F5)	Ongoing	• Continue providing support to local Dunecare groups and local residents to maintain dune as required and repair after a storm	• Would maintain existing beach amenity at this location • Social benefit of community participation in bush regeneration • No additional cost	• May need to be carried out more frequently in the future	$40,000 to $50,000	N/A	N/A	"No regrets" option to be implemented

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)	Description	Advantages	Disadvantages	Indicative Capital Cost	Costs (NPV 2050)	Benefits (NPV 2050)	Benefit-Cost Ratio (2050)
All issues	Emergency Management (F6)	As required	• Undertake pre, during and post storm actions as described in Section 7.8 when trigger for action is reached	• Public safety	• N/A	N/A	N/A	N/A	"No regrets" option
	Monitor beach for erosion and cliff lines for instability (F7)	Short term, ongoing	• Undertake monitoring of the beach to establish erosion and geotechnical instability	• Public safety • Would provide early warning of actions required to protect infrastructure	• None	N/A	N/A	N/A	"No regrets" option.

9 FEEDBACK FROM PUBLIC EXHIBITION

The Draft Coastal Management Study was exhibited in January and February 2015 and provided the following:

- Summary of the coastal hazard assessment for beaches between Forresters and Patonga;
- Consideration of all feasible management options to address current and future coastal risk (including climate change); and
- Identification of suitable management responses with consideration of the social, economic, aesthetic, recreational and ecological issues associated with land use along the coastline.

The document has been developed in conjunction with the Coastal Sub-committee which includes beachfront residents, community representatives from other locations in the LGA, special interest groups, NSW Government officers and Council staff. The Draft Study been developed in line with the NSW Governments' Guidelines for Preparing Coastal Zone Management Plans (2013) and with the assistance of the NSW Coastal Management Program.

Council held a series of community forum sessions in early February 2015 for people interested in learning more about the Gosford City coastline and how it is managed. These sessions aimed to gauge community attitude to management options, before preferred options are presented in more detail via a Draft Plan.

In summary, consultation activities carried out to date relating to this Coastal Management Study included:

- Public exhibition and community information sessions and brochures produced in early 2014 for the Coastal Process and Hazard Definition Study (WorleyParsons 2014).
- Draft Coastal Management Study document available for community review between 15 January and 15 February 2015.
- The Draft Study document was made available in hardcopy format at Council's Erina, Gosford, Kincumber and Woy Woy customer service centres during normal business hours.
- The Draft Study document was also available in the Items on Exhibition section of Councils webpage during exhibition.
- Letters sent to 949 property owners identified as being affected by DCP Chapter 6.2 (Coastal Frontage) on 17 December 2014.
- Media Release distributed (week of 12 January 2015)
- Promotion of exhibition in Central Coast Express Advocate via Gosford Connect – general info on exhibition (week of 19 January 2015)
- Media alert (week of 26 January 2015)
- Promotion of exhibition in Central Coast Express Advocate via – specific info on exhibition to include detail/timing of exhibition events (week of 26 January 2015)

More than 270 people attended a series of 3 hour community forums which were held as indicated below in Table 32.

In addition to the public exhibition, a workshop was held with Council's Coastal Sub-committee in late February 2015 to discuss the formal submissions and refine the list of initial management options developed for the Draft Study.

Table 32 – Coastal Management Study Community information sessions

Beach	Attendees	Date	Venue
Pearl	64	Monday 2 February 2015	Pearl Beach Progress Hall
Patonga, Umina/Ocean & Killcare/Putty	82	Tuesday 3 February 2015	Umina SLSC
MacMasters/Copacabana	32	Wednesday 4 February 2015	Copacabana SLSC
South/North Avoca	40	Thursday 5 February 2015	North Avoca SLSC
Terrigal/ Wamberal/Forresters	51	Monday 9 February 2015	Terrigal SLSC

A total of 56 formal submissions were received by Council from groups and individuals across the study area during the exhibition period, with the issues raised in each submission summarised in Appendix 5.

Figure 61 below illustrates the number of submissions received relating to each beach.

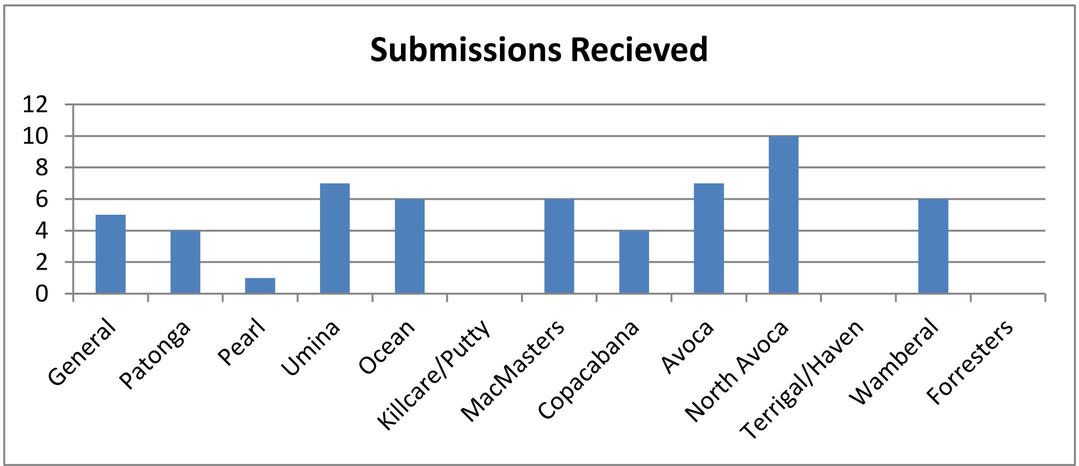

Figure 61 – Submissions received from each beach area

A summary of consultation feedback specific to each beach which includes responses to how consultation feedback has been addressed is included in Appendix 5. This includes comments specific to individual beaches. Key general issues raised during consultation (in no particular order):

Sea Level Rise – *overly conservative approach, need to use latest IPCC (AR5 Report Findings) and consider the report undertaken by Whitehead & Associates for NSW south coast councils.*

Council has recently considered sea level rise and has resolved to adopt a medium sea level rise projection as its strategic position to inform Council's planning and plan making processes. The sea level rise planning levels based on this projection are:

Local sea level rise projection (rates projected from current/2015 levels)

**Note: To obtain the absolute projected sea level elevation relative to AHD, a further 0.08m would need to be added to these values*

Year	Medium local sea level rise projection based on RCP8.5 measured in metres (m)
2015	0.00
2030	0.07
2050	0.20
2070	0.39
2100	0.74

The exhibited Draft Study presented a range of feasible options as opposed to recommending options or specifics associated with building lines. Sea level rise is not the only consideration in managing coastal hazards. The 2014 hazard lines are a projection based on a specific scenario which guides our understanding of potential future risk.

Consultation Process – *timeframe considered too short, lack of open forum, inability for community to understand complex issues in short timeframe*

There is no legal requirement under the *Coastal Protection Act 1979* for Council to exhibit the Draft Study. However, Council recognises the importance of community involvement and undertook a community engagement process that enabled communities to participate, build an understanding of coastal management issues facing their area and to contribute to the decision-making process.

Methodologies - *Application of acceptable risk development line, planning period to include design life, question of Bruun Rule, questions on economic assessment and social valuing.*

The exhibited Draft Study merely presents a range of feasible options and does not recommend options or specifics associated with building lines. Staff and the consultant acknowledge the need to consider acceptable risk and design life in the determination of building lines. The Draft Coastal Management Plan will provide recommended positioning and detail validation of that position.

Concern over the application of the 'Bruun Rule' was raised by some residents of the Avoca embayment. The Bruun Rule is a commonly applied rule to explain erosion of sandy shores in response to sea level rise. The Bruun Rule is based on rational coastal engineering principles and was applied in the 2014 hazard assessment in cognizance of the fundamental assumptions upon which it was based to estimate projected long-term recession due to sea level rise.

It is noted that the Bruun Rule has been questioned in the scientific literature. However, no alternative tool for practical application in the engineering community has been presented. Council acknowledges that the Bruun rule has several limitations and confirms that any limitations are being considered when the Bruun rule is applied for Gosford's beaches.

Firstly, the rule does not account for longshore interactions. However, this limitation may not necessarily apply for Avoca Beach due to this beach compartment being a 'closed system' and not subject to longshore sediment transport.

The second limitation is that the Bruun Rule assumes the wave climate is steady and hence the equilibrium profile remains the same - simply translated the beach profile will move landwards and upwards with the rise in mean sea level. Avoca Beach is considered to be in its equilibrium state and therefore a rise in sea level (under current coastal processes) will result in a corresponding recession relative to that rise and in maintaining the equilibrium.

WorleyParsons considers that the assumptions of the Bruun Rule are valid at Avoca Beach, as the beach is an enclosed embayment where cross-shore sediment transport is the dominant process and where the nearshore profile corresponds to an equilibrium profile shape.

However, it must be noted that the Bruun Rule is one tool used to address prediction of coastal response due to sea level rise and current coastal hazard assessment also includes the incorporation of historical beach behaviour information, knowledge of local coastal processes and local geomorphology.

The Draft Study has been amended to include improved consideration of economic factors. This includes additional explanation of the following economic considerations:

- Impact on Council revenues (inc transfer of costs onto rate base)
- Impact on State revenues
- Impact on Federal revenues (inc land taxes, stamp duty, etc.)
- Impact on property values
- Flow on impacts to the wider community
- Socio-financial impacts – impact of development restrictions on local employment and local services contractors

Additionally, accurate information on rates and land valuations (based on 2014 figures) of affected properties has been provided and taken into account to assist in assessment of costs and benefits for various management options.

Social values are discussed within the Draft Study and, as hoped, considerable insight was gained through community consultation. The feedback gathered from various communities has been integrated into the Study.

***Funding** –need for state and federal support, transfer of costs onto communities, how will costs be distributed*

Funding mechanisms will be explored further and described in the CZMP to provide supporting information on preferred option implementation. There is a need for guidance from the NSW Government who announced in November 2014 that the third element of the Stage 2 Coastal Reforms is focused on identifying sustainable funding and financing arrangements for coastal management activities.

One aspect of these arrangements is the availability of guidance on identifying effective and affordable management options that deliver net benefits to the community. This guidance will be included in a new coastal zone manual.

Another key issue is that the costs of coastal management actions often exceed councils' capacity to pay, and currently there is no clearly agreed approach for councils to identify who should be expected to contribute to those costs.

To address this, the new arrangements will be based on a set of cost-sharing principles to fairly and transparently identify who benefits from proposed coastal management actions, and therefore who should contribute to the costs. These principles will ensure that cost-sharing arrangements:

- fairly apportion the costs of coastal management actions between the beneficiaries of those actions
- include the full capital and ongoing expenditure associated with coastal management actions
- encourage the most efficient and effective way to deliver actions
- are simple to administer
- are decided in consultation with relevant parties, are transparent and reviewed regularly
- are aligned with local and strategic objectives.
- to support the new approach, OEH will review the various funding and financing mechanisms that exist to see if they can be better used by councils, and whether arrangements need to be put in place to make them more useful for councils' needs.

Information on the cost-sharing principles and funding and financing mechanisms, together with any other relevant guidance, will be captured in a funding and financing 'tool kit' that will form part of the new coastal management manual. At this stage the timing for the delivery of this information is unclear.

Development restrictions & impacts on property values *- unfair restrictions proposed, lack of community involvement in decision-making, positioning of building line vs hazard line?*

The exhibited Draft Study presents a range of feasible management options and does not recommend options or specifics associated with building lines. Coastal management planning is not intended to sterilise land for development. The direction taken by Council in the development of the existing Coastal Management Plans has been to manage the risk whilst facilitating development.

The coastal hazard lines represent a worst case scenario and have been developed in line with NSW Government requirements and widely accepted coastal engineering methodologies. They represent a theoretical line which assists in guiding the development of appropriate management options to deal with defined risk. However, they represent only one component in considering appropriate development going forward.

There is no direct evidence that property valuations (or marketability) suffer as a result of hazard definition processes as there are a range of factors with a larger influence on property pricing. In fact, consistent strategic management, such as that being undertaken by Council, has been seen to improve property valuations by removing uncertainty in development potential (i.e. as an example in Byron Bay the placement of hazard information and application through DCP/LEP showed no discernible impact on property price. Lennox Head beachfront property values markedly increased following implementation of protection strategies in the early 1990s).

The risk assessment studies (and the planning controls which ultimately flow from them) are used to ensure development is assessed to enable orderly and appropriate development to occur relative to identified risk/constraints.

Council will need to consider relevant legislation, the Guidelines for Preparing Coastal Zone Management Plans (2013) and ten Coastal Management Principles in determining strategic outcomes which provide the best outcome for community. Additionally, the 10 March 2015 resolution reduces Council's conservatism and this will be also considered in formulation of a management response.

The information gained through community preferences has greatly assisted in determining social acceptance of specific management options.

Clarifications *– community misunderstanding on event probability, consequences of loss, hazard line impact.*

The issues being discussed are both complex and challenging. The Draft Study has been updated to clarify many of these misunderstandings including an Executive Summary which provides a simple over view of key elements of hazard assessment and the planning process. Council has endeavoured to support its consultation process with the production of a range of education factsheets distributed during exhibition.

Dune management *– widely supported for all beaches, some concerns over species selection and view maintenance.*

The community have clearly articulated that they support ongoing dune management activities undertaken by Council and its Bushcare program. Dune management features as a priority 'no-regrets' management option for all beach embayments. Operationally the selection of species in dune management needs to be considered in respect to view maintenance issues raised during consultation.

Support for engineered solutions *– maintain development potential in high risk areas.*

The exhibited Draft Study presents a range of feasible management options and does not recommend options or specifics associated with building lines. Council will need to consider relevant legislation, the Guidelines for Preparing Coastal Zone Management Plans (2013) and ten Coastal Management Principles in determining strategic outcomes which provide the best outcome for community. Additionally, the 10 March 2015 resolution reduces Council's conservatism and this will be also considered in formulation of a management response.

Coastal management planning is not intended to sterilise land for development. The direction taken by Council in the development of the existing Coastal Management Plans has been to manage the risk whilst facilitating development.

Communities at North Avoca and Wamberal clearly highlighted their desire for continued development of lands in high risk areas by applying engineered approached (i.e. piling). Specific locations of building lines will be proposed in the draft CZMP.

An important factor for Council is to ensure that property owners are fully aware of the potential risk both in terms of the physical impacts to the land on their (and neighbouring properties) while ensuring landowner understanding of insurance (i.e. they would not be covered for impacts of the sea).

9.1 Options Selection

Based on the degree of erosion hazard, for each beach as determined in the Coastal Process and Hazard Definition Study, the options (in Section 8) to be considered for each beach were as follows:

- **Protection –** Who pays? When will it be needed? Impact on environment? Impact on community/social acceptance?

- **Development Controls –** 2050 or 2100 planning horizon? Do existing controls need to be changed? Should subdivisions be allowed?

- **Retreat –** Voluntary property purchase? Compulsory property purchase? Triggers for implementation? Provision of alternative access?

- **Monitoring/Do nothing –** Accept the existing risk, reassess in the future.

A combination of these approaches may be required at each beach. Thus the final CZMP will describe the overarching management philosophy to be adopted to address landuse and development issues for each area.

Specific actions have been developed in Section 8 for each precinct within each beach in the study area, addressing particular coastal management issues and hazards of concern.

Indicative costs have been determined for each option, together with the advantages and disadvantages of the options described in terms of economic, social and environmental benefits and disbenefits of each option.

The coastal hazard information at each beach has informed the options discussed in Section 8.

Each option has been assessed at each beach based on a cost benefit analysis, which describes the economic aspects of the options, as well as consideration of the environmental and social aspects of the optons.

For each beach, feedback received from Council's Coastal Sub-committee and the community submissions have allowed further refinement of the list of options from Section 8 (i.e. intangible benefits, acceptance by the community etc.).

Specific options flagged in Section 8 have been excluded from further consideration based on feedback from the community and these are described in Section 9.3 below. Additional options have been suggested in community submissions and these have been included in the list of management options provided below to go forward to the Draft Coastal Zone Management Plan where appropriate.

Each of the options to be incorporated into the final CZMP are to consider such issues as the effectiveness of each option in removing the coastal hazard risk, the compatibility of the option with the principles of ecologically sustainable development (ESD), and the likely community acceptance of each option.

For detailed options assessment, the 2050 planning period is suggested to estimate total maintenance and construction costs in considering the different spans of design life and frequency of maintenance for the various options.

Options assessed include those considered feasible for each area in terms of improving the coastal hazard risk with respect to landuse and development.

9.1.1 Economic Factors

For the assessment of the economic factors, a cost-benefit analysis has been carried out on all the options in Section 8. The economic costs of each option has been assessed in terms of net present value to 2050 and compared against the economic benefits, with the analysis presented as a benefit-cost ratio for each option. The quantifiable benefits of the alternative coastal management options relate to protecting housing, land and associated infrastructure and improving (or maintaining) beach amenity relative to maintaining the status quo. The benefits are, hence, often the avoidance of costs that would occur under the existing beach management strategy. If the economic benefits outweigh the costs (i.e. the benefit-cost ratio is greater than 1), then the option is considered to be economically viable. If, however, the economic costs far outweigh the benefits, then the option is considered to be not economically viable. “No regrets” options have been identified also which describes options which have a high benefit (which may be an intangible social or environmental benefit) for little or no cost and where the options are in accordance with current practice.

While many options can be excluded based purely on the economic benefit-cost ratio, the benefits and costs of many of the options, such as the social and environmental benefits and costs, are intangible and cannot be measured in currency. The environmental factors have been described in the “Advantages” and “Disadvantages” columns in the options tables in Section 8.

The cost-benefit analysis undertaken on each option provides some guidance on the most favourable options, with this guidance assisting in progressing towards an implementation schedule for the options to feed into the CZMP.

9.1.2 Social Factors

Examples of social factors that need to be considered in deciding on the options to be included in the final CZMP include:

- **Visual Impact** – options that have a positive visual impact are given a higher priority than options having a negative impact on the visual aspect.
- **Impact on recreational amenity and safety** – options which improve beach amenity, beach access and public safety are given a higher priority than those which detract from or provide only a marginal benefit to recreational amenity and safety.
- **Disruption to the community** – options that result in the least disruption to the community (e.g. low construction impact) are favoured over those which would cause a greater degree of disruption. This factor captures both the impact of construction and changes to the character and amenity of the existing beach area.
- **Acceptance by the community** – This factor captures the likely acceptance of the option by the community, based on feedback received during the public exhibition period of this Study.

These factors have been considered throughout the process of developing and refining the list of management options for the CZMP in conjunction with the Coastal Sub-committee and refined based on submissions received from the community.

9.1.3 Environmental Factors

Examples of environmental factors that need to be considered in deciding which options are to be included in the final CZMP include:

- **Disruption to Coastal Processes and preservation of natural beach system** – this is a measure of to what degree the option would disrupt the natural coastal processes – options that disrupt the natural coastal processes in a detrimental way and detract from the natural character of the beach are given a lower priority than those that work with or do not disrupt the natural coastal processes and improve the natural character of the beach.
- **Ecological impacts** – this is a measure of the impact of the proposed option on the local ecology of the area. Options that have a detrimental impact on the local ecology of the area are given a lower priority than options with a positive impact.

These factors have been considered throughout the process of developing and refining the list of management options for the CZMP in conjunction with the Coastal Sub-committee and refined based on submissions received from the community.

9.2 Included Options for Draft Coastal Zone Management Plan

Based on feedback received from the public exhibition, individual submissions from members of the community and workshops held with Council's coastal sub-committee, a set of recommended management actions for each precinct at each beach has been developed.

These management actions are based on those developed in Section 8, but have been refined based on feedback received during the public exhibition. Several additional options have been suggested by the community to address specific issues, as well as the omission of particular options due to their unacceptable economic, social or environmental impact, or the clear preference of the community of particular options over others. The list of management actions recommended for each precinct at each beach is given in the Tables below.

In addition to the site-specific management actions, more general management actions that should apply on an LGA-wide basis include:

- Continuing public education programs to inform the public about coastal management issues – through signage, support to local schools and community groups, dissemination of information through local libraries, Council website and Council's existing information networks.
- Development of emergency action processes which align with relevant combat agencies
- Establishment of a centralised repository and information system for geotechnical information relevant to coastal frontage development across the Gosford beaches. Individual development proponents have been providing geotechnical advice in line with the requirements of the existing DCP (which should continue). There is an opportunity to collate

this information for use in future coastal management planning processes to assist in building our understanding of geotechnical attributes across coastal hazard areas.

- Undertake an inventory and management strategy of rocky shore habitats across the study area. This information will contribute to the sustainable management of key sites in liaison with relevant state government stakeholders (i.e. NSW Department of Primary Industries, Crown Lands and Office of Environment & Heritage).
- Update and review of the Coastal Zone Management Plan on a regular basis, with a set timeframe suggested of 10 years.
- Development of a formal framework for apportioning costs and funding arrangements for proposed coastal management measures.

The above general management measures can be implemented locally by Council but would also require support from the NSW Government and OEH at the state-wide policy level.

Table 33 – Patonga Beach Management Options

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)
Immediate risk of erosion damage to main carpark and Patonga Drive access	Monitor performance of erosion protection works and monitor beach profile at main carpark	Short term (0 – 5 years), as carpark already under erosion threat
	Repair damage to carpark should storm erosion occur	As required
	Placement of sand sourced from western beach and shoals at creek entrance to provide buffer against storm erosion	Short term, then repeat as required
	Beach scraping	As required after storms
	Future relocation of carpark and associated infrastructure to an area landward of the coastal hazard area	Long term (> 20 years)
	Stabilisation of dunes in front of carpark with vegetation and fencing	Short term
Immediate erosion risk to boat ramp and access road	Monitor and assess existing erosion protection works	Short term
	Relocate access road as erosion occurs	Medium term
	Periodic nourishment of area with sand sourced from Patonga Creek entrance	Medium term, then repeat as required
	Monitor beach profiles	Short term/ongoing
Inundation due to wave runup	Ensure floor levels for new Development Applications are above inundation levels	Ongoing
	Upload flood/inundation information onto Council's website for access by property owners	Short term
	Beach scraping and dune management to maintain crest level of dune above wave runup level	Short term
	Continue and enhance dune vegetation management - Assist/encourage community groups with dune management actions including Dunecare/Bushcare	Ongoing

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)
	Complete a vegetation profile for Patonga Beach and support the natural vegetation profile.	Short term
	Investigate raising floor levels of existing buildings	Medium Term
Erosion in front of cottages at Dark Corner	Monitor and assess existing erosion protection works	Short term
	Implement erosion control works in front of cottages in accordance with Patonga Draft Plan of Management Crown Reserves and Dark Corner Cottages 2013	Medium Term
Shoaling at entrance channel of Patonga Creek	Investigate periodic maintenance dredging of sand from the creek entrance	Short term
	Investigate lengthening existing entrance breakwater	Medium-long term
	Beach scraping of built-up sand adjacent to creek entrance to mitigate against wave runup and erosion risk at other areas of the beach	Short term
Scour from stormwater and creek flows at eastern end of beach	Investigate installation of stormwater energy dissipation to reduce discharge velocities at outlet	Short term
	Post storm beach scraping to assist natural recovery of the dune and repair scour caused by stormwater discharge	As required
All issues	Emergency Management	As required

Table 34 – Pearl Beach Precinct 1 (south of Green Point Creek) – Management Options

Issues	Option	Timetable for adoption (short, medium, long term)
Immediate and future risk of erosion and reduced foundation capacity to four properties and sewage infrastructure Coastal inundation of lots south of Green Point Creek entrance	Erosion Protection works to be allowed for four properties south of Green Point Creek entrance (Pe1.1)	Short to medium term (0 – 20 years), two of these properties already have protection installed
	Monitor performance of existing erosion works at properties south of Green Point Creek entrance (Pe1.2)	Immediate and ongoing
	Erosion protection works for sewage pumping station and sewer line at end of Gem Road and south from Gem Road extending to protect infrastructure (Pe1.3)	Short term (0 – 5 years)
	Relocate sewer infrastructure and pumping station further landward (Pe1.4)	Short term (0 – 5 years)
	Investigate feasibility/sources of sand for beach nourishment (Pe1.5)	Medium term (5 – 20 years)
	Beach scraping to build dune in front of residences, Gem Road and restaurant (Pe1.6)	After storm events as required
	Continue dune vegetation management - Assist/encourage community groups with dune management actions including Dunecare/Bushcare (Pe1.7)	Ongoing
	Complete a vegetation profile for Pearl Beach and support the natural vegetation profile.	Short term
	Develop entrance management guidelines for mechanical opening of Green Point Creek (Pe1.8)	Short term
	Development controls as per existing DCP i.e. defined building line (e.g. existing building line) with new buildings to be founded into 2100 Stable foundation Zone. Residences and restaurant to be above inundation levels on redevelopment	Short term

Issues	Option	Timetable for adoption (short, medium, long term)
	of properties (Pe1.10)	
	Investigate “tripper” structure to control opening location of creek (Pe1.11)	Short term
	Identify floor levels to determine degree of inundation hazard (Pe1.14)	Short term
All issues	Emergency Management	As required
Beach amenity/heritage	Monitor rock pool for storm damage and repair if required	Ongoing

Table 35 – Pearl Beach Precinct 2 Management Options – Between Green Point Creek and Middle Creek entrances

Issue	Option	Timetable for adoption (short, medium, long term)
Immediate and future risk of erosion to playground area	Repair of playground area, toilet block, beach accessways and landscaping works following erosion in a large storm event (Pe2.2)	As required
	Beach scraping following storm event to build dune crest level and revegetation (Pe2.3)	After storm events as required
	Continue dune vegetation management - Assist/encourage community groups with dune management actions including Dunecare/Bushcare (Pe1.7)	Ongoing
	Complete a vegetation profile for Pearl Beach and support the natural vegetation profile.	Short term
	Develop entrance management guidelines for mechanical opening of Middle Creek (Pe2.5)	Short term
	Long term removal and relocation of playground should erosion escarpment move landward in future (Pe2.6)	Long term (>20 years)
Future risk of erosion to Pearl Parade and associated services	Future installation of erosion protection works once erosion escarpment reaches set trigger distance from road edge (Pe2.7); or Future closure of road and installation of alternative access (e.g. rear lane access to properties along Pearl Parade) (Pe2.8)	Long term (> 20 years)
	Repair and restoration of Pearl Parade should it be damaged by a future storm (Pe2.9)	Long term (>20 years)
	Landward relocation of water supply and electricity should it be damaged by future erosion (Pe2.10)	Long term (>20 years)
	Development controls as per existing DCP i.e. defined building line (e.g. existing building line) with new buildings to be founded into 2100 Stable foundation Zone (Pe2.11)	Short term

Issue	Option	Timetable for adoption (short, medium, long term)
	Monitor performance, upgrade/repair existing erosion protection works at the restaurant	As required
All issues	Emergency Management	As required

Table 36 – Pearl Beach Precinct 3 – Between Middle Creek and Pearl Beach Lagoon outlet

Issue	Option	Timetable for adoption (short, medium, long term)
Immediate erosion risk to dune	Encourage and assist Dunecare group to maintain and revegetate dune after a storm (Pe3.1)	Ongoing
	Complete a vegetation profile for Pearl Beach and support the natural vegetation profile.	Short term
	Post storm beach scraping to assist natural recovery of the dune and repair scour caused by breakout from Pearl Beach Lagoon and Middle Creek (Pe3.2)	After storm events as required
	Formalise entrance management guidelines for mechanical opening of Middle and Pearl Beach Lagoon entrances(Pe3.3)	Short term
	Monitor effectiveness of concrete wall on northern bank of outlet (Pe3.4)	Short term
	Continue dune vegetation management - Assist/encourage community groups with dune management actions including Dunecare/Bushcare	Ongoing
All issues	Emergency Management	As required

Table 37 – Pearl Beach Precinct 4 – Coral Crescent Beachfront properties

Issue	Option	Timetable for adoption (short, medium, long term)
Immediate and future erosion risk to Coral Crescent properties	Development controls as per existing DCP i.e. defined building line (e.g. existing building line) with new buildings to be founded into 2100 Stable foundation Zone (Pe4.1)	Short term
	Post storm beach scraping to assist natural recovery of dune (Pe4.3)	After storm events as required
	Investigate feasibility of terminal protection e.g. once erosion escarpment reaches trigger distance from defined building line (Pe4.4)	Long term (> 20 years)
	Encourage and assist Dunecare group to maintain and revegetate dune after a storm using low-growing vegetation (Pe4.7)	Ongoing
	Beach nourishment to increase buffer against storm erosion (Pe4.8)	Medium term (5 – 20 years)
Immediate and future inundation risk to Coral Crescent properties	Post storm beach scraping to assist natural recovery of dune and to maintain crest level of dune above wave runup level (Pe4.3)	After storm events as required
	Encourage beachfront residents to maintain crest level of dune and vegetate dune on private property in accordance with dune management practice (e.g. community education, provision of free plants) (Pe4.10)	Short term, ongoing
	Complete a vegetation profile for Pearl Beach and support the natural vegetation profile.	Short term
	Development controls as per existing DCP i.e. requirement for floor levels to be above wave runup level and be	Short term

Issue	Option	Timetable for adoption (short, medium, long term)
	compatible with inundation hazard (Pe4.11)	
All issues	Emergency Management	As required

Table 38 – Ocean Umina Beach – Precinct 1 (south of Ettalong Creek)

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)
Immediate and future risk of erosion and reduced foundation capacity to four properties and estuary entrance instability	Erosion Protection works to be allowed for four properties and carpark south of Ettalong Creek entrance (O1.1)	Short to medium term (0 – 20 years)
	Monitor performance of existing training wall works along northern side of Ettalong Creek entrance (O1.2)	As required
	Monitor storm run-up levels and dune erosion	Short term/ongoing
	Future relocation of residence on No.8 Berrima Crescent landward of immediate hazard area within same lot on redevelopment if revetment wall is not constructed (O1.3)	On redevelopment as per DCP
	Investigate feasibility of beach nourishment (O1.4)	Long term (>20 years)
	Beach scraping to build dune in front of residences at Berrima Crescent (O1.5)	Short term and as required (0-5 years)
	Encourage and assist Dunecare group to improve dune vegetation management using low-growing vegetation and consolidation of beach access at southern end of beach (O1.6)	Short term (0-5 years)
	Develop entrance management guidelines for mechanical opening of Ettalong Creek (O1.7)	Short term (0-5 years)
	Voluntary purchase of portion of at risk property (O1.9)	Short – medium term
	Development controls on redevelopment of properties within hazard area (O1.10)	Short term
	Construct “tripper” structure to control opening location of creek (O1.11)	Short term
Coastal inundation of lots south of Ettalong Creek entrance	Development controls for residences to be above inundation levels on redevelopment of properties (O1.12)	Short term
	Improve catchment controls and pollutant traps and integrate with stormwater management	Short – medium term
All issues	Emergency Management (O2.6)	As required

Table 39 – Ocean Umina Beach Management Options - Precinct 2 (between Ettalong Creek and Umina Beach surf club)

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)
Immediate and future risk of erosion to dunes and surf club carpark; Windblown dune erosion; dune ecology	Monitor existing erosion protection works in front of Umina Beach surf club (O2.1)	Short term and following storms as required
	Monitor storm run-up levels and dune erosion	Short term and following storms as required
	Repair of beach accessways and revegetation of dune following erosion in a large storm event (O2.2)	Short term and following storms as required
	Beach scraping following storm event to build dune crest level and revegetation (O2.3)	After storm events as required
	Install sand trapping fencing or other appropriate controls in beach access points where sand blowout occurs and in the vicinity of the SLSCs.	Short term
	Complete a vegetation profile for Umina and Ocean Beach and support the natural vegetation profile.	Short term
	Encourage and assist Dunecare group to improve dune vegetation management using low-growing vegetation and consolidation of beach access (O1.6)	Short term (0-5 years)
Community participation and beach amenity	Increase information signage near surf clubs on the ecology and history of Umina/Ocean Beach	Short term
	Implement traffic control techniques to facilitate easy risk free pedestrian access for major events including the Surf Life Saving carnivals.	As required
	Improve shade areas around the grassed areas and car parks near the SLSCs	Short term
	Maintain current signage and facilities on a regular basis	As required

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)
	Encourage and assist Dunecare group to maintain and revegetate dune after a storm using low-growing vegetation	Short term/ongoing
	Development of local area (Umina/Ocean Beach) online fact sheets and encourage local educational programs in schools regarding the dunes	Short term/ongoing
	Work with the Central Coast Surf Life Saving organisation to look at ways to support Surf Life Savings Australia's EcoSurf policy in the region – including Ocean and Umina Surf Life Saving clubs.	Short term
All issues	Emergency Management (O2.6)	As required

Table 40 – Ocean Umina Beach Management Options – Precinct 3 (between Umina Beach and Ocean Beach surf clubs)

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)
Immediate and future risk of erosion to dunes and surf club carpark; Windblown dune erosion; dune ecology	Monitor existing erosion protection works in front of Ocean Beach surf club (O2.1)	Short term and following storms as required
	Monitor storm run-up levels and dune erosion	Short term and following storms as required
	Repair of beach accessways and revegetation of dune following erosion in a large storm event (O2.2)	Short term and following storms as required
	Beach scraping following storm event to build dune crest level and revegetation (O2.3)	After storm events as required
	Install sand trapping fencing or other appropriate controls in beach access points where sand blowout occurs and in the vicinity of the SLSCs.	Short term
	Complete a vegetation profile for Umina and Ocean Beach and support the natural vegetation profile.	Short term
	Encourage and assist Dunecare group to improve dune vegetation management using low-growing vegetation and consolidation of beach access (O1.6)	Short term (0-5 years)
Scour due to stormwater outlet at all stormwater outlets including at Ocean Beach Surf Club and Berith St.	Investigate installation of stormwater energy dissipation to reduce discharge velocities at outlet (O2.4)	Short term (0 – 5 years)
	Post storm beach scraping to assist natural recovery of the dune and repair scour caused by stormwater discharge (O2.5)	As required
Community participation	Increase information signage near surf clubs on the ecology and history of Umina/Ocean Beach	Short term

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)
and beach amenity	Implement traffic control techniques to facilitate easy risk free pedestrian access for major events including the Surf Life Saving carnivals.	As required
	Improve shade areas around the grassed areas and car parks near the SLSCs	Short term
	Maintain current signage and facilities on a regular basis	As required
	Construction of a disabled beach access point outside Ocean Beach SLSC	Short term
	Encourage and assist Dunecare group to maintain and revegetate dune after a storm using low-growing vegetation	Short term/ongoing
	Development of local area (Umina/Ocean Beach) online fact sheets and encourage local educational programs in schools regarding the dunes	Short term/ongoing
	Work with the Central Coast Surf Life Saving organisation to look at ways to support Surf Life Savings Australia's EcoSurf policy in the region – including Ocean and Umina Surf Life Saving clubs.	Short term
All issues	Emergency Management (O2.6)	As required

Table 41 – Ocean Umina Beach Precinct 4 – East of Ocean Beach surf club to Ettalong Point

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)
Immediate and future risk of erosion to dunes; public safety due to steep erosion escarpments; Windblown dune erosion; dune ecology	Monitor storm run-up levels and dune erosion	Short term and following storms as required
	Repair of beach accessways and revegetation of dune following erosion in a large storm event (O2.2)	Short term and following storms as required
	Beach scraping following storm event to build dune crest level and revegetation (O2.3)	After storm events as required
	Collapse steep eroded escarpment and revegetate following erosion events	Short term and as required
	Complete a vegetation profile for Umina and Ocean Beach and support the natural vegetation profile.	Short term
	Encourage and assist Dunecare group to improve dune vegetation management using low-growing vegetation and consolidation of beach access (O1.6)	Short term (0-5 years)
Scour due to stormwater outlet at all stormwater outlets	Investigate installation of stormwater energy dissipation to reduce discharge velocities at stormwater outlets (O2.4)	Short term (0 – 5 years)
	Post storm beach scraping to assist natural recovery of the dune and repair scour caused by stormwater discharge (O2.5)	As required
Community participation and beach amenity	Development of local area (Umina/Ocean Beach) online fact sheets and encourage local educational programs in schools regarding the dunes	Short term/ongoing
All issues	Emergency Management (O2.6)	As required

Table 42 – Putty-Killcare Beach Management Options

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)
Immediate risk of erosion and inundation damage to surf club and carpark	Geotechnical investigation of surf club area	Short term
	Erosion Protection works at surf club if required based on outcome of geotechnical investigation (K1)	Short to medium term (0 – 20 years)
	Repair damage to surf club carpark should storm erosion occur (K2)	As required
	Investigate feasibility of beach nourishment in front of surf club (K3)	Short to medium term (0 – 20 years)
	Beach scraping to build vegetated dune in front of surf club above the wave runup level with vegetation and/or fencing (K4)	Short term (0-5 years)
	Future relocation of surf club and associated infrastructure to an area landward of the coastal hazard area if required (K5)	Long term (>20 years)
	Redevelop surf club on deep piled foundations (K7)	Long term (>20 years)
	Continue dune vegetation management - Assist/encourage community groups with dune management actions including Dunecare/Bushcare	Ongoing
	Complete a vegetation profile for Putty/Killcare Beach and support the natural vegetation profile.	Short term
Future risk of erosion damage to main carpark	Move carpark landward in future (K9)	Long term (>20 years)

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)
Stormwater erosion hazard	Improve stormwater outlet by installing energy dissipation to minimise scour and prevent sand ingress into outlet (K10)	Short term
	Regrade/repair scour caused by stormwater outlet	After storms as required
Future erosion damage to Putty Beach camping area	Future relocation of camping area infrastructure to an area landward of the coastal hazard area (K11)	Long term >20 years
All issues	Emergency Management (K12)	As required
	Monitor beach for erosion in front of surf club and camping area (K13)	Short term, ongoing

Table 43 – MacMasters Beach Precinct 1 – Management Options

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)
Immediate and future risk of erosion and reduced foundation capacity to surf club and Marine Parade	Erosion Protection works for MacMasters Beach Surf Club (M1.1)	Short term (0 – 5 years)
	Investigate whether SLSC is constructed on deep pile foundations and reconstruct on deep pile foundations on redevelopment of the club if required	Short term
	Monitor performance of existing erosion works around base of Norfolk Island Pine trees and at surf club at southern end of beach (M1.2)	Ongoing
	Erosion protection works for Marine Parade (M1.3)	Short term (0 – 5 years)
	Beach nourishment in front of surf club and Marine Parade (M1.5)	Medium term (5 – 20 years)
	Beach scraping to build dune in front of Surf Club, eroded pine tree roots and Marine Parade in the interim until erosion protection works are constructed (M1.6)	After storm events as required
	Undertake geotechnical investigation of area behind Marine Parade (M1.8)	Short term (0 – 5 years)
	Development controls for residences to be on piled foundations on redevelopment of properties within 2050 or 2100 hazard area (i.e. maintain status quo) (M1.10)	Short term (0 – 5 years)
	Landward relocation of sewer infrastructure along Marine Parade if erosion protection works not implemented (M1.11)	Short term (0 – 5 years)
	Repair damage to Marine Parade should it be damaged by future erosion if erosion protection works not	As required

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)
	implemented (M1.12)	
Scour due to stormwater outflow	Improve energy dissipation at stormwater outlet (M1.4)	Short term (0 – 5 years)
	Periodic beach scraping to repair damage caused by scour from stormwater outlet (M1.17)	After storm events as required
Dune vegetation management/ beach amenity	Encourage and assist Dunecare group to improve dune vegetation management using low-growing vegetation (M1.7)	Ongoing
	Improve pedestrian access onto beach from carpark and minimise scour caused by beach shower (M1.19)	Short term (0 – 5 years)
	Monitor rock pool for storm damage and repair if required	Ongoing
All issues	Emergency Management (K12)	As required

Table 44 – MacMasters Beach Precinct 2 Management options (south of Cockrone Lagoon entrance)

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)
Immediate and future risk of erosion and reduced foundation capacity to properties along seaward side of Tudibaring Parade	Geotechnical investigation and stability of cliff between 45 and 65 Tudibaring Parade	Short term
	Development controls for residences on Tudibaring Parade to be on piled foundations on redevelopment of properties based on a defined building line (M2.1)	Short term (0 – 5 years)
	Not allowing further subdivision of properties on seaward side of Tudibaring Parade (M2.2)	Short term
	Investigate feasibility of beach nourishment to increase erosion buffer in this area (M2.5)	Medium term (5 – 20 years)
	Encourage and assist Dunecare group and local residents to maintain and revegetate dune after a storm through provision of free plants and public education material (M2.6)	Short term (0 – 5 years)
Risk of erosion due to lagoon entrance instability	Seaward extension of existing training wall along southern side of entrance (M2.7)	Medium term (5 - 20 years)
	Undertake review of entrance management procedure as recommended by Gosford Coastal Lagoons CZMP. Implement management actions as required (M2.8)	Short term (0 - 5 years)
All issues	Emergency Management (K12)	As required

Table 45 – Copacabana Beach Management Options – Precinct 3

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)
Windblown erosion of dune	Encourage and assist Dunecare group and local residents to maintain and revegetate dune after a storm through provision of free plants and public education material (M3.1)	Short term (0 – 5 years)
Risk of future erosion damage to Del Monte Place, services/ utilities and Copacabana surf club	Erosion Protection works for Copacabana Beach Surf Club (M3.2)	Medium term (5 - 20 years)
	Investigate whether SLSC is constructed on deep pile foundations and reconstruct on deep pile foundations on redevelopment of the club if required	Short term
	Erosion protection works for Del Monte Place to be installed once erosion escarpment reaches set trigger distance from edge of road (M3.3)	Long term (> 20years)
	Landward relocation of sewer and water infrastructure as well as other utilities along Del Monte Place (M3.4)	Long term (> 20years)
	Beach nourishment in front of surf club and Del Monte Place (M3.5)	Long term (> 20 years)
	Repair damage to Del Monte Place, Surf Club and surrounding land should it be damaged by future erosion (M3.6)	Medium term and as required (> 5 years)
	Long term narrowing, removal and relocation or provision of alternative access for Del Monte Place if erosion protection works are not implemented (M3.7)	Long term (> 20 years)
	Development controls for residences and commercial premises to be on piled foundations on redevelopment of properties based on a defined building line (M3.10)	Short term (0 – 5 years)

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)
	Geotechnical investigation around surf club area to confirm level of bedrock and reduced foundation capacity hazard if surf club not on deep piled foundations (M3.11)	Short tern (0 – 5 years)
Scour and water quality issues due to stormwater management near Copacabana surf club	Improve energy dissipation at stormwater outlet (M3.12)	Short term (0 – 5 years)
	Improve existing outlet control structures to prevent scour of the base of the dune (M3.13)	Short term (0 – 5 years)
Dune vegetation management	Encourage and assist Dunecare group to improve dune vegetation management using low-growing vegetation (M3.14)	Ongoing
All issues	Emergency Management (M3.15)	As required

Table 46 – Avoca Beach Management Options – Precincts 1 and 2

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)
Immediate risk of inundation to Avoca Beach SLSC and carpark	Implement seawall to protect water and sewer infrastructure and improve beach access/amenity in front of the surf club	Short term
	Survey floor levels to determine degree of inundation hazard (A1.1)	Short term
Immediate and future risk of erosion and inundation damage to the surf club carpark	Repair damage to carpark and other infrastructure should storm erosion occur (A1.2)	As required
	Beach scraping to build vegetated dune in front of carpark (A1.4)	Short term (0-5 years)
	Monitor performance of existing rock works in front of surf club and carpark following a large storm (A1.6)	Short term and as required
Immediate and future risk of erosion to properties on Avoca Drive and undermining of Norfolk Island pines	Development controls based on a defined building line with new buildings to be founded into 2100 Stable foundation Zone (A1.7)	Short term
	Erosion protection works to be allowed for properties for emergency protection (funded by residents) (A1.9)	Short to medium term, some of these properties already have protection installed
	Investigate beach nourishment to increase erosion buffer in this area (A1.13)	Medium term
	Beach scraping to build dune in front of residences (A1.14)	Short term (0 - 5 years, ongoing)
	Repair of beach accessways and revegetation of dune following erosion in a large storm event (A1.15)	Short term and following storms as required

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)
	Encourage and assist Dunecare group to improve dune vegetation management using low-growing vegetation	Ongoing
Immediate and future risk of inundation risk to properties (south of Austral Avenue)	Development controls for residences to be above inundation levels on redevelopment of properties (A1.16)	Short term
Erosion risk to stormwater outlets	Erosion protection works in front and around the stormwater outlet should storm erosion occur (A1.17)	Short term
	Improve energy dissipation at stormwater outlets	Short term (0 – 5 years)
	Relocate stormwater outlets (A1.18)	Short term

Table 47 – Avoca Lagoon Entrance (Precinct 3) Management Options

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)
Immediate and future erosion and inundation risk to properties and infrastructure at Avoca Lake Entrance	Development controls for residences to be above inundation levels on redevelopment of properties (A3.1)	Short term
	Review entrance management guidelines for mechanical opening of Avoca Lake (A3.2)	Short term
	Allow lagoon frontage properties to self-protect (A3.3)	Short term
	Encourage and assist Dunecare group to improve dune vegetation management using low-growing vegetation	Ongoing
	Relocation of sand to improve beach access and amenity	Short term/ongoing
Inundation and erosion risk to Ficus Avenue carpark	Repair damage to carpark and other infrastructure should storm erosion occur (A1.19)	As required
	Beach scraping to build dune in front of carpark and properties 165 Avoca Drive to 15 Ficus Avenue (A1.20)	Short term (0 - 5 years)

Table 48 – North Avoca Precincts 4 and 5 – Management Options

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)
Immediate and future risk of erosion risk to properties at North Avoca Beach	Allowing development landward of a specially defined building line with piled foundations into the 2100 Stable Foundation Zone (i.e. similar to existing DCP, status quo, A4.2)	Short term
	Development approval conditions for new developments to specify that connection to services are to be maintained by owner in the event of storm erosion	Short term
	Erosion protection works to be allowed for properties for emergency protection (funded by residents) (A4.4)	Short to medium term, some of these properties already have protection installed
	Monitor storm run-up levels and dune erosion	Short term and following storms as required
	Terminal seawall protection for all the properties (A4.5)	Long term
	Terminal seawall protection for the properties north from the Surf Club only (A4.6)	Short – medium term (0 – 20 years)
	Beach nourishment to increase erosion buffer in this area (A4.10)	Short term
	Repair of beach accessways and revegetation of dune following erosion in a large storm event (A4.11)	Short term and following storms as required
	Encourage and assist Dunecare group to improve dune vegetation management using low-growing vegetation	Ongoing
Immediate and future risk of	Development controls for residences to be above inundation levels on redevelopment of	Short term

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)
inundation risk to properties at North Avoca Beach	properties (A4.12)	
Scour erosion due to stormwater outlet	Improve energy dissipation at stormwater outlets	Short term (0 – 5 years)
Immediate and future risk of erosion and inundation risk to the North Avoca SLSC and carpark	Repair damage to surf club carpark should storm erosion occur (A4.15)	As required
	Beach scraping to build vegetated dune in front of surf club and carpark above the wave runup level with vegetation and/or fencing (A4.19)	Short term (0-5 years)
	Investigate whether SLSC is constructed on deep pile foundations and reconstruct on deep pile foundations on redevelopment of the club if required (A4.20)	Medium term (5 – 20 years)
All issues	Emergency Management (A4.21)	As required

Table 49 – Terrigal Beach Management Options

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)
Beach erosion/inundation impacting on recreational amenity	Monitor performance of existing seawall in addressing erosion and inundation (TW1.1)	Short term, ongoing
	Monitor beach profile following significant storm events (TW1.2)	Short term, ongoing
	Beach nourishment to increase buffer against storm erosion (TW1.3)	Medium term
	Repair post-storm damage to existing infrastructure	Short term, ongoing/as required
Immediate and future inundation risk to Terrigal Surf Life Saving Club and Terrigal commercial district	Survey floor levels to determine degree of inundation hazard (TW2.1)	Short term
	Monitor performance of existing seawall against erosion and inundation (TW2.2)	Short term/as required
	Repair post-storm damage to existing infrastructure	Short term, ongoing/as required

Table 50 – Wamberal Beach Management Options

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)
Immediate and future erosion and inundation risk to properties and infrastructures along Wamberal Beach	Allowing development landward of a specially defined building line with piled foundations into the 2100 Stable Foundation Zone (TW4.2)	Short term
	Terminal protection (TW4.5)	Short –medium term
	Complete a vegetation profile for Wamberal Beach and support the natural vegetation profile.	Short term
	Continue and enhance dune vegetation management - Assist/encourage community groups with dune management actions including Dunecare/Bushcare (TW4.8)	Ongoing
	Investigate sources of sand and feasibility of beach nourishment for Wamberal Beach	Short term
	Beach nourishment coupled with a terminal revetment to increase buffer against storm erosion (TW4.9)	Short – medium term
Immediate and future erosion and inundation risk to properties south of the Wamberal Lagoon entrance	Review entrance management guidelines for mechanical opening of Wamberal Lagoon (TW5.1)	Short term
	Ensure floor levels for new Development Applications are above inundation levels	Ongoing
Future erosion and immediate inundation risk to Wamberal Surf Life Saving Club	Repair damage to surf club carpark should storm erosion occur (TW5.2)	As required
	Beach scraping to build vegetated dune in front of carpark (TW5.4)	Short term (0-5 years)

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)
	Continue and enhance dune vegetation management - Assist/encourage community groups with dune management actions including Dunecare/Bushcare (TW4.8)	Ongoing
	Check whether surf club is on deep piled foundations and re-construct on deep piled foundations upon redevelopment of club if required (TW5.6)	Short – medium term (5 – 20 years)
Immediate and future erosion and inundation risk to properties north of the Terrigal Lagoon entrance	Review entrance management guidelines for mechanical opening of Terrigal Lagoon (TW3.1)	Short term
	Allow lagoon frontage properties at southern end of Pacific Street to self-protect in accordance with existing legislation (TW3.2)	Short term
	Ensure floor levels for new Development Applications are above inundation levels	Ongoing
	Investigate purchase of small section of southernmost property (1 Pacific Street) to provide public access along lagoon frontage	Short Term
	Beach scraping from lagoon entrance to reduce erosion and inundation risk to properties at southern end of Pacific Street as well as enhance public access (TW3.3)	Short term
All issues	Emergency Management (TW5.7)	As required

Table 51 – Forresters Beach Management Options

Hazard/Issue Addressed	Management Option	Timetable for adoption (short, medium, long term)
Immediate risk of erosion damage to properties and minor structures	Geotechnical investigation to determine the Zone of Reduced Foundation Capacity (F1)	Short term
	Continue dune vegetation management - Assist/encourage community groups with dune management actions including Dunecare/Bushcare	Ongoing
	Complete a vegetation profile for Forresters Beach and support the natural vegetation profile.	Short term
	Collate geotechnical information obtained from DAs into a central database	Short term
All issues	Emergency Management (F6)	As required
	Monitor beach for erosion and cliff lines for instability (F7)	Short term, ongoing

9.3 Excluded Options for Draft Coastal Zone Management Plan

Several options developed in Section 8 or suggested by the community following the public exhibition process have not been recommended for further consideration for the Coastal Zone Management Plan, for the following reasons:

- the option is adequately addressed as part of another management action already in place;
- the option cannot be implemented due to legislative issues or the issue is dealt with in other planning documents or is outside of the scope of this Coastal Zone Management Study;
- the option has been ruled out based on feedback from key stakeholders in the community or from the Coastal Management Committee;
- the costs of the option far outweigh the benefits (low benefit-cost ratio <0.3);
- the option would have an unacceptable environmental or social impact;
- the option is not in accordance with the objects of the Coastal Protection Act 1979 and the goals, objectives and principles of the NSW Coastal Policy 1997, or the ten Principles of Coastal Management as described in OEH (2013).

The options at each beach which have not been recommended for inclusion and the justification for their exclusion are described in Table 52, below. Some of the options below, however, may still be considered in future revisions of the CZMP.

Table 52 – Options excluded from draft CZMP

Beach	Option	Reasons for exclusion
Patonga	Erosion Protection works at main carpark (P1), (P7)	Low BCR 0.05 – 0.1 Potential for adverse environmental impact Erosion risk not high enough to justify works at present time.
	Future relocation of main access into village (P8)	Not required to be addressed at this time
	Reinstate access road to boat ramp and erosion works following erosion event (P11)	Low BCR, lower risk option to relocate access road and protection works landward instead of reconstructing within erosion hazard area
	Maintain Status Quo (P24)	Not supported by the Gosford Coastal Committee
Pearl Beach	Future relocation of restaurant landward on redevelopment (Pe1.9)	Low BCR, high social impact
	Voluntary Purchase (Planned retreat) for two unprotected properties including restaurant (Pe1.12)	Low BCR, high social impact, opposed by community
	Erosion Protection works in front of playground area (Pe2.1)	Low BCR, potential for adverse environmental impact

Beach	Option	Reasons for exclusion
	Beach nourishment to increase erosion buffer in this area (Pe2.4)	Low BCR, potential for adverse environmental impact
	Development controls with building line based on 2100 Zone of Slope Adjustment with new buildings to be founded into 2100 Stable foundation Zone (Pe4.2)	Not supported by Pearl Beach representatives on the Gosford Coastal Committee as it adversely impacts development potential of existing allotments compared with existing DCP
	Voluntary purchase of individual properties once erosion escarpment reaches set trigger distance from defined building line (Pe4.5)	Low BCR, potential for adverse social impact, Not supported by the Gosford Coastal Committee
	Trigger limited consents (Pe4.6)	Low BCR, potential for adverse social impact, Not supported by the Gosford Coastal Committee
Ocean/Umina Beach	Voluntary purchase of at risk property (O1.8)	Low BCR
	Stringent controls on major developments seaward of West Street (excluding SLSCs)	Controls will only apply to developments within identified coastal hazard areas
	The two Crown Lots (foredunes) 7175/1066208 and 7002/1122309 to be rezoned from RE1 Recreation to E2 Conservation.	Current RE1 zoning is consistent with COSS system. E2 zoning allows development of single dwelling – Council is in liaison with the Department of Planning & Environment to establish new appropriate zone to ensure protection of environmentally valued lands
Putty-Killcare Beach	Maintain status quo (K8)	Not supported by the Gosford Coastal Committee
MacMasters-Copacabana Beach	Future relocation of surf club landward on redevelopment (M1.9)	Low BCR, social impact, opposition from Surf Club.
	Long term narrowing, removal and relocation or provision of alternative access for Marine Parade (M1.13)	Not technically feasible, not supported by the Gosford Coastal Committee
	Planned retreat from this area, including the voluntary purchase/relocation of the surf club, properties that would lose their access should Marine Parade be damaged by future erosion and closure of Marine Parade. (M1.14)	Low BCR, social impact, Not supported by the Gosford Coastal Committee, opposed by community
	Do nothing (M1.15)	High social impact, Not supported by the Gosford Coastal Committee
	Future voluntary purchase of properties offered when erosion scarp reaches set trigger distance from	Low BCR, high social impact.

Beach	Option	Reasons for exclusion
	buildings (M2.3)	
	Terminal protection structure for properties along seaward side of Tudibaring Parade (M2.4)	Low BCR, erosion risk currently not high enough to justify option at this time
	Future relocation of surf club landward on redevelopment (M3.8)	Low BCR, erosion risk currently not high enough to justify option at this time, social impact, Not supported by the Gosford Coastal Committee
	Voluntary purchase of properties affected by coastal hazards (M3.9)	Low BCR, adverse social impact, Not supported by the Gosford Coastal Committee
Avoca Beach	Beach nourishment in front of carpark (A1.3)	Low BCR 0.25
	Future relocation of carpark to an area landward of the coastal hazard area (A1.5)	Not required as protection is option chosen by Gosford Coastal Committee
	Development controls based on 2100 Zone of Slope Adjustment with new buildings to be founded into 2100 Stable foundation Zone (A1.8)	Not supported by Avoca Beach representatives on the Gosford Coastal Committee or by public submissions as it adversely impacts development potential of existing allotments compared with existing DCP
	Voluntary purchase of individual properties where buildings are seaward of 2050 Zone of Slope Adjustment. (A1.11)	Low BCR, adverse social impact
	Relocate sewer infrastructure further landwards (A1.12)	Low BCR, cost of repair lower than cost of relocation, protection is option chosen by Gosford Coastal Committee
	Allowing development landward of the 2050 Zone of Slope Adjustment with piled foundations into the 2100 Stable Foundation Zone (A4.1)	Not supported by Avoca Beach representatives on the Gosford Coastal Committee or by public submissions as it adversely impacts development potential of existing allotments compared with existing DCP
	Allowing development landward of the 2100 Zone of Slope Adjustment with piled foundations into the 2100 Stable Foundation Zone (A4.1)	Not supported by Avoca Beach representatives on the Gosford Coastal Committee or by public submissions as it adversely impacts development potential of existing allotments compared with existing DCP
	Planned retreat from this area, including the voluntary purchase of properties where buildings are seaward of 2050 Zone of Slope Adjustment (A4.7)	Low BCR, adverse social impact
	Voluntary purchase of properties where buildings are	Low BCR, adverse social impact

Beach	Option	Reasons for exclusion
	seaward of Immediate Zone of Slope Adjustment (A4.8)	
	Relocate sewer infrastructure further landwards (A4.9)	Low BCR, repair cost lower than relocation cost
	Erosion protection works at surf club (A4.14)	Low BCR and potential environmental impact, not required if club on piled foundations
	Beach nourishment in front of surf club and carpark (A4.16)	Low BCR, potential environmental impact
	Future relocation of surf club and associated infrastructure to an area landward of the coastal hazard area (A4.18)	Low BCR, social impact
Terrigal-Wamberal Beach	Allowing development landward of the 2050 Zone of Slope Adjustment with piled foundations into the 2100 Stable Foundation Zone (TW4.1)	Rejected by Coastal Committee as it adversely impacts development potential of existing allotments compared with existing DCP
	Allow residents to construct own permanent protection works combined with existing DCP controls (TW4.4)	Rejected due to potential for adverse impact of individual erosion protection works on neighbouring properties due to edge effects and impact on visual amenity.
	Planned retreat from this area, through voluntary purchase of properties where buildings are seaward of 2050 Zone of Slope Adjustment. (TW4.6)	Low BCR, adverse social impact
	Voluntary purchase of properties where buildings are seaward of Immediate Zone of Slope Adjustment (i.e. 61 properties) (TW4.7)	Low BCR, adverse social impact
	Beach nourishment in front of carpark (TW5.3)	Low BCR
	Future relocation of surf club and carpark to an area landward of the coastal hazard area (TW5.5)	Low BCR, adverse social impact
Forresters Beach	Erosion protection works (F3)	Low BCR, erosion risk currently not high enough to justify option at this time. Not supported by the Gosford Coastal Committee
	Placement of sand to provide buffer against storm erosion (F4)	Erosion risk currently not high enough to justify option at this time, not technically effective.

10 CONCLUSIONS

This Coastline Management Study has examined the issues and options for managing the Open Coast and Broken Bay beaches within Gosford City and has undergone review by Council's Coastal Sub-committee.

The Study was publicly exhibited in January/February 2015 and 56 formal submissions have been received. The Study has been refined to take into account the issues raised in the submissions, with additional coastal management options included for some beaches and others omitted based on community feedback.

The study has examined the process for setting out a Coastline Management Plan for Gosford City, in accordance with the framework described in the NSW Government Guidelines for preparing Coastal Zone Management Plans (OEH 2013).

The coastal processes and coastal risks for each precinct in the study area have been synthesized based on the outcome of the Coastal Process and Hazard Definition Study (WorleyParsons 2014). Risks to the coastal built and natural environment have been articulated for each precinct within the study area. Future beach recession due to sea level rise is a major factor influencing the underlying risk for consideration and contingency planning in the Coastal Zone Management Plan. However, the identified risks are manageable and factors and should be subject to ongoing monitoring and an adaptive approach to planning. Appropriate management responses would be required to prevent unnecessary and significant disruption to the community and the local economy.

The coastal hazard lines represent a worst case scenario developed in line with NSW Government requirements at the time and widely accepted coastal engineering methodologies. They represent a theoretical line which assists in guiding the development of appropriate management options to deal with defined risk. It must also be understood that they represent only one component in considering appropriate development going forward.

Review of the CZMP creates opportunity to think creatively in determining future DCP provisions to retain development potential in consideration of coastal hazards. The ultimate review of Council's DCP will involve revisiting concepts and established rules relating to development footprints, engineered design, counter levering, building design (i.e. relocatable buildings) and setbacks from street to maintain development potential: all in a view to enabling ongoing development in the short to medium-term. In doing so, Council must be confident it does not create further legacy implications for future generations.

Specific coastline management issues have been identified at each beach. These issues have been refined based on feedback from local communities obtained during exhibition of the Draft Study.

Based on the nature of the risks and issues identified at each beach, a suite of detailed management options have been developed and discussed, including timeframe for adoption, advantages and disadvantages of each and indicative costs. These have been refined based on feedback from local community and stakeholders following exhibition of the Draft Coastline Management Study.

Landuse and development issues are particularly relevant for some of the beaches in the study area, where the risks from coastal hazards to development are especially high given the current prognoses for future sea level rise. For these beaches and in the areas where risks to urban development and public/private infrastructure are particularly high, specific options to address landuse and development have been developed, together with indicative costs and benefit-cost ratios.

The outcome of this Study has been a defined and prioritised set of coastal management options to take forward to the Draft Coastal Zone Management Plan, supported by informed reasoning considering the uncertainties of sea level rise to address specific management issues for each beach in the Study area.

11 REFERENCES

Australian Terrestrial Biodiversity Assessment (2002), *National Land and Water Resources Audit*

Beavis, A. H. Donovan, D Camenzuli and Sorensen, K. (2009), *A Holistic Study of the Implications of Sea Level Rise and Shoreline Recession at Wamberal Beach NSW,* for Gosford City Council, November

Bent, S. (1990). A survey and assessment of the marine habitat and species assemblages at Lennox Head reef, northern NSW. Integrated Project for: The Centre for Coastal Management, Southern Cross University, Lismore, NSW, Australia.

Blackmore, K.L. & Goodwin, I.D. (2009) *Climatic Change Impact for the Hunter, Lower North Coast and Central Coast Region of NSW*. Consultancy report by Newcastle Innovation for the Hunter and Central Coast Regional Environment Management Strategy (HCCREMs). HCCREMS.

BMT WBM (2013), *Pearl Beach Lagoon, Draft Coastal Zone Management Plan*, Draft Report, May 2013, prepared for Gosford City Council.

BMT WBM (2014), *Coastal Zone Management Study for Gosford Lagoons,* prepared for Gosford City Council.

BMT WBM (2014), *Coastal Zone Management Plan for Gosford Lagoons,* prepared for Gosford City Council.

Brown, A.C. and McLachlan, A. (2002). Sandy shore ecosystems and the threats facing them: some predictions for the year 2025. *Environmental Conservation* **29**, 62-77.

Cardno (2010), *Brisbane Water Estuary Management Study*, LJ2717/R2471/V3, October 2010, prepared for Gosford City Council.

Cardno (2014), *Brisbane Water Foreshore Coastal Floodplain Risk Inundation Management Study and Plan,* Draft Report, LJ2828/Rep2584, Prepared for Gosford City Council, August.

Cardno Lawson Treloar (2010). “*Gosford Coastal Lagoons Process Study*”, report prepared for Gosford City Council by Cardno Lawson Treloar, July, 2010.

Carley, JT, IR Coghlan, MJ Blacka and R J Cox (2010) *Development of a Proposal and Environmental Assessment of Beach Scraping – New Brighton and Southern Golden Beach*, WRL Report no. 2008/19, February 2010

Central Coast NSW (2010), *History of the Central Coast*, viewed 7 July 2010, <http://www.central-coast-nsw.info/history-of-the-central-coast.php>.

CERC (2003) “Coastal Engineering Manual” US Army Corps of Engineers

Chelazzi, G. and Vannini, M. (Eds.) (1988). Behavioural Adaptations to Intertidal Life. Plenum Press, New York, pg. 524.

Coghlan, Ian, James Carley, Ronald Cox, Matthew Blacka, Alessio Mariani, Simon Restall, Warren Hornsey and Simon Sheldrick (2009), Two-dimensional Physical Modelling of Sand Filled Geocontainers for Coastal Protection, Coasts and Ports 2009, 19th Australasian Coastal and Ocean Engineering Conference and 11th Australasian Port and Harbour Conference, Wellington, New Zealand, 16-18 September

Colombini, I. and Chelazzi, L. (2003). Influence of marine allochthonous input on sandy beach communities. *Oceanography and Marine Biology: an Annual Review* **41**, 115-159.

Corkill, J. (2013), *Principles and Problems of Shoreline Law,* ACCARNSI Discussion Paper – Node 1 Coastal Settlements, December 2012.

CSIRO (2007) - McInnes, K.L., Abbs, D.J., O'Farrell S.P., Macadam, I., O'Grady, J. & Ranasinghe, R., *Projected changes in climatological forcing for coastal erosion in NSW - A project undertaken for the DECC NSW*, CSIRO Marina and Atmospheric research, Victoria.

Darkinjung Aboriginal Land Council (2014), viewed 13 March 2014, http://www.darkinjung.com.au/

Davey, K. (1998). A photographic guide to seashore life of Australia. New Holland Publishers (Australia) Pty Ltd, Sydney, NSW.

Defeo, O., McLachlan, A., Schoeman, D.S., Schlacher, T.A., Dugan, J., Jones, A., Lastra, M. and Scapini, F. (2009). Threats to sandy beach ecosystems: A review. *Estuarine, Coastal and Shelf* Science **81**, 1-12.

Department of Environment, Climate Change and Water [DECCW] (2010a), *Coastal Risk Management Guide: Incorporating sea level rise benchmarks in coastal risk assessments*, DECCW 2010/760, August, ISBN 978 1 74232 922 2

Department of Environment, Climate Change and Water [DECCW] (2010b), *Flood Risk Management Guide: Incorporating sea level rise benchmarks in flood risk assessments*, DECCW 2010/759, August, ISBN 978 1 74232 921 5

Department of Environment, Climate Change and Water [DECCW] (2011), "Reforms to coastal erosion management in NSW", online at http://www.environment.nsw.gov.au/coasts/coastalerosionmgmt.htm , page last updated 23 March, accessed 24 March

Department of Environment, Climate Change and Water [DECCW] (2011a), *Seabed Habitat Mapping of the Continental Shelf of NSW*, DECCW 2010/1057, December 2010, ISBN 978-1-74293-085-5

Department of Land and Water Conservation (2001), *Dune Management Manual*

Department of Planning (2010), *NSW Coastal Planning Guideline: Adapting to Sea Level Rise*, Pub No. DOP 10_022, ISBN 978-1-74263-035-9, August

Dugan, J.E., Hubbard, D.M., McCray, M.D., and Pierson, M.O. (2003). The response of macrofauna communities and shorebirds to macrophyte wrack subsidies on exposed sandy beaches of southern California. *Estuarine, Coastal and Shelf Science* **58S**, 25-40.

Gosford City Council (1995), *Coastal Lagoons Management Plan – Wamberal, Terrigal, Avoca and Cockrone*, Adopted July 1995, formulated by Coastal Management, Lagoon Management and Coastal Planning Committee.

Gosford City Council (2004) *Strategy Paper for Wamberal Beach*

Guringai Aboriginal Tribal Link (2013), viewed 13 March 2014, http://www.guringai.com.au/

Hacking, N. (1998). Macrofaunal community structure of beaches in northern New South Wales, Australia. *Marine and Freshwater Research* **49**, 47-53.

Hubbard, D.M. and Duggan, J.E. (2003). Shorebird use of an exposed sandy beach in southern California. *Estuarine, Coastal and Shelf Science* **58**, 41-54.

Insurance Council of Australia (2014), *Climate Change, Coastal Property Risks and Insurance, http://www.insurancecouncil.com.au/issues-submissions/industry-in-focus/coastal-vulnerability-risks*

Intergovernmental Panel on Climate Change [IPCC] (1990), *Climate Change: The IPCC Scientific Assessment*, Meteorological Organisation/UN Environment Programme, Cambridge University Press

Intergovernmental Panel on Climate Change [IPCC] (2001a), *Summary for Policymakers, A Report of Working Group I of the Intergovernmental Panel on Climate Change*

Intergovernmental Panel on Climate Change [IPCC] (2001b), *Technical Summary, A report accepted by Working Group I of the IPCC but not approved in detail*, Co-ordinating Lead Authors DL Albritton (USA) and LG Meira Filho (Brazil)

Komar, P.D. (1998). *Beach Processes and Sedimentation*. Second ed. Prentice-Hall, Englewood Cliffs, NJ, pg. 544.

Lee, E. (1996). “An assessment of the management options for the intertidal rocky shore environment at Hastings Point, northern NSW.” Integrated Project for: The Centre for Coastal Management, Southern Cross University, Lismore, NSW, Australia.

McIlgorm, A. and J. Pepperell (2013). “Developing a cost effective state wide expenditure survey method to measure the economic contribution of the recreational fishing sector in NSW in 2012. A report to the NSW Recreational Fishing Trust, NSW Department of Primary Industries”, November 2013. Produced by the Australian National Centre for Ocean Resources and Security (ANCORS), University of Wollongong,

McLachlan, A. (1985). The biomass of macro- and interstitial fauna on clean and wrack-covered beaches in Western Australia. *Estuarine, Coastal and Shelf Science* **21**, 73-88.

Manly Hydraulics Laboratory [MHL] (2003), *Wamberal Beach and Property Protection Environmental Impact Statement*, Manly Hydraulics Laboratory Report No. 935.

Martin, K.T., Speer-Blanl, R., Pommerening, J., Flannery, K., Carpenter, K. (2006). Does beach grooming harm grunion eggs? *Shore and Beach* **74**, 17-22.

New South Wales Department of Primary Industries (2013) "Policy and Guidelines for Fish Habitat Conservation and Management", ISBN 978 1 74256 283 4

NSW Department of Public Works and Services (1997) *Stage 1 Gosford City Beach Nourishment Feasibility Study*

NSW Department of Public Works and Services (2002) *Stage 2 Gosford City Beach Nourishment Feasibility Study*

New South Wales [NSW] Government (1990), *Coastline Management Manual*, September, ISBN 0730575063

New South Wales [NSW] Government (1992), *Estuary Management Manual*

NSW Marine Parks Authority (2010). Cape Byron Marine Park Operational Plan September 2010. NSW Government.

NSW National Parks and Wildlife Service (1993), *Wamberal Lagoon Nature Reserve, Plan of Management*, March 1993.

NSW Treasury (2007), *NSW Government Guidelines for Economic Appraisal*, Office of Financial Management, Policy & Guidelines Paper, July.

New Zealand Ministry for the Environment (2014), *Managing Coastal Hazard and Related Climate Change Risks* http://www.mfe.govt.nz/publications/climate/coastal-hazards-climate-change-guidance-manual/page7.html

Nielsen and Mostyn (2011). *Considerations in Applying Geotextiles to Coastal Revetments*, Australian Geomechanics Society Sydney Chapter Symposium October 2011.

Nielsen, AF, Lord, DB and HG Poulos (1992), "Dune Stability Considerations for Building Foundations", *Australian Civil Engineering Transactions*, Institution of Engineers Australia, Volume CE34, No. 2, June, pp. 167-173

NRMA Insurance (2011), *Draft Planning Circular on Coastal Hazard Notations on Section 149 Planning Certificates*, NRMA submission on draft planning circular to NSW Department of Planning and Infrastructure, March 2014.

O'Brien, C (2009), *Pearl Beach Environmental Guide*, prepared for Pearl Beach residents and visitors by Christine O'Brien, convenor Pearl Beach Environment Group.

Office of Environment and Heritage [OEH] (2011), *Coastal Zone Management Guide Note, Emergency Action Subplans*, 978 1 74293 300 9, OEH 2011/0631, July

Office of Environment and Heritage [OEH] (2013), *Guidelines for Preparing Coastal Zone Management Plans*, OEH 2013/0224, July, ISBN 978-1-74359-054-6

Office of Environment and Heritage [OEH] (2014), http://www.environment.nsw.gov.au/bioregions/SydneyBasin-Biodiversity.htm

Patterson Britton & Partners [PBP] (1998), *Broken Bay Beaches Coastal Processes Study*, Issue No. 5, May 1998, for Gosford City Council.

Patterson Britton & Partners [PBP] (1999), *Broken Bay Beaches Coastal Management Study,* Issue No. 4, March 1999, for Gosford City Council.

Peninsula News (2008), “Long-time residents answer survey”, Issue 194 – 07 Jul 2008

Public Works Department [PWD] (1985a), “Elevated Ocean Levels, Storms Affecting NSW Coast 1880-1980”, *PWD Report No. 85041*, Coastal Branch, prepared by Blain Bremner and Williams Pty Ltd, in conjunction with Weatherex Meteorological Services Pty Ltd, December

Public Works Department [PWD] (1985b). “Wamberal Beach and Avoca Beach Coastal Engineering Advice”. Report No. PWD 85040 prepared by A F Nielsen for Gosford City Council, May, 1985.

Public Works Department [PWD] (1986a), “Summary of Storm Damage and associated Sea and Weather Conditions on the NSW Coast – 1876 to 1981”, *PWD Report No. 86014*, Coastal Branch

Public Works Department [PWD] (1994), “Gosford Coastal Process Investigation”, Coast and Flood, September 1994.

Shirley Consulting Engineers (1996) *Tudibaring Headland Cliff line Hazard Definition Study*

Short, A.D. & Trenaman, N.L.(1992), *Wave climate of the Sydney region, an energetic and highly variable ocean wave regime*, Australian Journal of Marine and Freshwater Research, 1992, 43, 765-91.

Short, A.D (1993). *Beaches of the NSW coast*. Australian beach and Safety Management Program, Sydney. pg. 358.

Short, A.D. (2007), *Beaches of the New South Wales coast: a guide to their nature, characteristics, surf and safety*. Sydney: Sydney University Press.

Skapini, F., Buiatti, M., Dematthaeis, E. and Mattocia, M. (1995). Orientation behaviour and heterozygosity of sandhopper populations in relation to stability of beach environments. *Journal of Evolutionary Biology* **8**, 43-52.

South Australia Department of Environment and Heritage (2005), *Adelaide’s Living Beaches: A strategy for 2005- 2025*, Technical Report, p. 133

Tarr, J.G. and Tarr, P.W. (1987). Seasonal abundance and the distribution of coastal birds on the northern Skeleton Coast, South West Africa / Namibia. *Madoqua* **15**, 63-72.

Terras Landscape Architects (2013), *Patonga Draft Plan of Management Crown Reserves & Dark Corner Cottages,* prepared on behalf of NSW Department of Lands and Gosford City Council.

Townsend, M. (2005) *Semaphore Park offshore breakwater – a trial*. Proceedings of the Australian coasts Conference, Adelaide, September 2005.

WBM Oceanics Australia & Planning Workshop (1995), *Coastal Management Study and Coastal Management Plan, Gosford City Open Coast Beaches*, August 1995, for Gosford City Council

Wilson, S.P. (1988). A study of human impact on rocky shores. Integrated Project for: The Centre for Coastal Management, Southern Cross University, Lismore, NSW, Australia.

Withycombe, G, Walker, J, Nielsen, L, Pinzone, T and Morrison, C (2009) *Scoping Study for Extraction of Offshore Sands for Beach Nourishment – Outcomes, Lessons Learnt and Ways Forward*

WorleyParsons (2011). *Ex HMAS ADELAIDE Artificial Reef – Reef Community and Sediment Movement Surveys*, June 2011 for NSW Crown Lands

WorleyParsons (2014), *Open Coast and Broken Bay Beaches - Coastal Processes and Hazard Definition Study*, February 2014, for Gosford City Council.

WRL (1998) *Wamberal TPS Design Study*

APPENDIX 1 – COASTAL VEGETATION MAPPING

APPENDIX 2 – BEACH USAGE STATISTICS

APPENDIX 3 – COASTAL HAZARD SUMMARY

APPENDIX 4 – COASTAL HAZARD MAPPING

APPENDIX 5 – SUMMARY OF PUBLIC SUBMISSIONS