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South Coast Regional Sea Level Rise Policy and Planning Framework

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Shoalhaven City Council

eurobodalla shire council

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South Coast Regional Sea-level Rise Planning and Policy Response Framework

Prepared for Eurobodalla Shire Council and Shoalhaven City Council

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Synopsis:	Eurobodalla Shire Council (ESC) and Shoalhaven City Council (SCC) have engaged Whitehead and Associates Environmental Consultants (W&A), in consultation with Coastal Environment (CE), to develop a Regional Sea-level Rise Planning and Policy Response Framework that will inform coastal planning within the two Local Government Areas (LGAs). This study report outlines the context, methodology and outcomes of our study. SCC and ESC have prepared this document with financial assistance from the NSW Government through the Office of Environment and Heritage. This document does not necessarily represent the opinions of the NSW Government or the Office of Environment and Heritage.
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Disclaimer

The information contained in this report is based on independent research undertaken by David Wainwright of W&A and Doug Lord of CE. To our knowledge, it does not contain any false, misleading or incomplete information. Recommendations are based on an appraisal of available background research and consultation with the Partner Councils and stakeholders. The study was subject to the limited scope and resources available and the application of industry standards, where relevant. The conclusions made in this report are based on the information gained and the assumptions as outlined. The report has been specifically prepared for the Eurobodalla Shire and Shoalhaven City Local Government Areas. The findings may not be directly applicable to other Local Government Areas and we recommend that advice be sought if the findings are to be extended to other geographical areas. Under no circumstances, can it be considered that these recommendations have an indefinite lifetime or that we are able to make accurate predictions about future conditions. Limits to understanding climate change science, predicting future emissions and projecting future sea-level rise, mean that there is significant uncertainty and absolute predictions cannot be reliably made. The conclusions in this report have a limited lifespan and should be reviewed and updated periodically as better information becomes available.

Copyright Note

Executive Summary

Introduction

This study was jointly commissioned by Eurobodalla Shire Council and Shoalhaven City Council, with financial and technical assistance provided by the Office of Environment and Heritage.

Key aims of the study were to:

(i) Develop regionally relevant sea-level rise projections for the Shoalhaven and Eurobodalla coasts; and

(ii) Develop a *"Risk Assessment and Policy Response Framework"* to address sea-level rise for use by the Partner Councils in strategic planning, development control and consent activities.

Where possible, a risk based approach has been adopted within this study. However, there is presently no means to place robust numerical likelihoods on the rates of future sea-level rise. The prevailing view of science indicates that sea-level rise will continue for a number of centuries. **For many practical purposes it is not a question of whether a certain amount of sea-level rise will occur, but when.**

An adaptable approach is very important to accommodate the uncertainty associated with the timing of sea-level rise.

This summary and the report that follows can be broadly summarised as sections on:

- The risk management environment, including planning and legislation;
- An assessment of the science of sea-level rise;
- Advice regarding selecting an appropriate projection for future use; and
- Advice regarding the application of a projection in a Planning Framework and Policy response.

These four aspects of this report are summarised below.

Planning and Legislation

Sea-level rise has been recognised and planned for in NSW for at least the past 25 years. Over time, the legislation, regulations and guidelines applicable to planning for sea-level rise have become more complex. s733 of the *Local Government Act, 1993* aims to provide local councils with exemption from liability relating to coastal planning, providing that a genuine attempt is made (in *"good faith"*) to comply with a relevant gazetted manual. At the present time, that manual is the New South Wales Coastal Zone Management Plan guidelines (OEH, 2013c). The manual requires that councils should consider sea-level rise, indicating that councils should adopt projections that are "*widely accepted by competent scientific opinion*".

The present *Environmental Planning and Assessment Act, 1979* requires that the New South Wales Coastal Policy be taken into account. The Coastal Policy indicates that (i) actions should be taken to prevent problems for future generations; and (ii) a "risk-averse" approach should be taken regarding land use planning for sea-level rise.

Our review of the applicable legislation and a range of legal advice made available to us indicated that, **to take advantage of the s733 exemption, local councils cannot ignore future sea-level rise.** Underpinning our study and its outcomes is the assumption that both Project Partners wish to genuinely attempt to plan for sea-level rise.

Assessment of Sea-level Rise Science

Raw tidal time series data were obtained from the National Tide Centre (NTC) and Manly Hydraulics Laboratory (MHL). The data were processed to remove erroneous records, and to calculate the average water level recorded at each location, for each calendar year. In addition, processed altimeter data from offshore of NSW were obtained from CSIRO. Analysis of all records over approximately the past 20 years found that:

- There has been a continuing upward trend in mean sea level over the past 20 years, with a (straight line) trend of between 3.3 and 4.5 mm/yr., calculated depending on the location and data set considered;

- Short term variability, which correlates well with the *El Nino – Southern Oscillation* (ENSO), can cause local water levels to oscillate markedly around this trend from year to year;
- The upward trends are similar to trends reflected in globally averaged estimates reported in the IPCC's latest report (AR5);
- There was no discernible spatial variation in mean sea level trends between Sydney and the study area.

Given that mean sea level at all sites examined have adjusted quickly and in a similar manner; in response to local ENSO related variability, we have found no reason why there would not be an almost equivalent adjustment to longer, underlying sea-level rise. Accordingly, **we expect that sea levels offshore of the study area will rise at a similar rate to the global average, and that any differences between the study area and Sydney will be minimal**. We advise that existing monitoring of the mean sea level at Fort Denison provides enough information to determine contemporary mean sea levels that are directly applicable to the study area.

A range of scientific reports and papers were reviewed. Arguments relating to the outcomes of the previous and most recent Intergovernmental Panel on Climate Change (IPCC) reports (AR4 and AR5 respectively) were examined and considered. Information relating to the methods of modelling to "project" future sea-level rise was also examined and considered.

The level of scientific understanding is acknowledged to be imperfect in AR5 even though there have been significant improvements since AR4. We note that there is genuine scepticism relating to the reality of climate change, but among scientists that have an established track record in climate science and directly related fields, this point of view is apparently only held by a small minority of suitably qualified professionals. Having reviewed the IPCC's AR5 report, we have found it to provide a balanced representation of the present state of the science, including discussions relating to uncertainty and possible errors in assessment. **We consider that the modelled projections from the IPCC's AR5 report are *"widely accepted by competent scientific opinion"* as required by the CZMP guidelines** (OEH, 2013c). The AR5 projections form a suitable basis for deriving local projections of relevance to the study area.

As with all computational models of uncertain physical processes, the models which are used by the IPCC are not perfect. However, the approach of the IPCC is to use many different models to capture a wide variety of results. This process encapsulates the range of uncertainty associated with those model results. To acknowledge this uncertainty, each projection presented by the IPCC can be interpreted as a series of 3 individual future possibilities, which we have designated as "High" (around 15% chance of being exceeded), "Medium" (around 50% chance of being exceeded) and "Low" (around 85% chance of being exceeded).

There are four projections presented in AR5, referred to as *Representative Concentration Pathways*, or RCP's. RCP2.6 is a very low emissions scenario that includes the active removal of greenhouse gases from the atmosphere; RCP4.5 and RCP6.0 are mid-range emissions scenarios that include a gradual reduction of emissions towards the next century; and RCP8.5 is a high range emissions scenario which represents continuation with present patterns of energy use and energy sources. Considerations of importance are outlined in the following section.

Advice Regarding Projection Selection

Considering a range of issues associated with selecting a projection, we came to the following conclusions:

- That **RCP2.6 is not as plausible as the other projections and should not be used for coastal management and planning at this time;**
- That outputs from workshops involving professional staff from Shoalhaven and Eurobodalla Councils, OEH and the Department of Planning indicate that **the future adverse consequences of adopting a sea-level rise projection that is too low are more severe than through adopting a projection that is too high.** It must be cautioned that there are still potential negative consequences from adopting a projection that is too high;
- That the **planning guidelines and legal advices encourage a cautious approach** that promotes the selection of a higher sea-level rise projection as appropriate;
- That scientific analyses following release of the IPCC's AR5 indicated that **many scientists consider a rate and magnitude of sea-level rise which is significantly greater than that predicted by the modelling underpinning the IPCC projections is possible;**
- That there was **a tendency around Australia, and Internationally,** following the release of the IPCC's AR4 in 2007, **to adopt projections based on the fossil fuel intensive scenario (A1FI) for planning purposes. That scenario is most similar to RCP8.5** in the most recent IPCC assessment (AR5). There are no widely supported arguments for a change from this approach.

For these reasons, **we have advised that RCP8.5 is a suitable basis for a sea-level rise projection.** A comparison of that projection, adjusted for local conditions, with the previous State Government sea level rise policy values is provided as Table 12 of this report. "Low", "Medium" and "High" values are presented for the RCP8.5 projection. In most situations, we recommend use of the "High" line.

Application within a Planning Framework

While a projection based on RCP8.5 has been recommended**, it is important to recognise that all four of the available projections do not differ much (less than 3cm) between each other before 2050**. The projection adopted will not have a significant impact on planning for development that will have reached its end of life by 2050.

In many locations, **detailed studies will be required to translate offshore water levels into hazards at the shoreline or within estuaries**. Such studies include flood studies, coastal hazard studies and tidal propagation studies. In some locations, suitable studies have already been undertaken, but may need to be augmented.

We consider that much of the angst generated by the previous State Government sea-level rise policy related to implementation issues. These typically related to blanket application of the 2100 "benchmark" by local councils and a lack of communication from the State Government regarding an appropriate context within which to apply the benchmark values. Projected sea-level rise at 2100 is of minimal relevance to many short term, relocatable or expendable development / redevelopment activities. Conversely, **it is important to ensure that the possibility of sea-level rise is communicated in affected areas, while appropriately acknowledging the significant uncertainty associated with the timing of sea-level rise projections leading up to 2100 and beyond.**

From our review of the science, **the majority opinion is that sea levels will eventually reach the RCP8.5 values, but the time frame over which this might occur is significantly uncertain.** In comparison, projections for sea-level rise by 2050 sit within a much tighter range of uncertainty, and planning for sea-level rise within that time frame can be undertaken with relative confidence.

Considering these things, we recommend adoption of the following **Coastal Hazard Planning Areas (CHPA's) by the Project Partners**:

- **<u>Current Hazard</u>**: Areas that are **presently, or will become imminently threatened** by the 'design' hazards (e.g. design coastal storm, design flood) over the next 15 years. In this area, immediate actions are required to advise, prepare and prevent harm;
- **<u>Medium Term Projected Hazard</u>**: Areas that are projected to be **impacted within the next 15 to 35 years**. In this area, plan sensibly, monitor changes and respond to any unexpected changes;
- **<u>Strategic Projected Hazard Planning</u>**: Areas containing development that are projected to be impacted within the next 35 to 100 years. In this area, forward planning is called for along with monitoring to inform future actions;
- **<u>Possible Maximum Strategic Hazard</u>**: Areas of existing or proposed critical infrastructure that are projected to be impacted over the next 100 years if a very high sea-level rise scenario (greater than RCP8.5) occurs.

Different responses are required for development depending on its nature. **Existing development should be allowed to remain as long as it is feasible** from both practical and safety perspectives, without adversely impacting on neighbours or the broader community. **Proposed development should be adaptable and subject to controls that ensure the development is safe for the course of its expected life** and can be decommissioned or suitably adapted with relative ease. Areas of importance to the functioning of the broader community (e.g. Critical Community Utility) are subject to special conditions but will require detailed studies to justify the viability and worth of the development.

Finally, **successful management of sea-level rise will only be achievable if a consistent, fair, open and well communicated approach is adopted.** We have recommended that council develop a policy based on guiding principles dealing with:

- Integrity;
- Responsibility;
- Flexibility;
- Consistency;
- Communication and Transparency; and
- Avoiding Complexity.

Of these, the final principle will be the most difficult to achieve. By its nature, processes along the coast are highly uncertain, and this introduces complexity into planning when the desire is to achieve balanced long-term use of a changing coastline. To assist with achieving this balance **we recommend regular review of the policy, framework and future sea-level rise projections,** followed by adjustment of practices based on experiences and updated information.

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1 Introduction

The Shoalhaven and Eurobodalla Local Government Areas (LGAs) are two adjacent coastal LGAs covering some 235km of the South Coast of NSW. These LGAs contain numerous coastal lakes and tidal rivers, with settled areas concentrated around these estuaries and the coast. Many of these areas are already threatened by low level flooding and coastal inundation; any future sea-level rise will increase the severity of physical risk to development in the coastal areas of these LGA's.

Eurobodalla Shire Council (ESC) and Shoalhaven City Council (SCC) have engaged Whitehead and Associates Environmental Consultants (W&A), in consultation with Coastal Environment (CE), to develop a *Regional Sea-level rise Planning and Policy Response Framework* that will inform coastal planning within the two LGA's. This study report outlines the context, methodology and outcomes of our study. Throughout the remainder of this report, ESC and SCC will be collectively referred to as *"the Partner Councils"*, with W&A and CE referred to as *"the Consulting Team"*.

The two LGA's are collectively referred to as *"the Study Area".* A locality plan illustrating the Study Area is provided in Figure 1. That figure shows both LGAs comprising watersheds which generally drain eastwards from the slopes of the Great Dividing Range. The two largest rivers on the South Coast of New South Wales also lie within the study area; the Shoalhaven River, exiting to the ocean at Shoalhaven / Crookhaven Heads and the Clyde River which exits to the ocean through Batemans Bay.

Generally, the coastal plain narrows with distance south. The larger embayments and estuaries, such as Jervis Bay and St Georges Basin (near Sussex Inlet) are located within the Shoalhaven LGA, whereas Eurobodalla's estuaries tend to be smaller with a concentration of intermittently closing and opening coastal lakes and lagoons, also known as ICOLLs, towards the south of the LGA. Hence, there are a range of morphological characteristics, which bring a number of different issues that need to be considered when planning for a rising sea-level.

Figure 1 also indicates that individual settlements tend to be clustered adjacent to the coast. At a number of locations, development has occurred very close to the beach, or around the fringes of estuaries, in locations that would be exposed to greater physical coastal and/or inundation hazards by sea-level rise.

The broad aims of this project were:

- To develop regionally relevant sea-level rise projections under conditions of climate change; and
- The development of a risk assessment and Policy Response Framework addressing future sea-level rise.

The Project Partners required a means of addressing sea-level rise in a sensible manner when making strategic planning decisions and when assessing development applications. Guidance has been provided in a risk management framework.

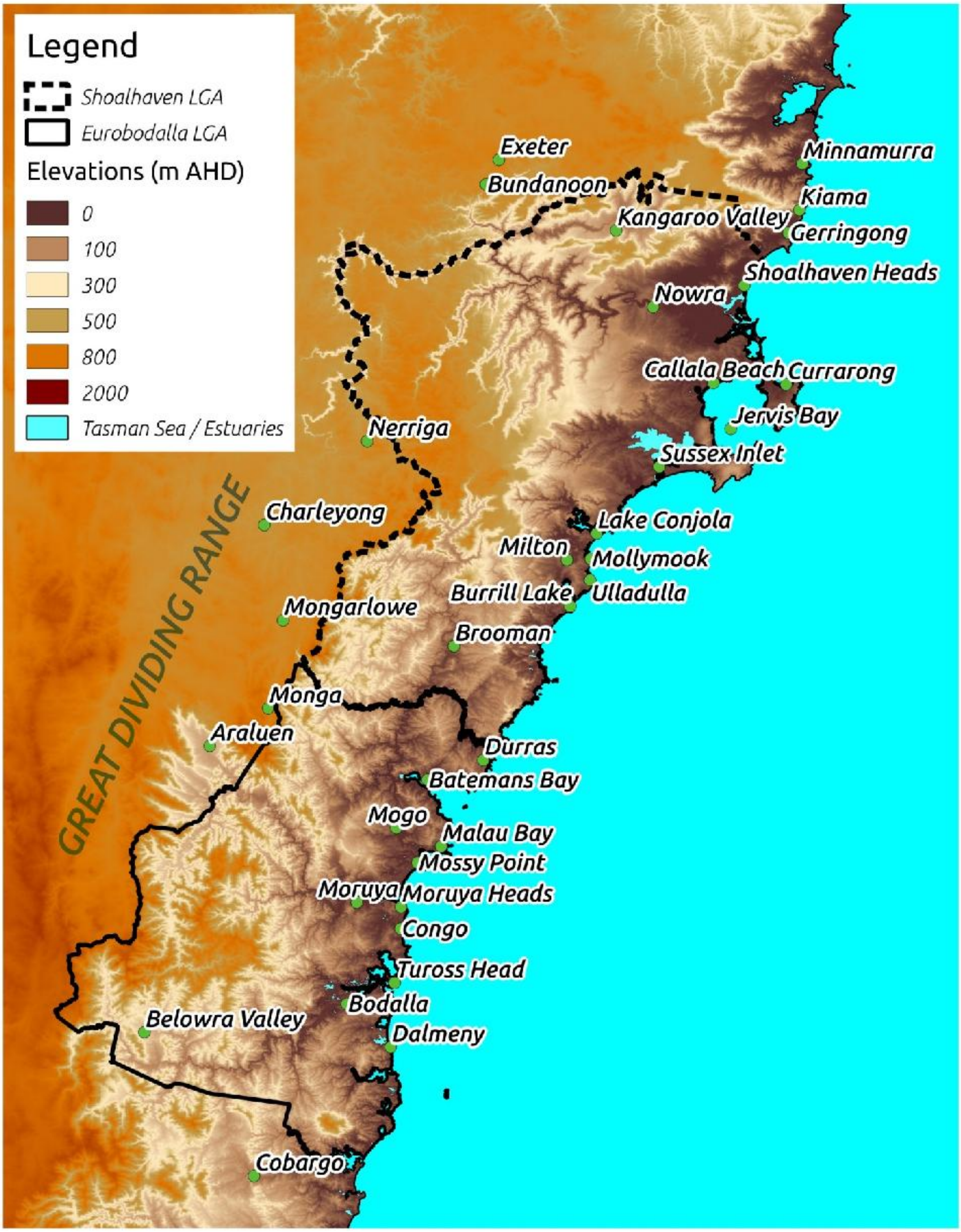

Figure 1: Site Location

South Coast Regional Sea Level Rise Planning and Policy Response Framework

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Revision	A
Drawn	DJW
Approved	DJW

In 2009, the state government of NSW adopted a Sea-Level Rise Policy (New South Wales Government, 2009) which set planning benchmarks of 0.4 and 0.9m above 1990 mean sea levels for 2050 and 2100 respectively. Following a review of the science behind the benchmarks, the NSW Chief Scientist and Engineer (2012) found that the science was 'adequate' in light of the evolving understanding of the associated issues.

However, the Chief Scientist and Engineer also highlighted uncertainty associated with sea-level rise projections and the possibility of undertaking more regionally specific calculations. Following these findings, the NSW government repealed the *NSW Sea-level rise Policy Statement, 2009* and its associated benchmarks, instead recommending that individual Councils could adopt a range of locally relevant projections commensurate with competent scientific opinion, and that these could be used for risk assessment under local planning instruments with suitable development controls.

To date neither of the Project Partners has adopted a long term policy position on sea-level rise, and both still apply the former NSW benchmarks. Jointly, the Project Partners now wish to establish their own regionally relevant sea level projections, in order to progress a number of activities associated with planning and management of the coastal zone.

The planning system in New South Wales is presently being reformed. The bills covering proposed changes to the planning system went before the NSW parliament at the end of 2013. However, following the request of substantial changes to the bills by the Legislative Council (upper house) the bill was withdrawn and the nature of the bills to be ultimately adopted is uncertain. In parallel to the planning reform process, the NSW Government is in the midst of a two stage coastal reform process. The first stage included abolition of the sea-level rise policy benchmarks and a loosening of previous constraints for the placement of large sandbags as part of coastal protection works. The second stage reforms are more strategic in nature and are closely linked to the introduction of the new planning system.

In addition to the planning and legislative changes, new scientific evidence is available. The NSW sea-level rise policy, now repealed, was largely based on the Intergovernmental Panel for Climate Change (IPCC) Assessment Report 4 (AR4) from 2007 (Meehl et al., 2007). The IPCC's Assessment Report 5 (AR5) is in the process of being prepared, with the first part of the report on *The Physical Science Basis* released online in January, 2014. That report provides an assessment of the published scientific understanding of climate change available up to 15 March, 2013. The text for the Working Group 2 report, on Impacts, Adaptation and Vulnerability was released in March, 2014. Both documents have been reviewed as part of this study.

The study reported herein has therefore been undertaken during a period of significant change in both the underlying context, governed largely by legal and planning considerations, and a recent update in the most credible available science on global climate change. Unsurprisingly, the first two chapters of our study report deal with these two items respectively. A section by section breakdown of the contents of our report is provided in Table 1.

Table 1 Report Breakdown

Report Section	Synopsis
2. Risk Management Preliminaries	Provides an introduction to the risk management methodology, establishes the risk management context and describes a number of physical sea-level rise related risks of relevance to the study area. This section was informed by two *Preliminary Risk Assessment Workshops* held in March 2014 during the study, one for each LGA. The planning and legal context, based on background research is also presented.
3. Technical Assessment	Contains a review of background research on sea-level rise, plus analysis of local effects and trends of sea-level rise relevant to the Partner Councils. Recommends projections for use by the Partner Councils.
4. Projection Selection	Summarises considerations that apply to the adoption of a locally applicable sea-level rise projection. This section also describes the high level risk analysis and evaluation steps which assisted with development of the Framework and the selection of a suitable projection. This was informed by two *Planning Policy Workshops* held in May 2014 during the study, one for each LGA
5. Policy and Planning Framework	Presents the Planning Framework which has been developed following the workshops and consideration of potential sea-level rise within the Study Area.
6. Conclusions and Recommendations	Provides an overall summary of the study and highlights the key findings and recommendations for future application of the framework.
Appendix A	Contains a detailed summary of the outcomes of workshops held during this study.
Appendix B	Provides a description of the Case Study sites used during the workshops and a preliminary assessment of issues and adaptation options for those sites.
Appendix C	Guide note comprising a plain English guide to the Council's policy and the reasoning behind it.

2 Risk Management Preliminaries

2.1 Key Points

- **Councils provide facilities, infrastructure and services for the well-being of their communities**
- **Strategic planning and development assessment need to consider sea level rise**
- **Planning and development assessment decisions should consider the likely life of development or land use**
- **A risk management approach encourages consideration of different time frames**
- **Sea level rise will exacerbate a range of coastal hazards.**
- **Sea Level Rise has been considered in planning and coastal management on the New South Wales coast for at least the last 25 years.**
- **Local Councils are presently required, by legislation, to adopt their own projections for sea level rise.**
- **NSW State government guidelines indicate that Councils "should consider adopting projections that are widely accepted by competent scientific opinion"**
- **Legal advice indicates that the projections should be based on sound technical advice and recent information.**
- **Legal advice indicates that Councils should clearly communicated this advice and information to their local communities.**
- **Legal advice indicates that a management strategy to for sea level rise should be adopted and clearly communicated to property owners**
- **The adopted strategy should be consistently applied and supported by Council**
- **It is most likely that a lack of public funding will significantly constrain the adaptation options available to Local Councils**
- **A cautious approach to planning for sea level rise which considers impacts on future generations is promoted by NSW legislation**
- **The planning system and management of New South Wales coastline is presently being reformed and the outcomes are uncertain**

2.2 Objectives and Scope

A formal definition of risk is "the effect of uncertainty on objectives" (Standards Australia, 2009). As part of the risk assessment, therefore, it is important to understand what the partner Councils set out to do. Attendees at the Risk Preliminaries Workshops were asked this question, and the responses were grouped into three different categories:

- **Provide Facilities and Infrastructure:** Parks and Gardens; Recreation; Roads; Water/Sewerage/Stormwater infrastructure; Waste management facilities; Libraries
- **Provide Services:** Strategic planning (consistent with risks); Development assessment; Construction and maintenance of facilities; Revenue collection; Waste collection; Water/Sewerage/Stormwater; Education (Communication); Community welfare; Compliance (e.g. Public Health); Environmental Management.

- **Behavioural:** Act in *"Good Faith";* Comply with the law and state government policy; Develop appropriate policy; Take care of people and the environment; Act as custodians for the future; Appropriately balance public and private interests; Be open and transparent (communicate); Be advocates for and act in the best interests of the community; Leadership and balance in decision making (i.e. risk management); Foster business and economic development, Financial responsibility, Be honest, objective and fair.

Clearly, Councils have an important role in the management of local communities. However, the scope of our study is limited to the impact that sea-level rise, and the development and implementation of a suitable policy will have on the objectives of Council. In the development and implementation of the policy, they should aim to achieve the behavioural ideals outlined above. In terms of services, the strategic planning and development assessment functions are those of most relevance concerning sea-level rise. Environmental Management is also of some significance, given the desire to maintain beaches as a recreational resource for the community in future. Also of importance is the impact of sea-level rise on facilities and infrastructure developed and maintained by Council, the impact of sea-level rise on these facilities needs to be considered when planning for asset installation, management and future adaptation.

With these objectives in mind attendees at the *Risk Preliminaries* Workshops were also asked to outline their expectations of the scope and nature of the framework. The following points of interest were raised:

- Strategic Planning and Development Assessment were seen as key, and the partner Councils require good policy that is applied in a consistent manner;
- The way in which time frames are handled will be important, particularly considering the uncertainty surrounding future sea-level rise projections; LEP's traditionally look forward strategically for around 20 years, however development assessment near the coast will likely need to consider shorter time frames. Commercial subdivisions tend to be planned for 30 to 50 year time frames. Residential subdivisions tend to be planned for 50 to 100 years, however it was noted that Surfside (northern Batemans Bay) was subdivided in the late 1800's and is a cause of present concern. Future public access to beaches also needs to be planned for. Today's decisions will impact on the community in the future.
- Asset planning may be undertaken in detail 10 years in advance, with looser planning out to 20-30 years.
- The way in which Section 149 certificates are handled will be important. However, the guidelines from the Department of Planning associated with these certificates are presently being changed.
- The policy should be realistic and consider the types of management options that can be achieved.

The scope of this study is to provide the background information and investigate the ideas to enable development of a sound policy. Furthermore, the *Framework* developed as part of the study does not aim to be prescriptive, but to provide enough information to enable development of codes of practice for strategic planning, development assessment and asset management.

2.3 The Risk Management Approach

Risk assessment is practiced by individuals and organisations all of the time. However, with the evolving complexity of society, a need for *Formal Risk Assessment* has arisen since the 1950's, beginning with studies of food safety and progressively adopted in the fields of public health and environmental impact (ECHCPDG, 2000). Formal risk assessment has proven to be an effective way of making decisions in situations involving considerable complexity and uncertainty. This study has adopted the international standard for formal risk management and associated guidelines as its basis (Standards Australia, 2009; IEC/ISO, 2009). Guidance of particular relevance to dealing with climate change risks has also been gleaned from Australian Government guidelines (Department of the Environment and Heritage, 2006)

In the last two decades, there has been an international move towards the adoption of formal risk methods for coastal management with a stronger focus on integrated stakeholder engagement (Nicholls et al., 2013). In New South Wales, research and practice is also moving towards a more formal assessment (Jongejan et al., 2012; Woodroffe et al., 2012; Rollason and Haines, 2011). This change in thinking has been partly driven by a need to incorporate the uncertainty associated with future sea-level rise.

Historically, coastal management focussed on identifying the hazards and then mitigating against them, typically by providing some form of engineered protection. However, with the realisation that shorelines were retreating in some locations, it has been recognised that the use of permanent engineered structures could cause a reduction in beach width. Hence there is a conflict between ensuring a permanent wide sandy beach for general amenity, access to the water and recreation; and the desire to protect property that is being eroded. Similar issues result from more frequent tidal inundation and flooding. The formal risk management approach emphasises the need to incorporate broad community and stakeholder consultation, because of these conflicts of interest. It is important that all points of view are acknowledged, and that the community realises there is no single solution which will give a perfect outcome for everyone.

More so than the economic consequence and technical aspects of coastal hazard assessment, making sure that the community understands the basis of the sea-level rise policy is probably the most difficult aspect of ensuring a successful policy. A key focus of the present study has been to enable development of a workable policy and documenting the basis behind it, from both a scientific evidence and risk-based point of view.

Figure 2 shows the risk management process as promoted by ISO 31000. For development of the Sea-level Rise Policy Framework, we have followed the first few steps, context establishment and risk identification in accordance with the standard. These two steps are detailed in the remainder of Section 2 of this report, and were the focus of the *Preliminary Risk Assessment Workshops*.

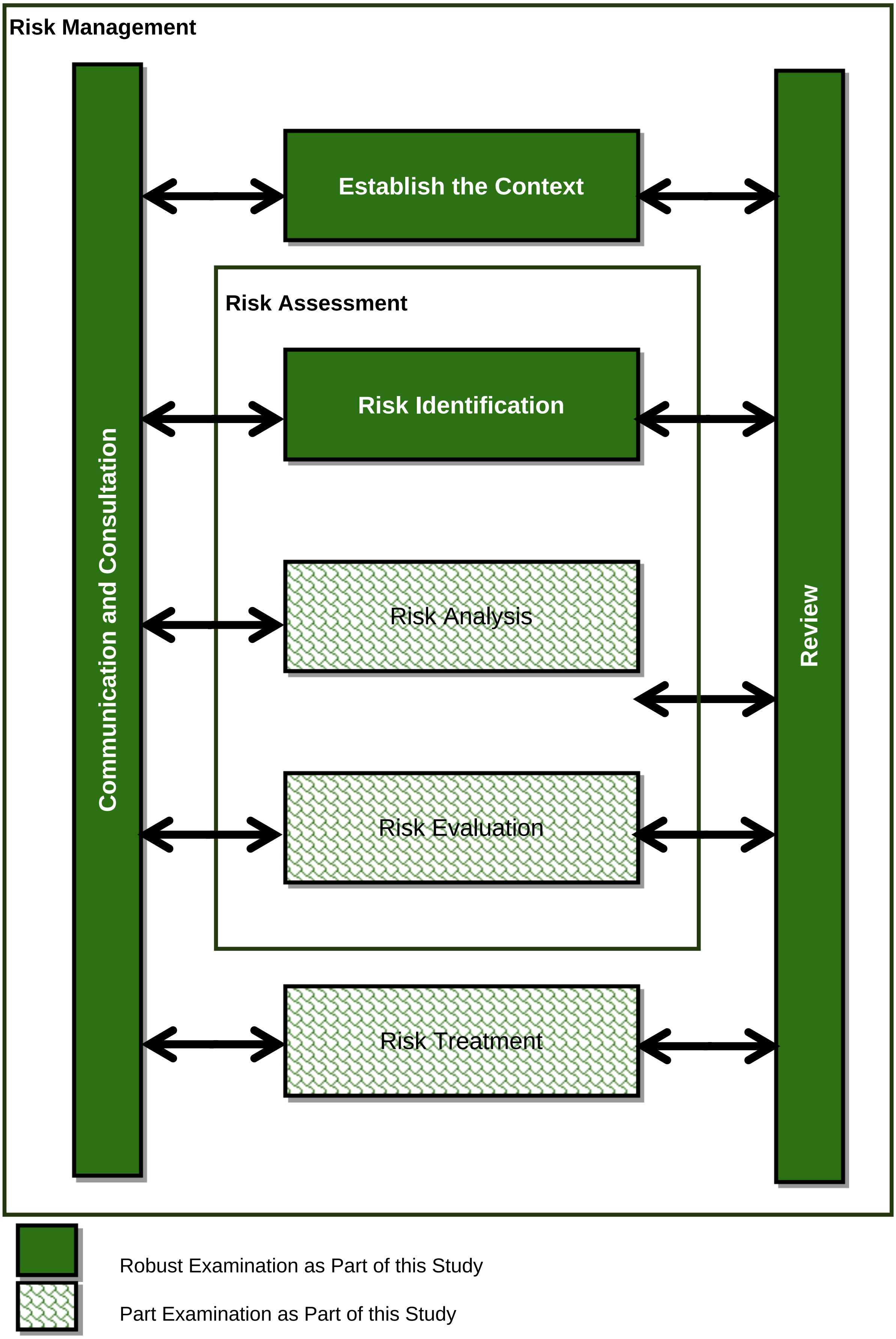

Figure 2 **The Risk Management Process from ISO 31000 (Standards Australia, 2009) Including the role of this study in the overall process.**

The remaining aspects of the risk management process (analysis, evaluation and treatment), were the focus of the *Planning Policy Workshops*, which revolved around the consideration of the case study sites considered by this study and how they might be treated by the Policy and Policy Response Framework developed as part of this study (Sections 4 and 5).

It was beyond the scope of the present study to undertake a robust risk analysis of the case study sites because:

- The study has only reviewed science relating to sea-level rise in the open ocean. This does not directly transfer to inshore locations and estuaries, where future morphological changes need to be considered when assessing hazards at a nearshore location; and
- Detailed modelling studies, each requiring a similar amount of effort to the present study, are required to properly analyse the physical hazards at nearshore locations. In NSW, these would typically involve Flood and Coastal Process studies, depending on the hazard being considered.
- More detailed hazard studies may be required in future to update previous ones and incorporate the guidance on sea-level rise recommended as part of the outcomes of this study.

Numerous studies of physical hazards have been undertaken of places such as Batemans Bay and Lake Conjola in the past. For most of the case study sites, it has meant that we have been able to construct realistic scenarios as part of our deliberations on the operation of the policy response framework. However, these scenarios are incomplete, and the information in Section 4 and Appendix A of this report should not be relied upon to provide site specific hazard or consequence information. The study has relied heavily on consultation with numerous stakeholders from inside local and state government. In addition, the study report has been placed on exhibition to seek feedback from the community. It is expected that ongoing consultation with the community will be required during development and adoption of the policy, particularly in affected areas as the situation around coastal planning and management in NSW evolves, and renewed hazard assessments and management plans are undertaken. These activities correspond to the ongoing *Communication and Consultation* and *Review* components of the risk management process in Figure 2.

The study context has been established in Section 2.1. The remainder of Section 2 broadly details the physical and legislative environment within which decisions regarding sea-level rise management need to be undertaken.

2.4 Physical Environment

The present State Government Guide for Coastal Zone Management Plans (or *CZMP's* OEH, 2013a) lists a number of hazards that need to be examined as part of the minimum requirements for a CZMP. These are listed in Table 2, which also provides a qualitative description of potential impacts.

Table 2 Coastal Hazards and the Potential Impact of Sea-level rise

Hazard	Potential Impact of Sea-level rise
Beach Erosion (during Storms)	Minimal long term impact in most locations, however, where areas are presently protected by reefs, a higher water level may enable more wave energy to reach the shoreline and increase the volume of sand eroded during storms.
Shoreline Recession	Following storms, if the beach is in a state of dynamic equilibrium (i.e. no net loss of sand, no change in mean sea level, tide range or wave climate), the beach will typically recover to its pre-storm, non-eroded state over time. This can occur in days or may take years. Increased shoreline recession is expected to be the main impact of sea-level rise on the open coast. Importantly, this will not manifest as a steady retreat of the shoreline, but as a series of storm erosion events, possibly separated by years, from which the beach does not fully recover. In other words, if a beach is already receding, sea-level rise is likely to exacerbate this trend; If a beach is presently stable, the beach will likely begin to recede; If a beach is presently accreting, the rate of accretion will slow, cease or reverse (i.e. the beach may begin to recede).
Coastal Lake or Watercourse Entrance Instability	The entrances to coastal lakes and estuaries will be affected by sea-level rise. However, predicting the impact is difficult and will differ at each entrance depending on the morphological characteristics of each estuary. At ICOLLs, it is likely that any enclosing barrier will gradually grow higher as sea-level rises, which will have a flow on effect to design flood levels. The increase in barrier height will most likely be similar to the amount of sea-level rise. Also, an increase in mean sea level may encourage some open but shoaled entrances to act as a 'sink' for coastal sediment. This could also affect adjacent coastlines which may recede more rapidly in the vicinity of these entrances compared to other locations along the coast. The tidal 'attenuation' in some estuaries will reduce, meaning that the tide range will increase. Changes in tidal currents within estuaries will likely modify the patterns of erosion and accretion within the entrance channels. Greater penetration of ocean waves into estuary entrances may also increase erosion at some locations.
Coastal Inundation, including estuaries	An increasing mean sea level will tend to increase wave run-up elevations against coastal dunes. Those dunes will tend to grow to be in 'equilibrium' with the prevailing wave/tide/wind conditions (depending on the available sand supply), but this will likely lag the increase in mean sea level. An increase in the wave run-up will increase the exposure of some low lying areas behind dunes to flooding from wave overtopping during storms. Wave run-up, overtopping and breaching of coastal dunes may occur in some locations and this will impact on the stability of dune vegetation and may locally impact ecologically important areas landward of the coastal dunes. In addition to the effects of wave run up, a rising mean sea level will also provide a more elevated base water level to which the effects of "storm surge" are added. It is important to recognise this distinction between the astronomical tide component (fundamentally affected by sea-level rise) and storm surge component (not affected directly by sea-level rise), The effects of projected climate change on storm surge, which is related more to weather patterns (wind, waves, low air pressure) are not well understood for the NSW coast.

Hazard	Potential Impact of Sea-level rise
Coastal Cliff or Slope Instability	Coastal cliffs tend to be more resilient to erosion and will recede slower than beaches in response to sea-level rise. They are highly variable in terms of composition, erosion rates, failure mechanisms and extent. If the cliff comprises hard rock, the practical impact on cliff instability is expected to be negligible over typical planning time frames. However, in the case of coastal bluffs comprising soils and loose rock, the increase in water level will mean that the erosive impact of waves on the bluff will increase and the recession rate will therefore be larger, particularly if the bluff is presently protected by a rock platform and a rise in water levels reduces that protection. Failures in cliffs and bluffs tend to occur suddenly (compared with dune erosion which is slower) and sudden, catastrophic failure of poorly sited development is a possibility that needs to be considered when assessing risk.
Tidal Inundation (including estuaries)	Tidal inundation refers to the effect of normal astronomical tides (see above, under "*Coastal Inundation*") without significant storm surge. There are notable examples of settled areas around Australia that are already inundated by the highest normal astronomical tides (e.g. "King Tides"). With an increasing mean sea level, the elevations of the peaks of these high astronomical tides will also rise, meaning that susceptible areas will be inundated to greater depths and more frequently with the impact increasing over time. Some low lying areas that aren't already inundated will become susceptible. Tidal inundation will occur regularly and in a reasonably predictable manner, however there will be thresholds in frequency and depth that will be crossed which render affected land unsuitable for various land uses. Changes in salinity and water quality in estuaries may result. Saline interfaces will migrate further upstream over time. One additional and often overlooked impact is the impact on groundwater elevations adjacent to the coast. Depending on local geology, a reasonable first order estimate is that groundwater elevations adjacent to the coast will rise by an amount similar to mean sea level. The increase in groundwater elevations may impact buried services
Erosion within Estuaries	Erosion inside estuaries will be affected by sea-level rise. Entrance instability and erosion within entrance channels is dealt with above under *Coastal Lake or Watercourse Entrance Instability.* Entrances will be affected by destabilisation (variations in the shoaling and accretion patterns) as the system adjusts to a new tidal regime. The fringing foreshores around the main body of estuaries, particularly lakes or lagoons, will be affected by general recession and, potentially, a higher energy foreshore wave climate caused by deepening of water adjacent to the foreshore. A higher energy wave climate will tend to flatten sandy foreshores around estuaries (high rates of recession of unprotected sedimentary shorelines).

While many of these hazards are well known and have been studied in detail over time, our ability to quantify many of them, particularly those associated with erosion, sedimentation and sediment transport remains relatively poor. Those hazards directly related to changes in water level (i.e. inundation hazards) can be more accurately quantified, but assessments are limited by our lack of certainty relating to the amount of sea-level rise that will actually occur in the long-term future.

In addition to these assessment limitations, a number of the hazards listed in Table 2 will combine to interact in ways that are not presently predictable. The behaviour of these interacting and overlapping hazards is complicated. Ensuring appropriate, dedicated and ongoing monitoring is key to the future management of coastal areas. With appropriate analysis, the present network of available tide gauges is suitable for determining contemporary mean sea levels in the study area. Nevertheless, the amount of uncertainty present in our estimation of future behaviour means that a risk management approach, which directly considers uncertainty, is appropriate when dealing with sea-level rise and other climate change impacts.

2.5 Statutory Environment

2.5.1 Coastal Management in NSW is Evolving

The consideration of sea-level rise has been an integral part of coastal management for nearly 25 years. However, in the past five years, there has been significant change in the way that the issue has been handled and the situation is still evolving rapidly. The adoption of a sea-level rise policy by Local Government at the present time needs to be informed by this context and a historical account is provided here for that purpose.

Coastal management and development of coastal infrastructure in NSW dates back to the first days of European settlement in Sydney Harbour in 1788. The importance of coastal trade in initial settlement of NSW resulted in a population scattered along the coast with the reliance on coastal shipping for transport and trade (Strachan et al., 1997). This resulted in the rapid development of the coastal fringe, a population distribution which remains to the present day. The legacy of this early settlement includes the construction of key infrastructure and subdivision and privatisation of land at a time when the full extent of coastal hazards and coastal fluctuations was not well understood. The legacy of many of these early decisions and subsequent further development in the coastal zone have resulted in coastal development not fully compatible with our present day understanding of coastal hazards and potential climate change impacts.

Coastal Management as a Government supported and funded process formally commenced in NSW as a response to the widespread coastal damage resulting from storms during the late 1960s and 1970s. While coastal management remained a function of Local Government, the State formalised the procedures to be followed and provided technical support to local government through the establishment of a Coastal Engineering Branch within the Department of Public Works and the implementation of the *Coastal Protection Act 1979* (NSW). The Government also supported the development of coastal management plans and the implementation of those plans through dollar for dollar Local Government funding programs.

Since the establishment and implementation of the NSW Coastal Management Program and Estuary Management Program in the late 1980s (Watson and Lord, 2005), the approach to coastal management closely followed the procedure and steps as set out in the 1990 New South Wales Government “Coastline Management Manual” and 1992 “Estuary Management Manual” (NSW Government, 1990, 1992).

The Coastline Management Manual was published by the NSW Government to guide a whole of Government approach to managing and developing the coastline. The manual laid out a progressive approach to managing coastal risks which is summarised by the following steps:

- development of an understanding of coastal processes and coastal behaviour at the local level based on data collection and historical review;
- definition of coastal hazards and their potential present day and future impact on the coastline, identifying vulnerable development and land use;
- assessment of all appropriate management options to manage the coastal unit and reduce/remove the perceived hazards;
- selection and recommendation of a particular management strategy for the area;

- development of a coastal zone management plan for the area incorporating the preferred strategy and how it is to be implemented;
- community exhibition for comment/review of the proposed strategy;
- adoption and implementation of the plan by Local Government; and
- Implementation and ongoing review/revision of the Management Plan.

This process has been supported continually by the NSW Government through targeted grants to Local Government, the provision of technical advice, data collection and review. Significantly, the manuals recognised the issues associated with climate change and included allowance for future sea-level rise in preparing management plans. Consideration of climate change impacts has been integral to coastal zone management in NSW since 1990.

The approach to planning and implementing coastal zone management in NSW has continued evolving over recent years.

2.5.2 NSW Coastal Reforms

Amendments to the Coastal Protection Act in 2002 introduced significant changes to the Act, including that completed Coastal Zone Management Plans (CZMPs) must be submitted and approved by the relevant Minister and gazetted by Local Government upon completion. This amendment was introduced to give stronger, statutory power to the plans, with amendments to the plans to be permitted only through revision and re-gazettal of an updated plan.

With a growing concern at the implications of sea-level rise, the Government embarked on a review of the coastal management approach in NSW. In 2009, the Sea Level Rise Policy Statement (New South Wales Government, 2009) was adopted advocating sea-level rise planning benchmarks of 0.4 and 0.9m above 1990 mean sea levels by 2050 and 2100 respectively. At the time that policy also abolished the existing Coastal Hazards Policy which underpinned the coastline Management Manual and formally abolished the coastal and estuary manuals, which were to be replaced by a series of Guidelines to be published on the Departmental web site from time to time. The government grant programs for coast and estuaries were combined in a single program and a series of guidelines covering the preparation of CZMPs and allowable emergency protection works were introduced. Further changes to the Coastal Protection Act were gazetted in early 2009 which formally put these changes in place.

Following the change of State Government in NSW in March 2011, the new Government decided to revisit the changes and approach to coastal management in NSW. In particular, concerns were expressed at the fixed sea-level rise benchmarks enshrined in the policy and also with the new provisions for emergency protection which allowed temporary coastal protection works to be implemented by individual property owners.

The legislative amendments (Coastal Protection Amendment Act 2012) associated with **Stage One** of the NSW Government's coastal reforms commenced on 21 January 2013 and are summarised on the NSW Office of Environment and Heritage (OEH) web site (March 2014) and below. They include amongst other things:

- simplification of the procedures for implementation of temporary protection works (formerly called emergency protection works);
- clarification of the information that local councils must place on Section 149 certificates relating to land affected by future sea-level rise;

- withdrawal of the state-wide sea-level rise benchmarks included in the *NSW Sea Level Rise Policy Statement*, giving Councils flexibility to consider coastal hazards in the context of their own local circumstances;
- developing a guide for coastal erosion hazard mapping by councils;
- an extra 12 months for Local Government to prepare their CZMPs with their communities and for councils to determine the potential future coastal hazards which reflect local conditions; and
- deferment by the Minister of certification of any further CZMPs while the Government undertakes further Stage 2 reforms and determines how these plans can better link with other legislation.

The **Stage 2** reforms are currently under consideration by the NSW Coastal Ministerial Taskforce, supported by the Coastal Expert Panel appointed by the Government. These reforms have a strategic focus and are closely linked to the current planning reforms and local government reviews. The Coastal Ministerial Taskforce has approved the scope of the **Stage 2** reforms, which are intended to deliver longer term improvements in the management of erosion risks by councils and landowners. To this end, the NSW Government is now preparing more detailed proposals in three key areas:

- establishing a simpler and more integrated legal and policy framework for coastal management
- providing improved guidance and technical advice to councils, while enabling and supporting local decision making
- identifying potential funding options, particularly to implement coastal asset management strategies.

The OEH, on their web site, advises that these Stage 2 reforms were to be developed during 2013 and that community and stakeholder input to this process is vital. Consultation on specific proposals were scheduled to occur late in 2013, however the process has been delayed.

2.5.3 The Current Approach to Coastal Zone Management in NSW

The current state of coastal zone management in NSW has some uncertainty awaiting the release of the Stage 2 reforms. The NSW Government has placed a moratorium on the certification and gazettal of all CZMPs and a direction has been issued to certain Councils to prepare and submit CZMPs by the 30th June 2014. The preparation of these plans for certification must comply with the requirements of the NSW Coastal Protection Act 1979 (as amended) and with the various guidelines and practice notes prepared by the NSW Government and which are published from time to time on the OEH website. At the time of preparation of this report, the key documents guiding preparation of the CZMPs are listed below. A brief précis of these documents as relevant specifically to this project are included.

(a) **Code of Practice under the Coastal Protection Act (OEH, 2013a).**
http://www.environment.nsw.gov.au/resources/coasts/130637copcoast.pdf

The code of practice sets out the procedures and specifications to be followed in installing temporary protection works (formerly emergency protection works) in accordance with the requirements of the Coastal Protection Act 1979 and the Regulation. More details are provided in the associated guide.

(b) Guide to the Statutory Requirements for Temporary Coastal protection Works (OEH, 2013b).
http://www.environment.nsw.gov.au/resources/coasts/130638guidestatregs.pdf

This guide supersedes the document *Guide to the Statutory Requirements for Emergency Coastal Protection Works* published in March 2011 by the former NSW Department of Environment, Climate Change and Water. This guide is designed to help land owners understand the statutory requirements for installing, maintaining and removing temporary coastal protection works, and how following these rules helps protect the NSW coastal environment. Works may only be constructed in accordance with the guide and at authorised locations as listed in the Guide and the regulation to the *Coastal Protection Act 1979* (NSW).

Although this guide discusses regulations, it is not an official statement of regulation and may not be relied upon in lieu of the *Coastal Protection Regulation 2011* (NSW) when undertaking coastal development. It reflects the changes to the *Coastal Protection Act 1979* (NSW), the *Coastal Protection Regulation 2011* (NSW), which commenced on 21 January 2013) and the *Code of Practice under the Coastal Protection Act 1979* (NSW), published in August 2013.

(c) Guidelines For Preparing Coastal Zone Management Plans (OEH, 2013c).
http://www.environment.nsw.gov.au/resources/coasts/130224CZMPGuide.pdf

These guidelines present the minimum requirements to be followed in the preparation of draft CZMPs in accordance with Section 55D of the Coastal Protection Act 1979. It supersedes the previous version of the Guideline issued in 2010 and continues as a replacement for the Coastline Management Manual and the Estuary Management Manual. The Guideline delineates 10 principles which must be addressed and reflected in the draft CZMP. These principles are:

- Principle 1 – Consider the objectives of the Coastal Protection Act 1979 (NSW) and the NSW Coastal Policy 1997.
- Principle 2 - Optimise links between plans relating to the 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

- Principle 10 - Support recreational activities consistent with the goals of the NSW Coastal Policy

(d) Coastal Zone Management Guide Note - Emergency Action Subplans http://www.environment.nsw.gov.au/resources/coasts/110631gdntemacsubs.pdf

This Guide Note outlines the requirements for an emergency action subplan which forms an integral component of a CZMP. An Emergency Action Subplan outlines a council's intended response to a coastal erosion emergency and explains ways in which and where beachfront property owners can place emergency coastal protection works according to the *Coastal Protection Act 1979* (NSW).

(e) Coastal Erosion Storm Safe Guide
http://www.stormsafe.com.au/uploads/81/coastal-erosion-generic-web-version.pdf

This Guide is prepared by the SES and outlines appropriate actions to be undertaken during an emergency erosion event. The Coastal Erosion StormSafe Guide is produced as a web document and can also be localised for coastal council areas. The NSW SES will provide councils with print-ready and web-ready versions of the guide which have council logo, contacts and local coastal erosion images. Councils can then print these for their communities or have this version available on their websites.

(f) NSW Coastal Planning Guideline: Adapting to Sea Level Rise
http://www.planning.nsw.gov.au/Portals/0/PlansForAction/pdf/SeaLevelRise_Policy_web%5B1%5D.pdf

This planning guideline from August 2010 covers all coastal areas in NSW including estuaries, coastal rivers and the open coast; along with adjacent and surrounding areas that may be subject to future sea-level rise. The guideline contains out of date references to the 2009 NSW sea-level rise policy. The guideline builds on six broad principles:

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

Coastal risks refer to coastal erosion, tidal inundation and coastal flooding. Coastal risk areas include those currently at risk and additional areas likely to be at risk in the future as sea level continues to rise.

Two guidelines for incorporating sea-level rise into (a) flood risk assessments (NSW Department of Environment Climate Change & Water, 2010a) and (b) coastal risk assessments (NSW Department of Environment Climate Change & Water, 2010b) were also prepared. These provide guidance on how the sea-level rise benchmarks are incorporated in determining planning zones. These two guidelines still make explicit reference to the old sea-level rise benchmarks.

2.6 Present Management/Planning Approach and Legal Requirements

In preparing and implementing a CZMP, a council is bound by the requirements outlined by the NSW Government through the relevant legislation, policy and supporting Department of Planning (DoP) and OEH Guidelines. Integral to this is the exemption from liability (Section 733 of the *Local Government Act 1993* (NSW)), which may protect a council acting in good faith to prepare and implement those plans. For this project a critical consideration for council is how they incorporate and make allowance for future sea-level rise in the initial determination of future hazard and the subsequent management of the risk which those hazards may create at some future time. This issue can be discussed as three distinct issues, which are independent of the sea-level rise allowance subsequently adopted:

- what is considered best practice;
- what are the requirements built into the legislation and guidelines; and
- what do the legal opinions sought by various Councils advise.

2.6.1 Best Practice

Preparation and implementation of CZMPs have been fundamental to coastal management in NSW for approximately 25 years. In formalising the process the Coastline Management Manual (NSW Government, 1990) listed two objectives:

- to assist local councils in developing balanced plans for management of the coastline; and
- to provide information that assists present and future users and occupiers of the coastline to understand the nature of the coastline hazards and the options available for their management.

While the expression of these objectives has been adjusted and refined in the intervening period, in essence they have not changed and are reflected in the current NSW Coastal Policy and the *Coastal Protection Act 1979* (NSW, as amended) and within the various guidelines and technical notes published by the NSW Government. Recognition of future sea-level rise and the impact on future coastal hazards has always been an integral element of this coastal zone management process.

2.6.2 Legislative Objectives and Requirements for CZMPs

The most recent (as of March 2014) version of the *Coastal Protection Act 1979* states in Part 1, Section 3 as its object:

> *"to provide for the protection of the coastal environment of the State for the benefit of both present and future generations…"*

A more detailed objective is given, amongst others:

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

The NSW Coastal Policy (NSW Government, 1997) states in Appendix B as one of its underlying principles

> *"The precautionary principle should be used in the assessment of natural hazard issues, including climate change and sea level rise".*

This appears a clear direction towards a conservative approach when considering hazards that may result in significant environmental harm and where the level of scientific knowledge is still developing. This is also legislated through the *Coastal Protection Act 1979* which states as a specific object of that Act in Part 1, Section 3(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"*

The *Coastal Protection Act 1979* (NSW) definition of the principles of ecologically sustainable development refers to the description in section 6 (2) of the *Protection of the Environment Administration Act 1991* (NSW). The *Protection of the Environment Administration Act 1991* at Section 6(2) states:

> *"the precautionary principle—namely, that if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In the application of the precautionary principle, public and private decisions should be guided by:*
>
> *(i) careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment, and*
>
> *(ii) an assessment of the risk-weighted consequences of various options"*

Prior to the release of the NSW Sea Level Rise Policy Statement in 2009, which advocated sea-level rise benchmark levels for use in preparing CZMPs, councils relied on guidance from recognised technical and Government sources, generally based on findings of the Intergovernmental Panel on Climate Change (IPCC). Each council was then able to interpret this information and incorporate appropriate allowances into their CZMPs. When the policy was released, the NSW Government's intention at the time was to ensure that all councils were dealing with sea-level rise appropriately and that planning and development responses were consistent with the best available scientific information and applied consistently across local government boundaries.

The benchmark values advocated within the policy were based on the best scientific information available at that time and were somewhat higher than the most commonly applied values being used by local government over the preceding 20 years. The publicity associated with the release of the policy, together with a requirement that yet to be completed CZMPs must be revised to accommodate the new benchmark values, resulted in a backlash from some sections of the community that saw the incorporation of 50 year and 100 year hazard lines projected into the planning process as unfair and unnecessary. The notification of the future hazards on Section 149 Planning certificates (under the *Environmental Planning and Assessment Act, 1979* (NSW) was also contentious.

In 2011, the then newly elected NSW Government called for an assessment of the policy and the benchmarks by the NSW Chief Scientist and Engineer (Professor Mary O'Kane). Professor O'Kane's report (NSW Chief Scientist and Engineer, 2012) advised, amongst other things, that

> *"The way the science has been used to date to determine benchmarks for sea level rise in NSW is adequate, in light of the evolving understanding of the complex issues surrounding future sea levels."*

The report continued to include within its recommendations that:

> *"The NSW Government could look toward more regionally specific calculations that take into account specific sea level, topography, flood risk and other conditions along the NSW coast. This would allow factors such as probability of extreme events (e.g. severe storms and surges) and impacts to be incorporated into local planning."*

Subsequently, in 2012 the NSW Government determined to abolish the NSW Sea Level Rise Policy and to amend the legislation to permit local government to once again assess and adopt their own allowances for sea-level rise in preparing their CZMPs. Section 55D of the *Coastal Protection Act 1979* states that

> *"A council is to prepare a draft coastal zone management plan in accordance with the Minister's guidelines".*

This reference is to the 2013 "Guidelines for Preparing Coastal Zone Management Plans" (OEH, 2013c) which at Section 3.1 advises on sea-level rise that a draft CZMP should include

> *"projected climate change impacts on risks from coastal hazards (section 55C(f) of the Coastal Protection Act 1979), based on council's adopted sea level rise projections or range of projections. Councils should consider adopting projections that are widely accepted by competent scientific opinion."*

There is no suggestion that sea-level rise can be ignored, and it is clear that the effects of climate change need to be considered in adopting future sea level projections.

2.6.3 Available Legal Opinions and Decisions

Since the decision by the NSW Government to withdraw the 2009 Sea Level Rise Policy Statement, local Councils have been considering an appropriate approach to determine and use the allowance for sea-level rise in their forward planning. The issues being considered include:

- the future extent of sea-level rise;
- how that should be defined and incorporated into forward planning;
- what are the responsibilities of local government; and
- how can these responsibilities be discharged while appropriately addressing the local government duty of care under the various pieces of legislation.

Specific legal opinions have been requested by various councils and bodies to address some of these issues. A selection of those advices is broadly available and these have been accessed to provide further insight to these matters. We stress that legal advice as provided to various clients is relevant only to a specific issue or question and a particular set of conditions and locations as advised by the client when requesting the advice. The following comments are based on our reading of such advice and only identify broad conclusions or consistencies that may assist the Partner Councils in developing their own approach to planning for sea-level rise. It is strongly reiterated that the following discussion does not constitute legal advice and is not intended as such. Anyone seeking to use the information in that manner should arrange for their own specific and detailed legal advice rather than relying on the broader inferences herein.

Three pieces of legal advice that were made available to us and considered in the following discussion are:

- Advice from Sparke Helmore Lawyers to Eurobodalla Shire Council titled "Advice re Coastal Planning Reforms and Sea Level Rise Policy dated October 2012. The advice addresses the effect of the proposed legislative amendments in the Coastal Protection Amendment Bill and the withdrawal of the NSW *Sea Level Rise Policy Statement*. While this advice has not been publicly released, a copy has been provided to us for the purpose of this study.
- Advice by HWL Ebsworth Lawyers to the Sydney Coastal Councils Group (SCCG) titled "CSIRO Sea Level Rise Hazard Mapping – Hazard Mapping Information in A Changing Legislative Framework" dated March 2013. It was prepared for the SCCG member councils to address the obligations of a council upon receiving detailed information (in this case inundation resulting from future sea-level rise) and whether disclosure or use of the information, or decisions not to do so, poses risks. HWL Ebsworth stated that the advice is provided to the SCCG in general terms only and by reference to the changing legislative framework, including the NSW Government's Stage 1 Coastal Planning reforms and the foreshadowed Stage 2 amendments. The advice has been subsequently presented and discussed at SCCG workshops which were widely attended.
- Advice by Beatty Legal titled "Sea Change Taskforce Coastal Councils Climate Change Legal Risks Report"; Part A & B dated August 2013. This advice was prepared for the member Councils of the Sea Change Task Force specifically to identify the legal risks that councils may face which are created by the actual and projected impacts of climate change. The advice deals with the legal framework within which various Councils operate around Australia, and the report is not intended to and does not provide specific legal advice. Part A of the report can be downloaded from the Sea Change Taskforce web site.

We recognise that these three advices do not address all issues that may concern local councils in relation to their responsibilities and obligations relating to sea-level rise. We are aware also that many other legal opinions have likely been sought on these matters and do exist. It is likely that some additional opinions might provide a different perspective to the conclusions we have drawn from the above mentioned and available opinions.

On the issue of determining appropriate sea-level rise allowances, there appears broad consensus that Councils have the responsibility to determine the extent and approach they will take to incorporating appropriate sea-level rise allowances into their coastal planning and development controls. Sparke Helmore advised that:

> *"The Council still has obligations to consider and plan for climate change and sea level rise"*

Beatty Legal subsequently advised that:

> *"the most prudent approach for coastal Councils to adopt is to assume climate change is real and its impacts will become more pronounced over time"*

The advice used to determine an appropriate allowance should be based on sound scientific information. It is not surprising that this accords with the requirements of the various legislation, polices and guidelines as discussed in Section 2.5. Many local councils have implemented sea-level rise policies or interim policies based on the earlier NSW Government sea-level rise benchmarks. Given the advice of the NSW Chief Scientist and Engineer that the scientific basis for those values was "adequate'" there is no requirement that a council rescinds or replaces their existing policy. At the present time some advice to councils (Statewide Mutual advice to local government clients based on legal advice to them in March 2013) is that:

"…Councils not move away from the benchmarks set out in the NSW Sea Level Rise Policy Statement until further guidance is given by OEH as to what new approach for sea level rise planning is to be adopted."

Similar advice was provided by Sparke Helmore to Eurobodalla Council that:

"we do not think that it is necessary for the Council to rescind its interim sea level rise Policy at this stage"

and that

"it may be prudent for Council to delay an amendment or repeal of its Interim Sea Level Policy until OEH has released its proposed guidelines."

While councils clearly have the option of determining their own sea-level rise allowances, this advice must be based on good science and must be clearly incorporated into the planning and development controls. Importantly, the basis for that advice must be clearly communicated and available to the broader community. Where relevant information is received by Council (such as updated IPCC, CSIRO or Government advice, published scientific literature or specialist consulting reports) these must be given due consideration by Council and not simply accepted without question. If Council chooses to discount such advice, they need to clearly document the reasons why they are discarding that information and present to the community the reasons for selecting the information they choose to rely on instead. In this regard (pertaining to coastal mapping provided to Councils by CSIRO) HWL Ebsworth advise that

"In this instance where mapping information has been prepared by CSIRO it could be considered to be scientifically reliable. Having revoked the SLR Policy, the State is suggesting Councils use CSIRO mapping as a tool when setting local sea rise projections".

They go on to state

"This does not mean that any Council is required by legislation or obligated per se to adopt or use the Mapping Information. However, as it is in Council's possession it would be prudent to have regard to it and give it proper consideration before determining that course".

In preparing and implementing their coastal planning (including sea-level rise) Council must be able to demonstrate that they have acted in "good faith" to avail themselves of the protection offered under Section 733 of the local Government Act.

Beatty Legal advises in this regard that:

"the relevant case law suggests that this requires a council to have made a real attempt to perform its functions (i.e., more than mere "honesty and ineptitude"). Section 733(4) specifies that a council is taken to have acted in good faith if its actions or advice has been substantially in accordance with the most recent manual notified by the Minister of Planning under s733(5). In NSW the following manuals have been gazetted for the purpose of s733:

- *Floodplain management manual 2005; and*
- *Guidelines for preparing Coastal Zone Management Plans 2013 (gazetted for the purposes of s733 on 19 July 2013)."*

The good faith protection provided by Section 733 remains largely untested in respect of CZMPs and sea-level rise in particular. Also, it is not the only basis for a legal challenge or litigation against Council planning decisions.

Once the information to be used has been selected it must be acted upon. Beatty advises:

> *"Good information and good policy will be of little use if they are not consistently implemented in practice. Development of a policy necessitates a willingness to support it …."*

They conclude further that:

> *"A policy that is not implemented is often a greater liability than having no policy at all".*

The legal opinions cited provide much more detail than the above discussion and the reader is encouraged to review those opinions and reports in full to better understand the nuances of the legal framework and future implications surrounding the uncertainties of coastal planning.

2.6.4 Conclusion

The preparation of CZMPs by local government in NSW have since their inception 25 years ago required assessment of future sea-level rise and its potential impacts when defining and addressing coastal hazards. The recent amendments to the *Coastal Protection Act 1979* (NSW) still require assessment and inclusion of appropriate allowance for sea-level rise which must be based on competent scientific opinion and should consider projections of future climate change.

The language used in the various documents which relate to sea-level rise (including scientific reports, government guidelines and legislation) can be confusing, prescribing different meanings to some everyday terms. The term "regional" may differ significantly when used in the global context (such as the IPCC), nationally (such as CSIRO) or in a state or local government context. Similarly, terms such as "sea level" may have different meanings for the deep ocean, within a constrained tidal inlet or during the peak of a storm event. It is very important that the discussion of sea level and in the context of sea-level rise is undertaken from a common position of understanding.

It is appropriate for local government to review the current information relating to future sea-level rise and to consider the scientific evidence available and the implications arising from that advice. While councils once again have the freedom to determine what allowance they will make for sea-level rise and how that will translate into future planning and development controls, the following are clear:

The existing legislation and guidance for local government in preparing and implementing a CZMP requires that sea-level rise is taken into account;

- That allowance must be based on sound technical advice and the most recent information so far as practical;
- The information once accepted by council must be clearly conveyed to communities in terms of the hazards likely to affect the foreshores and the timeframe over which those hazards are likely to be realised;
- councils must prepare a management strategy aimed at ameliorating the hazards or adapting the land use to accommodate any residual risks to an acceptable standard;
- The strategy must be clear to current and potential property owners and users and must be able to be funded and implemented within the adopted timeframe;

- The strategy must be consistently implemented and supported by council;
- As and when appropriate the strategy should be reviewed and modified to reflect updated scientific research and future understanding.

2.7 Other Risk Environment Factors

At the *Risk Preliminaries* workshop, a brainstorming exercise was also undertaken which aimed to identify other factors relating to the risk environment of both councils that would affect the risk based decision making. These can be broadly divided into external (outside of Council) and internal (Inside Council) factors:

2.7.1 External Factors

The following external factors were identified:

- Community members that are directly affected by sea-level rise tend to be vocal. These include actual land owners and the real estate industry. Significant concern is expressed over the impact on coastal property prices;
- There is still disbelief in the validity of climate change science and sea-level rise from some individuals, meaning that any attempt to address this issue is not well accepted by those individuals;
- The broader community, who are not directly impacted can be apathetic about the issue, even though future solutions may require substantial expenditure that would be borne across the community;
- There is a general reluctance of government to allocate money for implementation of the recommendations of management plans. Given the limited available funding, this is unsurprising;
- It is generally easier to obtain funding in a *post-disaster* situation, meaning that forward planning is not necessarily given the attention it should be. This may be significant when expensive public assets are threatened by coastal erosion;
- Inconsistent views can be expressed from a range of external stakeholders, including Federal and State Government departments, Environmental Groups, Academia, Tourists, non-residential owners and the Insurance industry;
- There are some views that conflict with the prevailing science on climate change, meaning that interested parties can provide countervailing arguments against what is known to be the most widely accepted and authoritative science. Council staff do not always have the expertise to effectively engage in these arguments; and
- Populations are ageing in the two LGA's and growth areas include aged care and tourism. The flat, accessible lands near the coasts are preferred by these industries. Tourism centres and facilities tend to coalesce around the coast, meaning that the infrastructure is susceptible to sea-level rise. There is high youth unemployment.

2.7.2 Internal Factors

The following internal risk factors were identified:

- The structure of the council and communication between different departments can be a problem. For example, seemingly inconsistent approach to sea-level rise might be taken by different departments, e.g. Assets takes a shorter term view than Strategic Planning. Interdepartmental communication is important;

- The professional judgement of council staff may be at odds with the expectations and desires of the councillors ultimately responsible for making decisions. This may result in the prolonged adoption of “draft interim” policies and guidelines, a source of confusion and potential for mixed messages;
- There is a tendency for a “risk-averse” approach, commonly brought about through a lack of certainty;
- Funding is very constrained, and the sensible distribution of available funds may be overly affected by short term public preferences. For example, spending money for the adaptation/upgrade of a surf lifesaving club building is more palatable than upgrading sewerage infrastructure. A large amount of funding may be required in future, which conflicts with the overall pattern of reducing government expenditure; and
- Councils may not presently consider the coast and beaches as assets themselves, instead focussing on maintaining the built assets at the beach.

3 Sea-level rise: Technical Assessment

3.1 Key Points

- **The information from IPCC reports is widely accepted and utilised for planning purposes**
- **Sea level rise information from AR5, the most recent report of the IPCC, was reviewed in detail**
- **The peer review and clear attempts to consider genuine alternative points of view indicate that the IPCC assessment is sound**
- **There are vocal sceptics and deniers but the prevailing view among appropriately qualified scientists is that human influence on the climate system is clear**
- **The nature of regional effects which might cause variation from the global mean offshore of NSW were reviewed.**
- **Regional effects are expected to make sea levels rise up to 10% more, offshore of New South Wales, when compared to the global average rise.**
- **Historical information from local tide gauges and satellite altimetry data were analysed.**
- **It was found that sea levels offshore of New South Wales have increased in line with the global average values over the past 130 years;**
- **It was found that spatial variation in mean sea level along the open coast between Sydney and Eurobodalla is insignificant;**
- **It was found that the trend in mean sea levels over the last 20 years, along the coastline of the study area is comparable to the global mean (~3.5 - 4.5 mm/yr.);**
- **We consider it very unlikely that mean sea levels offshore of the study area will vary significantly from those measured at Sydney**
- **We recommend that the Fort Denison tide gauge as a suitable gauge for monitoring mean sea levels for Shoalhaven and Eurobodalla, primarily because of the length of its record**
- **While changes in mean sea level can be monitored at Fort Denison, we do not consider that the historical record is a suitable basis for projecting future mean sea levels. The climate is changing and past behaviour does not provide a reliable basis for predicting future behaviour**
- **The highest values of sea level rise projected by AR5 to 2100 do not differ largely from the information presented in previous IPCC reports, or the previous NSW state government policy**

3.2 Review of International Literature

3.2.1 Sources of Scientific Information

The present CZMP Guidelines state:

> *"Councils should consider adopting projections that are widely accepted by competent scientific opinion"*

There are three key terms here:

- Projections: Meaning that the Project Partners should consider future climatic conditions in planning for sea-level rise;
- Widely Accepted: Opinions vary on the future of regional sea levels and it is not expected that a consensus will be achieved in the near future. However the Project Partners are prompted to accept the most prevailing views of science;
- Competent: The processes contributing to changes in local mean sea level are complicated and our review of recent developments in this field illustrates that the level of understanding required is substantial.

In terms of adopting projections for future sea-level rise, we do not consider it appropriate to fit a straight line through historically measured mean sea levels and project this forward over many decades or centuries to estimate future conditions. Such an approach, which may be quite competently achieve in a mathematical sense, is not widely accepted by climate scientists as being representative of expected conditions as the Earth warms.

Instead, an appropriate future scenario needs to allow for at least some increase in the rate at which sea level rises in the future, commonly referred to as an *acceleration* of the sea-level rise in the scientific literature. The commonly adopted sea-level rise projections of the IPCC which rely on process-based computer model simulations, indicate that this acceleration will occur for all of the future scenarios considered in AR5 (known as Representative Concentration Pathways (RCPs))

The IPCC is a scientific body established in 1988 by the United Nations which aims to provide a clear view of the current state of climate change science, regularly releasing widely accepted and competent scientific opinion. The IPCC primarily acts to review and assess available information, and this is achieved through the voluntary assistance of thousands of scientists from across the globe (IPCC, n.d.).

Perhaps the most notable activity of the IPCC is the preparation of assessment reports, which are released approximately every 6 years. The most recent report (Assessment Report 5, hereafter AR5) was being released over the course of the present study, and the previous report (AR4) was released in 2007. The IPCC does not carry out research independently, but gives priority to peer-reviewed research in its assessment. AR5 comprises a number of separate documents:

- The Working Group 1 report on the Physical Science Basis;
- The Working Group 2 report on Impacts, Adaptation and Vulnerability;
- The Working Group 3 report on Mitigation of Climate Change; and
- The Synthesis Report

The *Physical Science* and *Impacts, Adaptation and Vulnerability* reports were released in September, 2013 and March, 2014 respectively and both have been reviewed as part of this project (IPCC, 2014, 2013a).

The *Physical Sciences* report assesses nearly 10,000 peer-reviewed scientific studies, involving three rounds of detailed review by 1089 individuals. Reviewers included experts in the subject matter and government representatives in an effort to ensure balance and accuracy (Sherwood and Alexander, 2013).

The *Physical Sciences r*eport reviewed literature available at mid-March, 2013. The assessment is clearly the most up to date and widely accepted summary of international work on climate change by competent scientists available today and has been used to underpin our findings. More recent and regionally specific information has been incorporated into our assessment where appropriate.

Despite the strongly supported theories underpinning climate change science, the scientific process is not perfect. For example, investigations of the so called “Climategate” controversy in 2009 found that the leaked or stolen emails and documents demonstrated (Lahsen, 2013)

> *“tendencies to resist transparency about data supporting their scientific findings and to exclude the work of certain scientists in peer reviewed journals and assessments based on extra-scientific considerations”*

The scientists involved were largely exonerated and Lahsen noted that none of the findings have affected the prevailing conclusion that greenhouse gases are changing the global climate. AR5 now expresses more certainty about the anthropogenic impact on global climate than AR4.

Even so, Oreskes (2013) noted that, given the history of science, with both “facts” and theories of well-established scientific knowledge being disproven, we must assume that at least some aspects of the theory of climate change will be rejected in the future. However, to reject the claim that climate change is real is to take:

> *“….a position that is contrary to the conclusions of the thousands of highly trained experts who have dedicated some or all of their scientific careers to probing this issue.”*

We must acknowledge that the science is imperfect and uncertain. Our review of the IPCC reports has shown that this is clearly acknowledged and we see no compelling reason to not take note of their findings. Regardless, the Project Partners should not blindly accept the findings without first understanding the nature of the arguments proposed and the uncertainties around the underpinning concepts and modelling. This section aims to provide that understanding.

3.2.2 Climate Change Science 101

The Earth is warming. This would not be remarkable considering variations that have been known to occur over geological time scales were it not for the influence of human beings.

AR5 states:

> *“Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, **sea level has risen**, and the concentration of greenhouse gases have increased” (our emphasis)*

And:

> *“Human influence on the climate system is clear. This is evident from the increasing greenhouse gas concentrations in the atmosphere, positive radiative forcing, observed warming and understanding of the climate system”*

The concept of radiative forcing and its relationship to greenhouse gases is important. The broad understanding of this phenomenon is well established. The balance of heat in the atmosphere is illustrated in Figure 3 and a very simplified description follows.

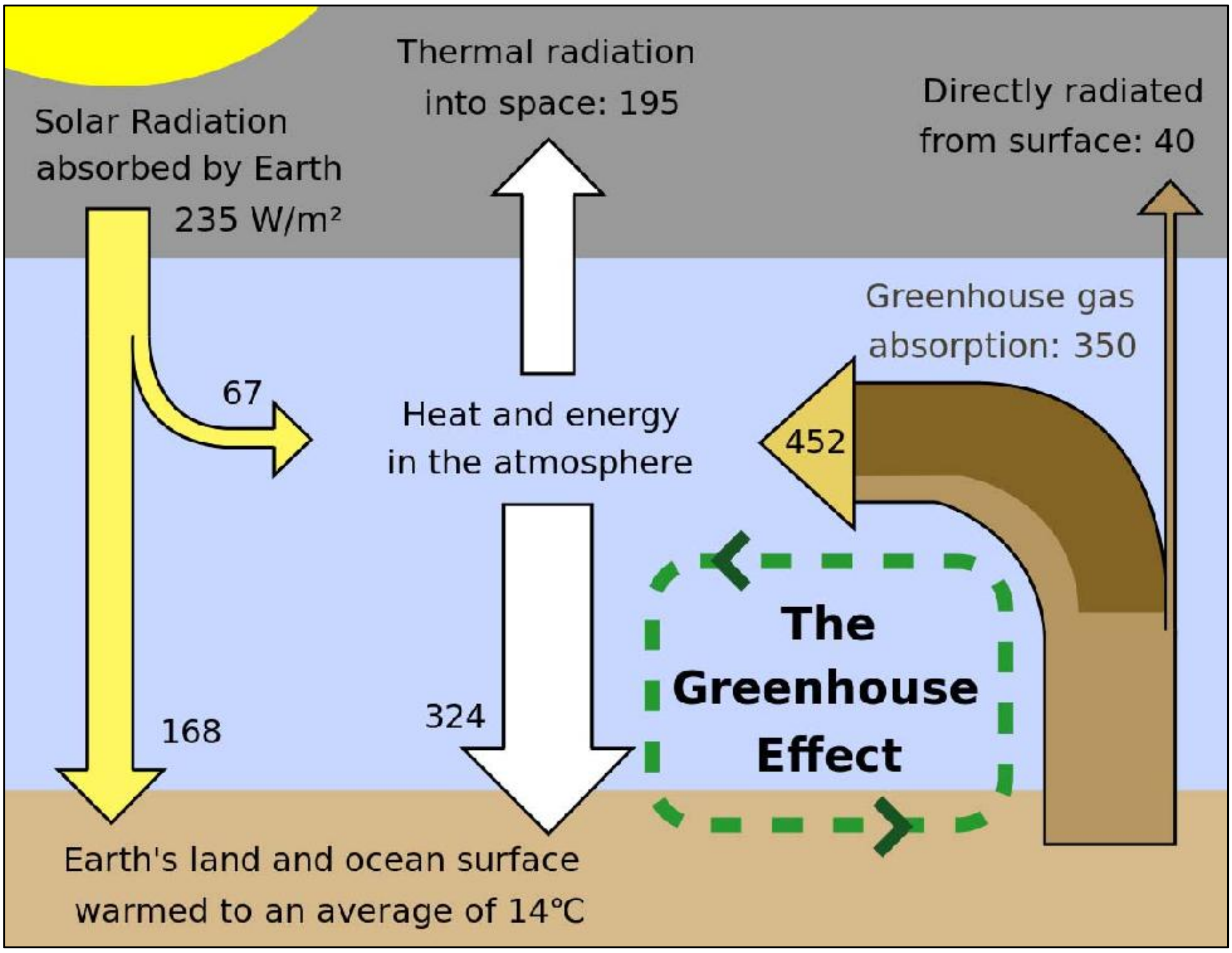

Figure 3 Solar Radiation Balance and the effect of Greenhouse Gases (source: Wikipedia)

When the system is in balance (as shown in Figure 3), the amount of solar radiation entering the atmosphere equals that being radiated back into space. An increase in greenhouse gases upsets this balance, with incoming solar radiation exceeding outgoing radiation, as the additional greenhouse gases trap heat until such time as a new equilibrium is reached and the system is in balance again.

The increase in trapping efficiency, related to the increase in atmospheric temperatures is referred to as radiative forcing and is measured in W/m^2 (Watts per square metre). An increase in radiative forcing increases the amount of heat radiating from the atmosphere back down towards the land and ocean surface as part of the cycle known as the greenhouse effect. If there is a sudden increase in greenhouse gases, and hence radiative forcing, the earth will again reach an equilibrium temperature when solar radiation entering the atmosphere equals that being radiated back out into space. However, if greenhouse gases keep increasing, the temperature will continue to rise.

The system is more complex than the above description with spatial variations, changes in incoming radiation and absorption of some of the heat and gases into the oceans. Heat is continually exchanged between the atmosphere and the oceans and the rates and direction of exchange vary with location. This results in density variations across the global oceans which drive large scale upwelling and sinking at different locations. Globally, these motions combine as the *Thermohaline Circulation*, an oceanic heat "conveyor belt" which plays a significant role in distributing heat around the globe on millennial time scales. The ocean circulation participates in feedbacks between the ocean and the atmosphere that are yet to be fully understood and quantified.

The ocean has a huge capacity to absorb heat. In absorbing that heat, the water expands slightly, meaning that a greater volume of water needs to be held in the oceans, and hence sea levels tend to rise.

There are a number of atmospheric greenhouse gases, including water vapour, carbon dioxide methane, nitrous oxide and ozone. Carbon dioxide is the most significant greenhouse gas and this is often expressed simply in terms of “Carbon” or “Carbon emissions” even though the other gases are also significant.

The world’s oldest continuous Carbon Dioxide (CO_2) monitoring station is located at Mauna Loa in Hawaii. The record from that station is illustrated in Figure 4. Clearly, concentrations of CO_2 in the atmosphere are increasing and the rate of increase is accelerating. The Mauna Loa record began in 1958 and the available record, up to and including March 2014, has been examined. During the first half of the record, the concentration rose from 315 to 347 ppm (+32 ppm). In the second half of the record the concentrations rose from 347 ppm to 397 ppm (+50 ppm). The sawtooth ‘wiggles’ in Figure 4 arise through seasonal variations in atmospheric concentrations.

3.2.3 What is a “Projection” and What Projections are Available

In the context of climate change, projections are representative future scenarios for various climate related parameters. They are not “predictions” with an associated likelihood. Instead, the projections represent “what-if” scenarios that depend on pre-determined plausible scenarios of either economic development or concentrations of greenhouse gases.

- In AR4 (and AR3), emissions scenarios known as the SRES were adopted. These were derived by starting with socio-economic scenarios and building a set of greenhouse gas emissions trajectories and thence changes in atmospheric concentrations of those gases.
- In AR5, four *Representative Concentration Pathway* (RCP) scenarios were adopted. These are prescribed pathways for atmospheric greenhouse gas and aerosol concentrations, together with land use changes. The four RCP’s are characterised by their radiative forcing at the end of the 21st century. RCP8.5, RCP6.0, RCP4.5 and RCP2.6 correspond to scenarios that reach 8.5, 6.0, 4.5 and 2.6 W/m^2 respectively. While consistent and plausible, the RCPs are not based on any given socio-economic scenario in the way that the SRES were.

Jubb et al. (2013) described the derivation and reasoning behind the shift from SRES to RCP’s and characterised the four RCP’s as presented in Table 2. The trajectories of the equivalent $C0_2$ concentrations for the four RCP’s and similar SRES are presented in Figure 5

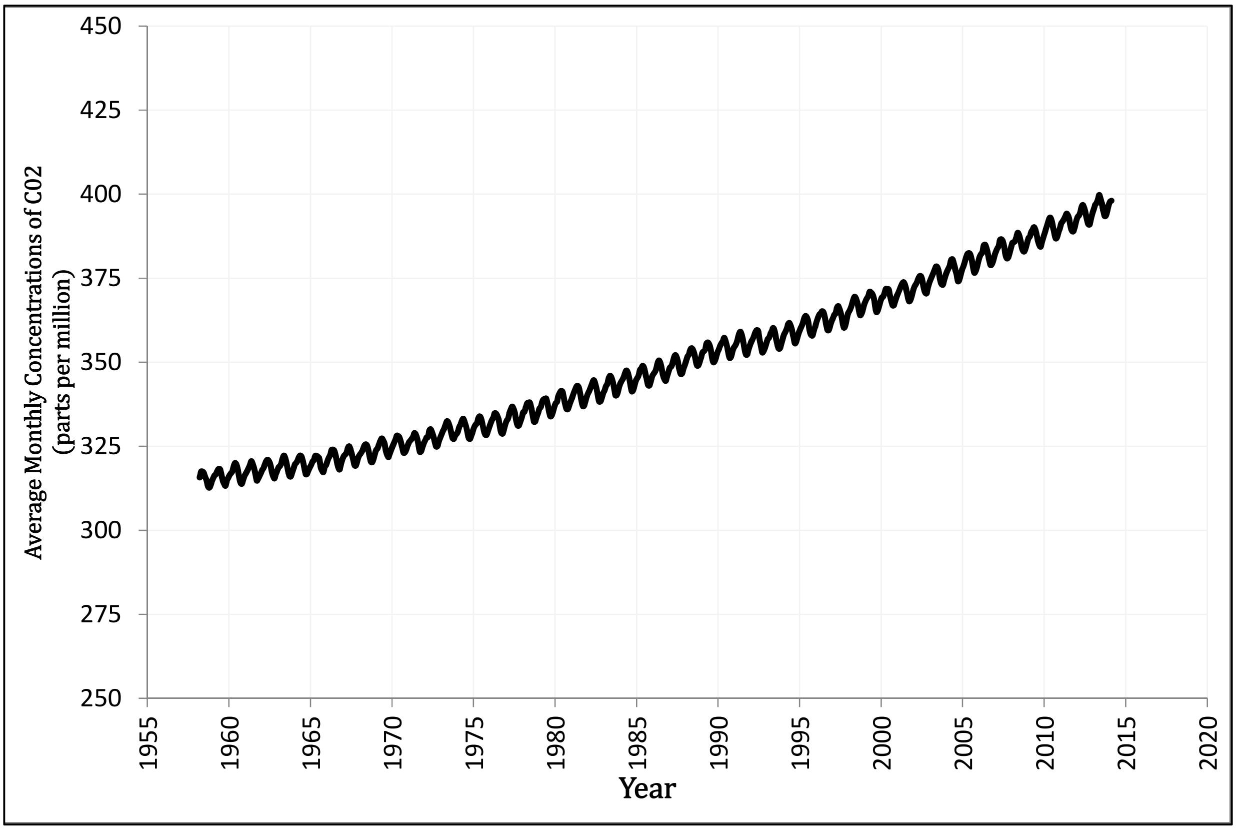

Figure 4 Carbon Dioxide Monitoring Record from Mauna Loa Observatory (Data available from www.esrl.noaa.gov/gmd/dv/ftpdata.html)

Table 2 Characterisation of RCP's adopted in AR5 (adapted from Jubb et al. (2013))

RCP	Radiative Forcing end of 21st Century	Equivalent Peak $C0_2$ (ppm)	Description (from Jubb et al. (2013))	Comparable SRES Scenario
RCP8.5	8.5	>1370	Very high baseline scenario. Little effort to reduce emissions and warming not curbed by 2100.	A1FI
RCP6.0	6.0	850	Medium Scenario. Stabilises soon after 2100	A1B.
RCP4.5	4.5	650	Medium Scenario. Stabilises after 2100	B1 (at 2100)
RCP2.6	2.6	490	Very Low "Ambitious" scenario. Emissions peak early at 3.0 W/m^2 then fall due to active removal of $C0_2$. Also known as RCP3PD.	Lower than all SRES scenarios considered in AR4

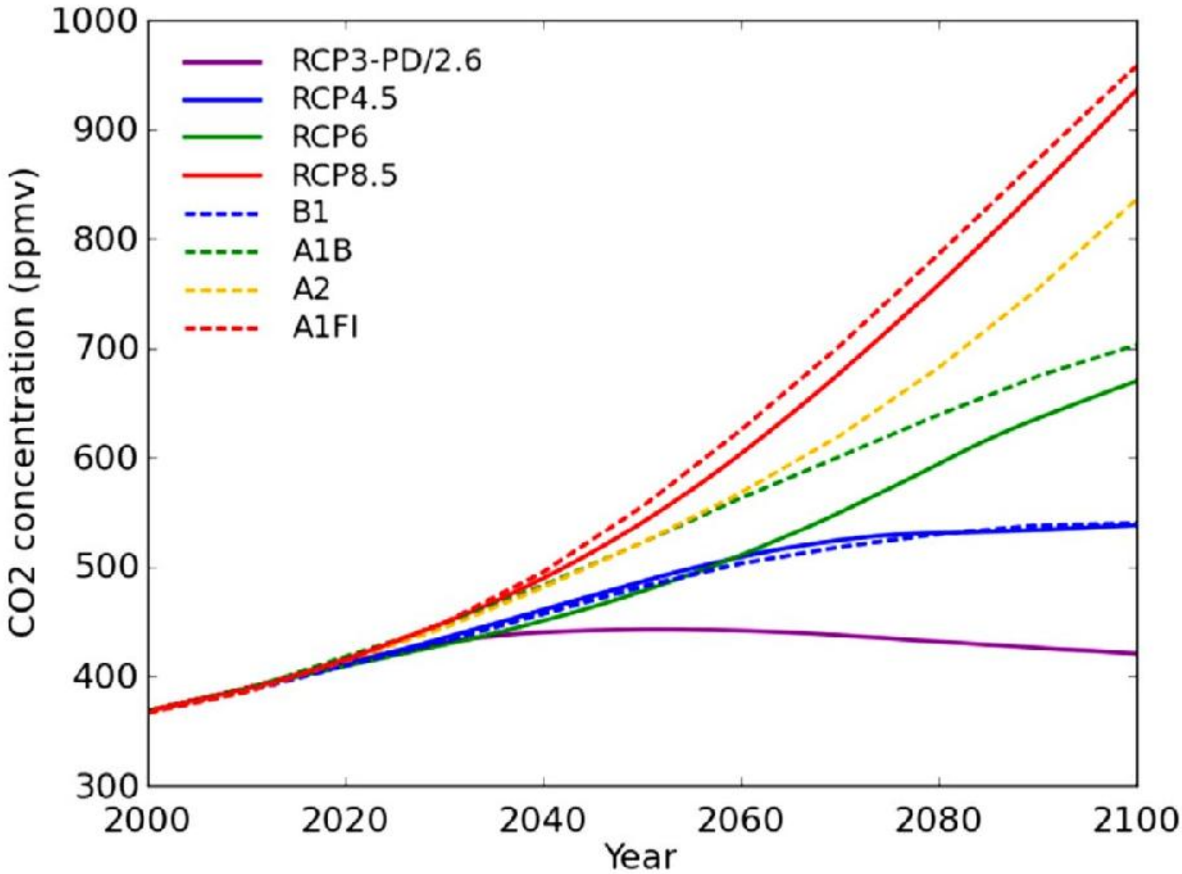

Figure 5 Atmospheric $C0_2$ Concentrations for RCPs and Equivalent SRES's (from Jubb et al. (2013))

These future scenarios are the aspect of making decisions regarding sea-level rise that are subject to the most uncertainty. We cannot reliably predict the way in which the long-term future behaviour of the global population will evolve, so no level of certainty can be attributed to any of the RCPs. Given that all scenarios have similar concentrations and radiative forcing at 2020 ($C0_2$ between 411.1 and 415.8 ppm, Table AII.4.1 in AR5), it is difficult to predict whether any of the four RCPs are representative of the present condition. AR5 notes that the RCPs should be considered "plausible and illustrative" and do not have "probabilities attached to them".

From the Mauna Loa data, CO_2 during the past 5 years (2008-2013) has increased at 2.18ppm/yr. on average. If we consider that this rate remains constant, CO_2 concentrations would reach around 411.7ppm in 2020, higher than the two lowest RCPs. However, if the rate increases in line with past patterns of CO_2 concentrations, they would reach around 412.4ppm in 2020, which is higher than the three lowest RCPs. This brief calculation is provided for illustrative purposes only. Given the minimal time frames involved, it is likely that short term economic factors will impact on the carbon dioxide concentrations that are actually reached by 2020.

The four RCP's were used as inputs to 61 different General Circulation Computer Models run by scientific and research organisations throughout the world. These models simulate the response of the atmosphere and ocean, and the interactions between them, including sea-level rise. These models are described in more detail in Section 3.3.

3.2.4 What are the Key Components of Global Mean Sea-level rise (GMSLR)

As greenhouse gas concentrations increase, so too does radiative forcing and the Earth warms. A warming Earth will contribute to sea-level rise in two main ways:

- As the oceans heat, the water expands. This is known as thermal expansion;
- As the atmosphere heats, ice previously supported directly on the earth's crust (i.e. not floating) will melt and ultimately flow into the ocean. Key sources for this contribution are glaciers and ice caps and the ice sheets of Greenland and Antarctica.

Both processes are expected to occur not only while greenhouse gas concentrations are rising, but to continue for many centuries to millennia even if concentrations are able to be stabilised. Historically, global mean sea level is estimated to have risen by around 19 cm between 1900 and 2010 at an average rate of 1.7mm/yr. Of the rise already experienced, around 40% can be attributed to thermal expansion, 40% to the melting of glaciers and ice caps, with the remaining contributed by the melting of ice in Greenland and Antarctica and changes to terrestrial storage of water (Church et al., 2011).

AR5 indicates it is *virtually certain* that inter-annual and decadal changes in the large scale wind and ocean circulation will cause local sea levels to vary from the global mean. Local effects are described in more detail in Section 3.4.

3.2.5 Global Mean Sea-level Rise in AR5

A summary of results presented in AR5 (Table AII 7.7), modified to represent projected rises from 2015 onwards, is presented in Table 3.

Data provided in AR5 indicate that thermal expansion is now expected to contribute more to sea-level rise during the remainder of the 21st century, than other components such as changes due to mass loss from Antarctica, mass loss from Greenland, mass loss from glaciers or changes to land water storage. There still remains some uncertainty around the potential for rapid ice-sheet changes in both Greenland and Antarctica. It is, however, not expected that these will cause global mean sea level to rise substantially above the ranges identified in Table 3. It is not expected that collapse of the marine based sectors of the Antarctic ice sheet could cause more than several tenths of a metre of sea-level rise during the 21st century. For the higher RCP scenarios, contributions from the Greenland ice sheet are expected to become more marked during the latter half of the 21st century.

AR5 also discusses sea level rise beyond 2100. This is important for the planning process as sea levels are expected to continue rising for a number of centuries into the future. In addition, it sea-level rise which is greater than that projected by AR5 remains a possibility. The advice in AR5 (Section 13.5.4) indicates that for RCP8.5, the maximum modelled sea level rise at 2200 is around 2.0m. Similarly, a value of around 4.0m is estimated for 2300.

Alternatively, much higher estimates of potential sea level rise by 2100 also exist, produced by *semi-empirical models* (Pfeffer et al, 2008, Sriver et al, 2012). This research indicates that the absolute upper limit of physically plausible sea level rise, largely governed by physical limits to the speed at which ice can melt, is between 2.0 and 2.25 at 2100. Related research, based on the opinions of over 90 sea-level rise experts, also indicates that the projected values at 2100 may be too low (Horton et al, 2014). For RCP8.5, Horton et al indicated that there is a 5% chance that sea level rise of 1.5m would be exceeded by 2100. For 2300 a corresponding value of 4.0m is indicated.

3.3 Are Global Atmospheric / Ocean Climate Models "Reliable"?

> *"Remember that all models are wrong; the practical question is how wrong do they have to be to not be useful"*
>
> George E.P. Box (1987)

For AR5, the RCP's were used as inputs to many different computer models as part of phase 5 of the Coupled Model Intercomparison Project (CMIP5). Simulations were executed by 28 different organisations internationally using a total of 61 different models. These model simulations were used to derive the projections presented in Table 3.

Table 3 Projections of Global Mean Sea-level rise from AR5 (relative to 2015[4], based on Table AII.7.7 from AR5)

Year[1]	RCP2.6			RCP4.5			RCP6.0			RCP8.5		
	Low[3]	Middle[2]	High[3]	Low[3]	Middle[2]	High[3]	Low[3]	Middle[2]	High[3]	Low[3]	Middle[2]	High[3]
1995[5]	-0.03	-0.03	-0.04	-0.03	-0.03	-0.04	-0.03	-0.03	-0.04	-0.03	-0.03	-0.04
2007[5]	-0.02	-0.02	-0.03	-0.02	-0.02	-0.03	-0.02	-0.02	-0.03	-0.02	-0.02	-0.03
2015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2020	0.02	0.02	0.03	0.02	0.02	0.03	0.02	0.02	0.03	0.02	0.02	0.03
2030	0.05	0.07	0.09	0.05	0.07	0.09	0.05	0.06	0.09	0.06	0.07	0.09
2040	0.09	0.11	0.15	0.09	0.11	0.15	0.08	0.11	0.14	0.1	0.13	0.16
2050	0.12	0.16	0.21	0.13	0.17	0.22	0.12	0.16	0.21	0.15	0.19	0.24
2060	0.14	0.2	0.28	0.17	0.22	0.3	0.15	0.21	0.28	0.2	0.27	0.34
2070	0.17	0.25	0.34	0.21	0.29	0.38	0.2	0.27	0.36	0.27	0.36	0.46
2080	0.2	0.29	0.41	0.24	0.35	0.47	0.24	0.34	0.46	0.33	0.45	0.59
2090	0.22	0.34	0.47	0.28	0.41	0.55	0.29	0.41	0.56	0.41	0.56	0.73
2100	0.24	0.38	0.54	0.32	0.47	0.64	0.34	0.49	0.66	0.49	0.68	0.9

[1]Projections for 1st January of each year considered
[2]Median predictions of all model results in CMIP5 (i.e. half of the models predicted higher sea-level rise than the median and half predicted lower)
[3]Low and High levels encapsulate the range of predictions from 90% of the models (i.e. 5% predicted values less than the "Low" value and 5% of the models predicted values greater than the "High" value). AR5 states that the GMSL rise if a given RCP is realised it is *likely* (i.e. greater than 66% probability) to be within the Low and High levels. Given the approximate symmetry of upper and lower bounds around the median, we have assumed that the probabilities are also symmetrical within this *likely* range. By extension, if an RCP is precisely realised, there is an 83% (~85%) chance that the lower bound will be exceeded, but only a 17% (~15%) chance that the upper bound will be exceeded.
[4]To convert these values to an absolute datum (e.g. relative to AHD), the mean sea level to AHD at 2015 needs to be determined and added to these values. Analyses presented in Section 3.5.6 indicate that the mean sea level at 2015 will be around 8cm above AHD at Fort Denison. This includes a rise of around 5cm since 1995, which is slightly higher than the global average.
[5]Values for 1995 and 2007 are based on values provided in AR5 Table AII.7.7, for which model results are based on rise relative to the calculated global average between 1985 and 2005. As we are interested in future sea-level rise, values for 2015 have been zeroed and values are reported relative to 2015.

It is important to assess the reliability of models on which planning decisions are to be made. AR5 states the following with an assessed "very high confidence":

> *"Climate models have improved since the AR4. Models reproduce observed continental-scale surface temperature patterns and trends over many decades, including the more rapid warming since the mid-20th century and the cooling immediately following large volcanic eruptions"*

In commenting on the utility of climate models, albeit while examining the effects of large scale circulations on Australian rainfall, Kiem and Verdon-Kidd (2011) argued that the AR4 models were useful at global and continental scales, but inappropriate when applied at the regional scale. This is still identified as an issue in AR5. However, when considering mean sea level, we are less concerned with the replication of short term events (e.g. individual floods) and more interested in processes that act over much longer time frames. Furthermore, as the world's oceans are all connected, we can be assured that a global rise in sea level will eventually be realised around the coastline of Australia, although there are some local factors that need to be considered in planning.

It is worthwhile to examine how well the AR5 models perform against historical data, and global mean sea level estimates derived from both modelling and measurements. Figure 6 has been adopted from AR5. It is clear that the models have tended to under predict mean sea-level rise and adjustments are still needed to account for the contributions of melting ice to sea level. This was an issue in the AR4 modelling as well, although the ability of models to account for these contributions has improved. Consequently, the upper limit of ranges projected in AR5 is higher than the corresponding limit in AR4, which advised that an additional 0.1 to 0.2 could be added to the projections to account for dynamical ice sheet responses. In the projections provided in AR5 (reproduced in Table 3) the effects of dynamical ice sheet response and the uncertainty in their estimates is incorporated.

Knutti and Sedlacek (2013) discussed the fact that the CMIP (AR5) model projections for temperature and rainfall still predicted similar spatial trends to those produced in AR4. The spread of model results has not reduced between AR4 and AR5, despite improvements in computational capacity and the representation of climate processes in the models. However, this response is not unexpected. As more is understood about processes affecting the climate, and that understanding is incorporated into models, additional sources of uncertainty are also introduced to the models (Hannart et al., 2013).

There are presently arguments that the ranges of sea-level rise provided in AR5 are too small. Subsequent to the release of the AR5 WGI report (IPCC, 2013b), a formal survey of sea-level rise experts was undertaken to elicit expected sea-level rise values for RCP2.6 and RCP8.5 (Horton et al., 2014). 500 experts were selected based on their publication record since 2007 of which 90 individuals successfully and anonymously filled out an online survey. The median likely ranges obtained from this process for RCP2.6 were 0.4 to 0.6 m by 2100 and 0.6 to 1.0m by 2300. For RCP8.5, the corresponding ranges were 0.7-1.2 and 2.0 to 3.0. These are higher than the corresponding ranges in AR5 and comparison is provided in Table 4.

Table 4 Comparison of Likely Ranges of Sea-Level rise at 2100 from AR5 and Expert Elicitation in Horton et al (2014)

Scenario	Median "Likely" Range (Horton et al., 2014)	"Likely" Range (AR5)[1]
RCP2.6	0.4 to 0.6 m	0.26 to 0.55
RCP8.5	0.7 to1.2 m	0.53 to 0.98

[1]These ranges differ from those shown in Table 3. Values in Table 3 were adjusted to a start point of 2015. Ranges in this table are rise relative to the average of the period 1986 – 2005.

The projections of AR5 have relied on *process based* computer models for their derivation. In their assessment of the alternative *semi-empirical* models, the IPCC noted that there was *no consensus* regarding the reliability of these models and therefore *low confidence* in the projections obtained from them. Semi-empirical models tend to project sea-level rise values that are significantly higher (up to 2 times) than the predictions of process based models.

Furthermore, when considering the geological record, there are numerous times when the sea level has risen at a greater rate than has been measured over the past 20 years (~ 3.2 mm/yr.) as discussed in Cronin (2012).

In conclusion, we consider that the process based models and their projections are useful for planning. No model is perfect, and this needs to be considered in making policy decisions. The execution of a number of independent models as part of the CMIP5 project provides confidence that the actual sea-level rise that will be realised for a future scenario is within the ranges of projected values provided.

Although the inclusion of results from many models generates uncertainty, the overall projection of an accelerating future sea-level rise is clear, even if that acceleration cannot yet be unequivocally proven based on the presently available measured record (see the following for an overview of present debate: Church and White, 2006; Watson, 2011; Baart et al., 2011; Boon, 2012; Dean and Houston, 2013; Houston and Dean, 2011, 2013). In terms of alternative arguments regarding the "reliability" of the process based models, the peer reviewed scientific literature seems to indicate that higher projected values of sea-level rise are a possibility, as compared to those projected by the IPCC (Horton et al., 2014; Pfeffer et al., 2008; Rahmstorf, 2007; Sriver et al., 2012). This issue has been considered in our guidance for choosing an appropriate sea-level rise projection for the study area in Section 4.

We recommend consideration of the AR5 projections of global mean sea-level rise as a basis for a Sea Level Rise Policy. To bring this to a local scale, regional effects need to be considered (refer Sections 3.4 and 3.5). The critical decision relating to planning is which future scenario should be adopted now (i.e. which RCP to use) and this is discussed in Section 4.

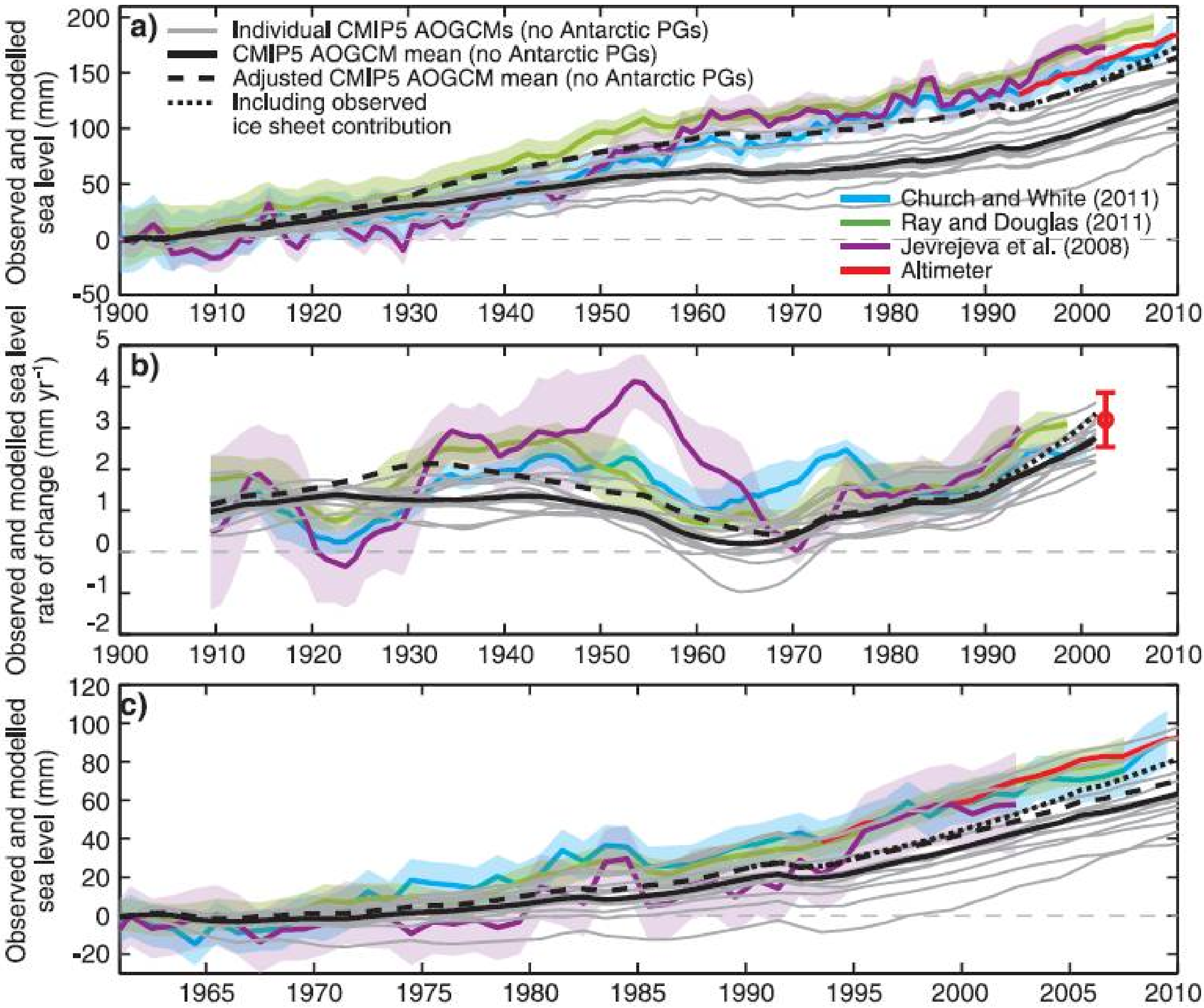

Figure 6 Performance of CMIP5 Models against estimates of Historical Global Mean Sea Level (adopted from Figure 13.7 of IPCC (2013b)).

(a) Observed and modelled sea level for 1900 to 2010
(b) The rates of sea level change for the same period, with satellite altimeter data shown as a red dot for the rate. Note that the rate (in mm/yr.) has been greater than zero for all historical reconstructions since the 1920s. Conversely, some model simulations simulate a negative rate (falling sea level) during the 1960s.
(c) The observed and modelled sea level for 1961 to 2010.

Shading indicates the uncertainty estimates from different estimates of global mean sea level, (Jevrejava et al, 2008; Church and White, 2011; Ray and Douglas, 2011) to two standard deviations; Solid black line is mean of grey lines each of which represent different model simulation estimates of the summed sea-level rise from (i) thermal expansion, (ii) land water storage and (iii) glaciers excluding those peripheral to Antarctic ice sheet. The Dashed black line corrects the black line to include measured ice losses from glaciers instead of modelled values. The dotted black line adjusts the model results further by including ice sheet observations (from 1993 onwards). This last adjustment also includes the glaciers peripheral to the Antarctic ice sheet.

3.4 Discussion of Regionally Specific Effects

Sea-level rise is not expected to evolve uniformly in time or space. There are identified modes of climate variability which influence sea levels. The most important modes identified for the New South Wales Coast are the El-Nino / Southern Oscillation (ENSO) and the Interdecadal Pacific Oscillation (IPO). ENSO introduces fluctuations to mean sea level that oscillate irregularly over periods of a few years, whereas the IPO, which was more recently identified

(Power et al., 1999) appears to have a period of some 50-60 years. The IPO is closely related to another oscillation, the *Pacific Decadal Oscillation* or PDO.

The IPO and ENSO are measures of broad scale spatial patterns of sea surface temperature and mean sea level pressure across the South Pacific Ocean. The state of these patterns affects the strengths of wind speeds, ocean currents and weather around Australia. Typically, fluctuations will tend to oscillate around the global mean sea level, however, there are some important interactions with a warming globe that are projected to cause the mean sea level at any particular location to diverge from the global mean. A number of processes are expected to cause local variations to mean sea level and these are summarised below.

Glacial Isostatic Adjustment and Tectonic Effects

The release of water mass which is presently supported on the Earth's crust also results in rebound of that crust as the weight is removed and redistributed. This process is known to be occurring following the melting of ice sheets that covered much of North America and Europe until around 20,000 years ago. Movement of the mass of water contained in the ice sheets and addition of that mass into the oceans has caused the base of the oceans to be pushed down and areas previously covered by ice to be pushed upwards.

Glacial Isostatic Adjustment (GIA) is the term used to describe this ongoing response. On a globally averaged basis, the mean rate of GIA is considered to be lowering sea levels relative to the land by 0.3mm/year. This is around 10% of the rate of average global sea-level rise estimated from altimetry over the past two decades.

As a result of the melting ice the sea level in New South Wales is thought to have risen from a level of around 140 m below present to be close to its present level about 6,500 to 6,000 years ago (Chapman et al., 1982; NSW Government, 1990), following which it has remained relatively stationary. Clearly, the evidence points strongly to significant fluctuations of sea level over geological time frames. However, the purpose of the present assessment is to examine how sea levels may vary over future planning time frames, and the present effect of GIA in the study area is therefore of interest.

Variations in the movement of the land relative to the centre of the earth are presently measured by Geoscience Australia as part of the Australian Regional Global Navigation Satellite System (GNSS) Network. The data are readily downloadable for analysis and stations of interest to the present study exist at Port Kembla, Nowra, Ulladulla and Tuross Lake. Inspection of those data indicates that no stations have been in place since before 2010 and the record is too short to make long term predictions. The land rises and falls seasonally due to loading and unloading caused by the hydrological cycle. In the area of interest this appears to account for a typical 30 mm of annual oscillation, and this would need to be averaged out to determine a long term trend once the record is sufficiently long.

Overall, Australia has been relatively geologically stable for the past 200 million years given that the continent sits on the middle of a tectonic plate (Johnson, 2009). Earthquakes, volcanoes and vertical changes in elevation due to uplift or subduction are not significant contributors to changes in the elevation of the land relative to the sea over planning time scales in New South Wales.

Due to this overall stability, the GIA effect is more important than plate tectonics in Australia. GIA model results files, dating from 13 August, 2012, were downloaded from the Permanent Service for Mean Sea Level and inspected. The model results applied were based on the ICE-5G (VM2) model (Peltier, 2004). Those results indicate GIA induced relative falls in sea level of -

0.22mm/yr. and -0.20mm/yr. for Sydney and Bermagui respectively. A number of different GIA models exist. However, the Peltier model is widely recognised and the results are freely available. Analysis of the model results against trends measured using GPS, as presented in Schon et al. (2010) indicates that the model tends to under predict the effect in the Southern Hemisphere, although the effects offshore of the NSW coast are minimal.

Relating to GIA and Tectonic effects are the concepts of “Relative” and “Absolute” sea-level rise. *Absolute Sea-level Rise* relates to the amount that the sea level rises vertically, when compared to the centre of the earth. However, at the same time, the land may be rising (or falling) relative to the centre of the earth as well. The combined effect of these results in *Relative Sea-level Rise*. For example, if the ocean at a particular location is rising at 4.0 mm/yr. in absolute terms, but the land is also rising at 0.2 mm/yr., the *Relative Sea-level Rise* 3.8 mm/yr. The projections of interest to planning represent *Relative Sea-Level Rise* and should include GIA and Tectonic effects.

Gravitational Effects

The melting of large ice sheets and glaciers will change the earth’s gravitational field. The mass of water contained in large ice sheets and glaciers presently exerts a gravitational pull that raises mean sea levels in adjacent regions. As that mass of ice melts and is dispersed throughout the oceans, the local gravitational pull eases, resulting in a relative fall of mean sea level in those regions. This effect is already being experienced, for example, in areas adjacent to Greenland. Changes in the mass distribution will also slightly affect the rotation of the earth.

The expected spatial variation in mean sea-level rise is provided in Figure 7. The figure warrants some explanation. For both panes, it is assumed that the global average rate of sea level is 1mm/year. In the top pane, the sea-level rise is caused entirely by the loss of ice from Greenland, and in the bottom pane, entirely from Antarctica. There is no time frame associated with these plots, but they indicate how the regional rate of rise will vary proportionally to the global mean depending on changes to the gravitational field of the earth.

Offshore of New South Wales, there is only a minor expected variation from the global mean. Negligible variation is expected from ice that is lost from Greenland, but the global sea-level rise rate contributed by the West Antarctic Ice Sheet could be increased by 5-10% to obtain a regionally applicable value along the New South Wales coast for this specific component.

Therefore, the contribution of melting ice from Antarctica is of most interest. *Figure 13.10* from AR5 shows the relative contribution of Antarctic ice melt to overall sea-level rise for the different RCP’s and the proportional increase in sea-level rise along the coast of New South Wales that might arise from resultant changes to the gravitational field are presented in Figure 7. For a sea-level rise of 0.9m by 2100 (RCP8.5), an adjustment for gravitational effects would amount to less than 1cm (0.8% of 90cm = 7.2mm). This effect is insignificant along the coast of New South Wales.

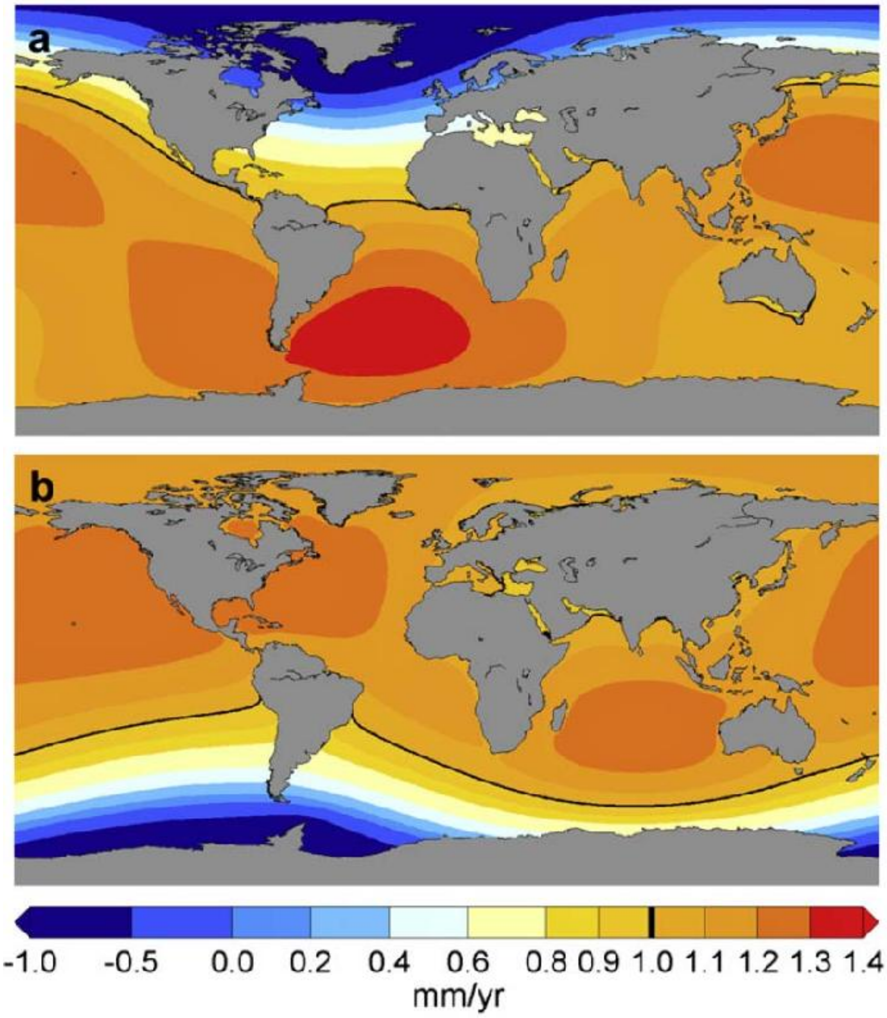

Figure 7 Sea Level change arising due to mass loss from (a) Greenland and (b) West Antarctica.

The ice loss in both cases is enough to raise the global average sea level by 1mm/yr. Figure (a) indicates that the effect will be close to the global average 1 mm/yr. along the NSW coast for losses from Greenland. Figure (b) indicates that between 1.0 and 1.1 mm/yr. would be experienced due to losses from West Antarctica. In effect, these results indicate that any contribution to Global Mean Sea-level rise from west Antarctica could be increased by 10% to calculate the regional impact along the New South Wales Coast. Figure taken from Cronin (2012), which was adapted from (Tamisiea and Mitrovica, 2011)

Table 5 Allowance for Antarctic Ice Sheet Gravitational Effects in Coastal NSW

Quantity	RCP2.6	RCP4.5	RCP6.0	RCP8.5
Median SLR (2081 – 2100)	0.41	0.48	0.48	0.64
Median Contribution from Antarctic (2081 – 2100)[1] (m)	0.05	0.05	0.05	0.05
% Of Total Contribution from Antarctic (m)	12.2%	10.4%	10.4%	7.8%
% Adjustment Required to GMSL projection for NSW[2]	+1.2%	+1.0%	+1.0%	+0.8%

[1]These values are estimated from Figure 13.10 of AR5, noting that the same allowance for Antarctic Ice Sheet Dynamics was made for each of the RCPs in AR5.
[2]Using the upper range of the 0-10% band indicated by Figure 7, to get the required adjustment for coastal NSW.

Changes to Average Weather Patterns and Currents

Global changes to the climate are expected to modify the global patterns of wind and weather systems. While ocean scale oscillations such as ENSO, the PDO or the IPO will continue to cause variability in the climate, the strength of oceanic currents and the speed with which the main contributors to sea level rise translate across the globe, a shift in the “equilibrium” patterns may also cause sustained regional variations to mean sea level. Modelled results relating to these changes are presented in AR5 and the relevant figure from the physical science basis report is Figure 13.21. The model results indicate that sea-level rise along the continental shelf offshore of New South Wales will deviate by less than +10% from the global mean value. Indeed, the variation in sea-level rise around the coastal fringe of Australia is within 10% of the global average, mostly higher than the global average but with a small length lower than the global average (by less than 10%) along the Victorian coastline. The same pattern of typically lower sea-level rise around the fringes of the coast is also illustrated in Figure 8, albeit for all of the RCP’s (Figure 13.21 only shows results for RCP4.5). The variation along the coast of NSW, when compared to values further out in the Tasman Sea, is related to expected changes in the dynamics of the East Australian Current (pers comm. John Church, 10 June, 2014).

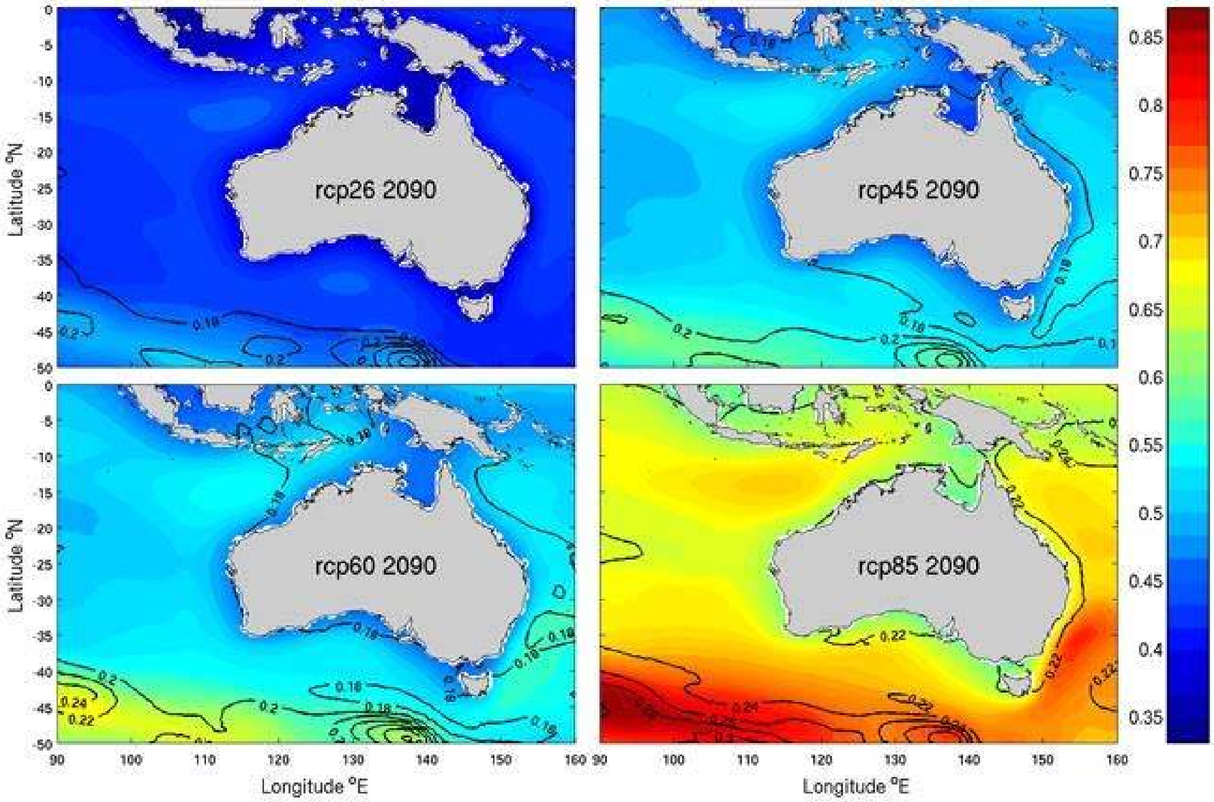

Figure 8 Local Change in Mean Sea Level, consistent with AR5, over approximately 100 years of simulation for all RCP’s.

Provided courtesy of John Church from CSIRO. It represents draft outputs that highlight similar patterns to those presented in AR5, but with more detail in the Australasian region. The shading is the projected rise in 2081-2100 compared with 1986-2005 and the contours are an estimate of the uncertainty. It shows that there is a lowering of the sea-level rise predicted for the NSW coast when compared to values further out in the Tasman Sea

3.5 The Historical Regional Sea-level Rise Response along the South Coast

3.5.1 Introduction

Most of the sea level records (tide gauges and altimeter) that are available for the south coast of New South Wales are less than 20 years long. This creates problems in ascertaining long term trends of sea-level rise, because natural variability or oscillation of mean sea level over time is relatively large. On time scales of less than a decade such oscillations are caused by large scale global patterns such as the El-Nino Southern Oscillation (ENSO).

Even with very long time series, such as at the Fort Denison tide gauge, care needs to be taken to ensure that even longer term oscillations are properly accounted for. Overall, this makes the job of estimating historical sea-level rise rates difficult.

The following sections detail a relatively simplistic approach, applying linear fits to the available data, to determine trends over the past two decades. The values calculated by this method are not suitable for the projection of future sea levels. However, for comparison of the last two decades at the different sites considered, the analysis is very useful.

3.5.2 Data from the National Tide Centre

The National Tidal Centre (NTC) of the Bureau of Meteorology manages tidal gauges around Australia. Data were obtained for two of the NTC gauges, Fort Denison and Port Kembla.

Tide levels have been recorded at Fort Denison, in Sydney Harbour, since 1866. Monthly and annual mean levels have been checked and adjusted from 1886 onwards, however hourly records are only present from 1914 to the present (Hamon, 1987). The data were found to be mostly complete (i.e. most years > 95%) with notable exceptions in 1914 (~56% complete), 1930 (0%), 1941 (78%) and 2000 (88%).

Tide levels were recorded at Port Kembla from 1957, however the early data is sparse, and significant gaps in the record exist from 1957 through 1965, and 1972 through 1983. The data from 1983 onwards appear reasonable (i.e. most years > 95%) with exceptions in 1983 (~87% complete), 1984 (~79%) and 1989 (~87%).

For each of these records, erroneous data were removed, the annual average mean sea level was calculated, and that value was adjusted to Australian Height Datum. Australian Height Datum was established as equal to mean sea level between 1966 and 1968 using 30 gauges around Australia. Fort Denison and Port Kembla were two of those gauges. The annual mean sea levels for both stations are plotted in Figure 9. The plots for both gauges have remarkably similar temporal characteristics, particularly from the mid 1990's onwards.

The average rate of rise was determined for both gauges from 1996 to 2013 (Table 6). This period was chosen to correspond with the period for which other data are available (discussed below). The difference of 10% between gauges shows how minor differences over small periods can affect the calculated rate of rise. However, our comparison to results from other data sources, described below, illustrates that there is no robustly discernible regional variation in sea-level rise between Sydney and the study area. This means that Fort Denison is a suitable long term record for assessing the likely historical trends on the South Coast.

Table 6 Linear Fit to Annual Mean Sea Levels at NTC Gauges from 1996-2013[1]

Gauge Location	Rate of Rise (mm/yr.)	Standard Error (mm/yr.)
Sydney (Fort Denison)	3.3	1.1
Port Kembla	3.6	0.7

[1]These rates are unsuitable for long term estimation of sea-level rise, refer to text

3.5.3 Data from Manly Hydraulics Laboratory

Manly Hydraulics Laboratory (MHL) collects and provides tide data along the New South Wales coast on behalf of the New South Wales Office of Environment and Heritage. Data were received from a total of 10 stations. Following preliminary analysis and research, the following gauges were excluded from analysis for the following reasons:

- Port Hacking: This gauge was excluded as it is considered to have both "over-ranging" and datum issues in the early part of the record (Couriel and Modra, 2013);
- Shoalhaven Heads: The gauge was excluded as it is located inside the Shoalhaven Estuary, and its tidal connection to the ocean varies, being normally connected through Crookhaven Heads via Berry's canal, and occasionally directly through Shoalhaven Heads following floods. The gauge tends to plot well above the ocean gauges and is not considered useful for mean sea level analysis within the open ocean. This record would prove useful for site specific analyses inside the Shoalhaven Estuary.
- Crookhaven Heads: This gauge was excluded due to problems in the early record related to over-ranging and subsequent removal of these resulting in unrepresentatively high mean sea levels (Couriel and Modra, 2013);
- Ulladulla: The gauge was excluded as the record is presently too short to be meaningful for sea level trend analysis (<10 years, see Section 3.5.2);
- Batemans Bay Offshore: Data from this gauge were excluded as the record is adjusted for Mean Sea Level each time it is deployed, meaning that any underlying change in mean sea level is not captured.
- Eden: This gauge was excluded as it is well south of the Study Area. Initial inspection indicated that it has a constant datum shift issue similar to Bermagui, but of larger magnitude than Bermagui (see below), meaning that it consistently records around 0.1 m below the other gauges relative to AHD.

The remaining gauges were processed in a similar manner to the National Tide Centre gauges. Details of the records and relevant comments are provided in Table 7. The four gauge records are plotted in Figure 10. The correlation between records on that figure is less obvious than for the NTC gauges. However the following points are noted:

- Bermagui consistently plots around 2-6cm below the other gauges, although the temporal variation is consistent with other gauges indicating a persistent datum error. The cause of this datum error is unknown. An alternative plot with the gauge record raised by 4cm is also provided;
- The Princess Jetty and Jervis Bay records both tend to plot high, particularly during La Nina periods, when mean sea level pressure is lower on average, and mean sea level rises along the New South Wales Coast. An additional characteristic of La Nina years is increased rainfall, and given the location of both these gauges (inside estuaries), it is

possible that additional rainfall and runoff into the estuary cause higher average water levels during some years.

- The adjusted Bermagui record and Sydney follow similar patterns although there is still some variability along the coast. The differences do not display a consistent trend in time. Interestingly, while Fort Denison and Port Kembla plot very similar values, since 1997, the gauge at Sydney (Middle Head, also in Sydney Harbour) is not as close as might be expected to the Fort Denison Gauge over this period. Differences are still less than 2cm, but this shows the type of local scale variation that can occur with mean sea levels inside estuaries on a yearly time scale, even if they are relatively open to the ocean.

Table 7 Summary of Manly Hydraulics Laboratory Gauge Data Used

MHL Gauge	Start Year	End Year	Comments
Sydney (Middle Head)	1987	2013	Years with less than 90% of record: 1987(24%), 2013(82%).
Jervis Bay	1989	2013	Years with less than 90% of record: 1989(27%), 1991(85%), 1992(85%), 1993(85%), 2002(44%), 2003(80%), 2006(84%), 2013(54%),
Princess Jetty (Batemans Bay)	1995	2013	Years with less than 90% of record: 1995(48%), 1997(86%), 2009(25%), 2010(15%), 2013(87%)
Bermagui	1987	2013	Years with less than 90% of record: (1987(43%), 1988(69%), 1989(0%), 1990(64%), 1994(89%). Datum shift issue ~ see text

Linear trends have been fitted to the MHL records for the period over which we have data for all four stations (1996 – 2013). This period is not long enough to predict long term rates of rise (refer Section 3.5.2). It has been argued that a record of at least 60 years length and longer in some locations, is required to determine an underlying rate of sea-level rise (see Houston and Dean (2013) for a detailed discussion).

The purpose of the present analysis is to determine whether there is a significant spatial variation within the study area and between Sydney and the study area. We have found no such variation.

An ordinary least squares regression of the data was undertaken and the results are presented in Table 8. The two *slightly estuarine* gauges (Jervis Bay and Princess Jetty) have a greater standard error and steeper trends. This is related largely to La Nina years in the latter part of the record, as discussed above. Overall, these rates are reasonably consistent with the global mean reported for the last 20 years in AR5 (~ 3.2 mm/yr.), and the rate at Fort Denison (see Table 8). The findings are also in agreement with a recent, substantial study on ocean water levels around Australia (White et al. 2014).

Table 8 Linear Fit to Annual Mean Sea Levels at MHL Gauges from 1996-2013[1]

Gauge Location	Rate of Rise (mm/yr.)	Standard Error (mm/yr.)
Fort Denison[2]	3.3	1.1
Sydney (Middle Head)	3.6	1.3
Jervis Bay	4.2	1.4
Princess Jetty	4.2	1.8
Bermagui	3.4	0.9

[1]These rates are unsuitable for long term projections of sea-level rise (refer Section 3.5.2)
[2]Fort Denison Gauge, which is managed by the National Tide Centre, is provided for comparison purposes only.

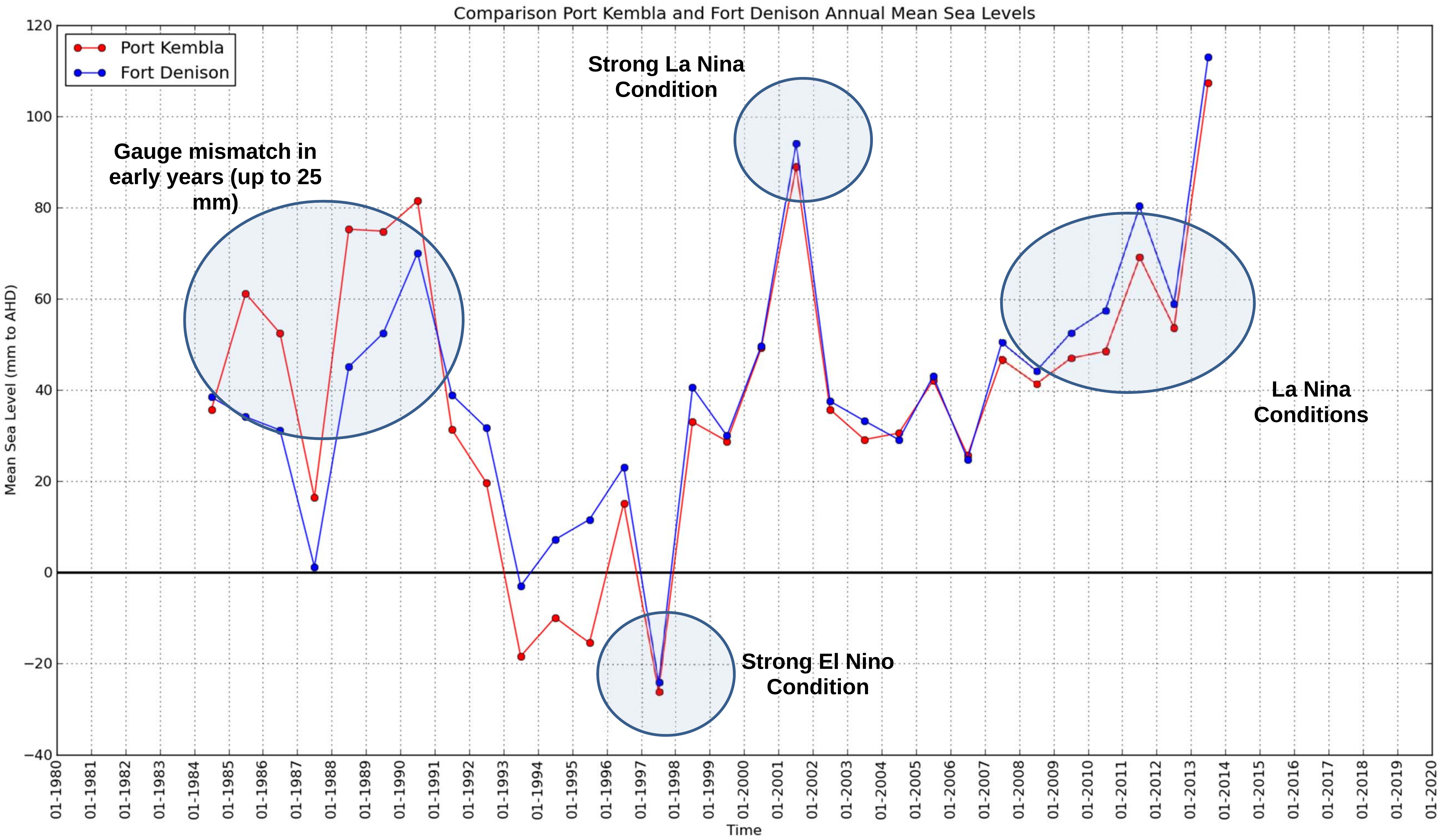

Figure 9 **Annual Mean Sea Level Values at National Tidal Centre Gauges**

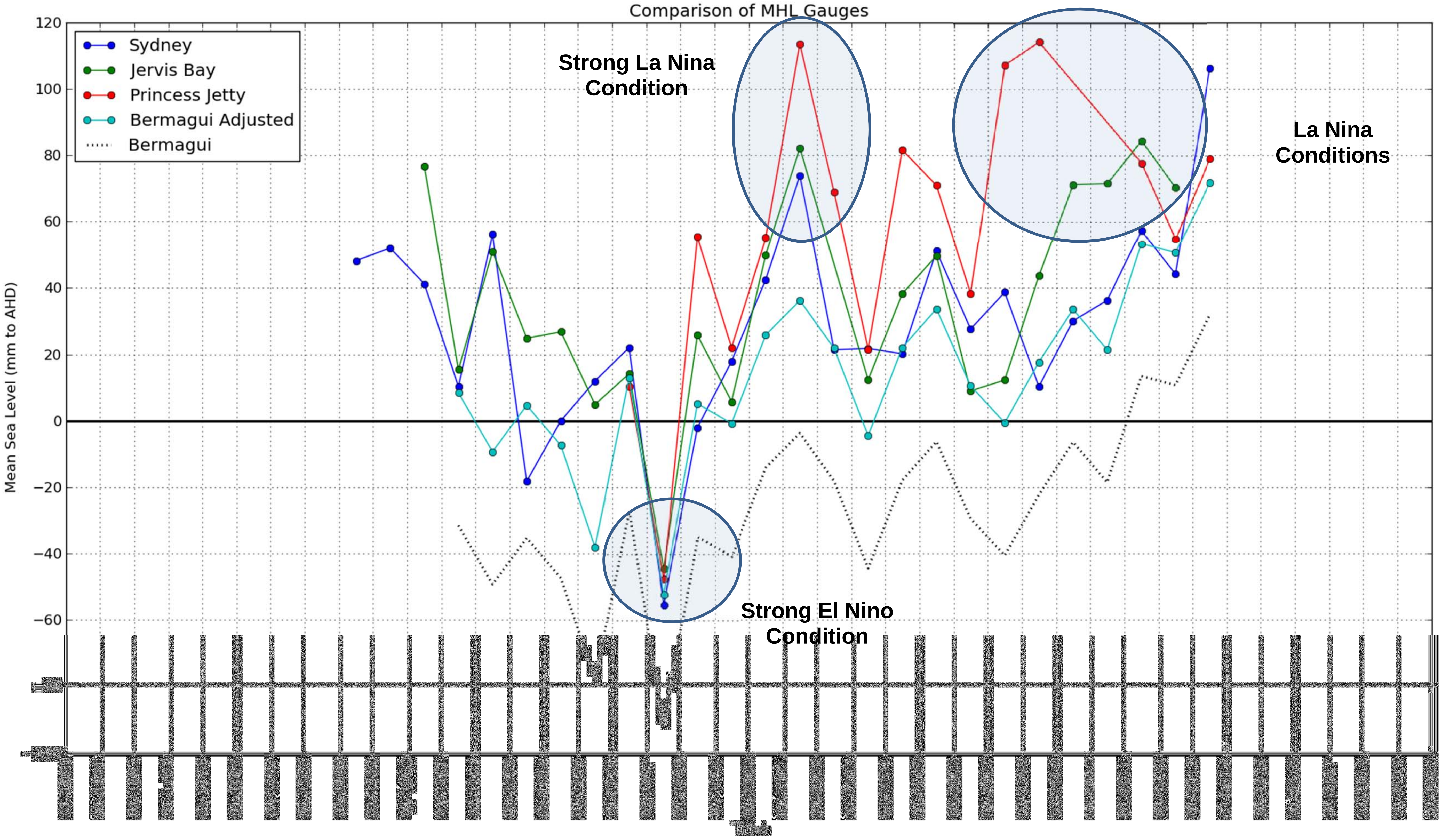

Figure 10 Annual Mean Sea Level Values at Manly Hydraulics Laboratory Gauges

3.5.4 Satellite Altimeter Data

The CSIRO updates and provides satellite altimeter datasets. As presented, the data comprise a monthly time series of mean sea level on a 1˚ grid across the globe. Different files are available comprising a number of corrections to the raw data, including an inverse barometer adjustment (to account for sea level pressure), the removal of a seasonal trend and a correction for glacial isostatic adjustment. For our purposes, we have averaged data annually, meaning that the seasonal trend is removed. In addition, to facilitate direct comparison with the tide gauges, which don't have an inverse barometer correction applied, this correction was not desirable. However, to enable direct comparison, inclusion of the GIA effect was desirable and it is those results which were adopted for our analysis.

Time series from all land based grid cells between 150 and 153˚ E and -34 to -37 ˚ S were processed to annual average values and these are plotted in Figure 11. This area covers the region between Sydney and Eden and extends some 200km seaward. From these data it is very clear that there is some variation in Mean Sea Level, particularly around La Nina periods. However, all points follow very similar overall patterns and linear trends over the full 20 year period. As for the MHL and NTC data, the linear fit was made to the time series for all of these grid cells between 1996 and 2013, to enable direct comparison.

The similarity in temporal characteristics is notable. There is very little discernible spatial variation over time. Of interest is that the best fit trends are higher than for the MHL gauges, although the standard error bands of all estimates overlap. The plots show very little spatial variation along the coast of NSW. The temporal change in sea level is broadly consistent with the globally calculated trend from AR5 of 3.2 mm/yr., although the period assessed here is slightly longer than that available for AR5.

Table 9 Linear Fit to Annual Mean Sea Levels at MHL Gauges from 1996-2013[1]

Gauge Location	Rate of Rise (mm/yr.)	Standard Error (mm/yr.)
151E, -37S	4.5	1.7
152E, -37S	4.4	1.5
153E, -37S	4.4	1.4
151E, -36S	4.3	1.8
152E, -36S	4.2	1.6
153E, -36S	4.3	1.4
151E, -35S	4.1	1.8
152E, -35S	4.1	1.5
153E, -35S	4.2	1.3
152E, -34S	4.2	1.4
153E, -34S	4.3	1.2

[1]These rates are unsuitable for long term projections of sea-level rise

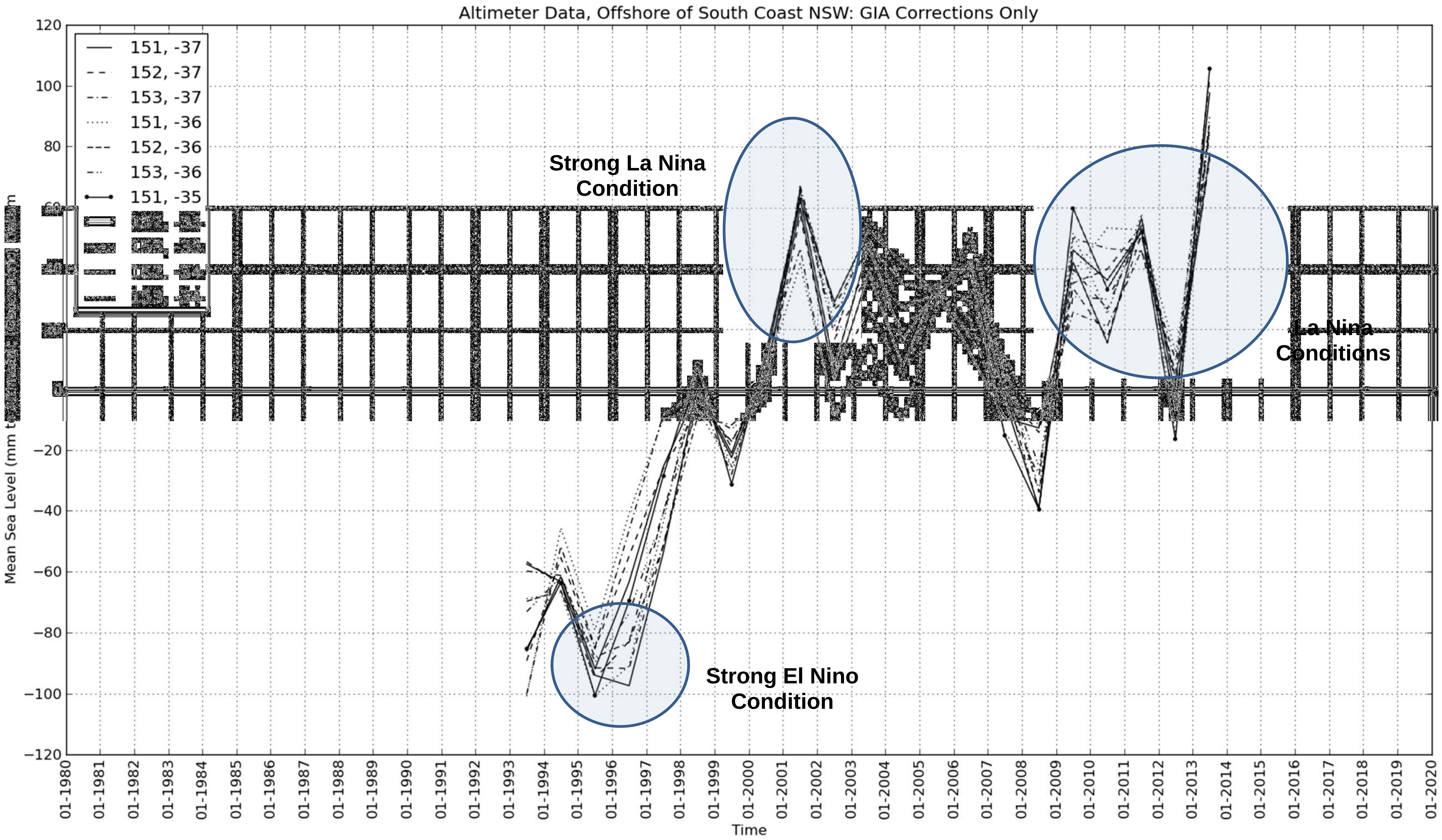

Figure 11 Annual Mean Sea Level Values from Altimeter Grid Points offshore of the NSW Coast

3.5.5 Comparison of Recent Sea Level Trends

The location of all data sources and the calculated linear trends between 1996 and 2013 are illustrated in Figure 12. The Altimeter data grid points are well seaward of the coast and in deep water. While there are small differences in the rates of sea-level rise between all locations, these are well within the bounds of error that might be expected given the short length of record. Different data sources will result in slight variations in the rates discerned.

It is logical to assume that long term deep water sea-level rise within the Study Area will be entirely consistent with that experienced in deep water at Sydney. A recent, independent study focussing on the Shoalhaven Area has reached the same conclusion (Couriel and Modra, 2013), and from this we now turn to the full Fort Denison gauge record to examine long term historical trends.

3.5.6 Long Term Historical Sea-level Rise at Fort Denison

The full record of annually averaged sea levels at Fort Denison is presented as Figure 13. In addition to this time series of annual values, a “filtered” time series, which smooths out the variations that correspond to oscillations less than around 15-20 years in length (e.g. El Nino related oscillations) is also shown. A coarse linear fit over the entire time series is also provided. That linear fit indicates an average sea-level rise trend of 0.7mm/yr. with a standard error of 0.07 mm/yr., and is consistent with previous analyses by others.

The descriptions presented in Hamon (1987), indicated that the Fort Denison data prior to 1914 are not as reliable as the later data. For that period, an alternative fit to the shorter period is also provided. That fit indicates a sea-level rise trend of 1.0 mm/yr., with a standard error of 0.09mm/yr.

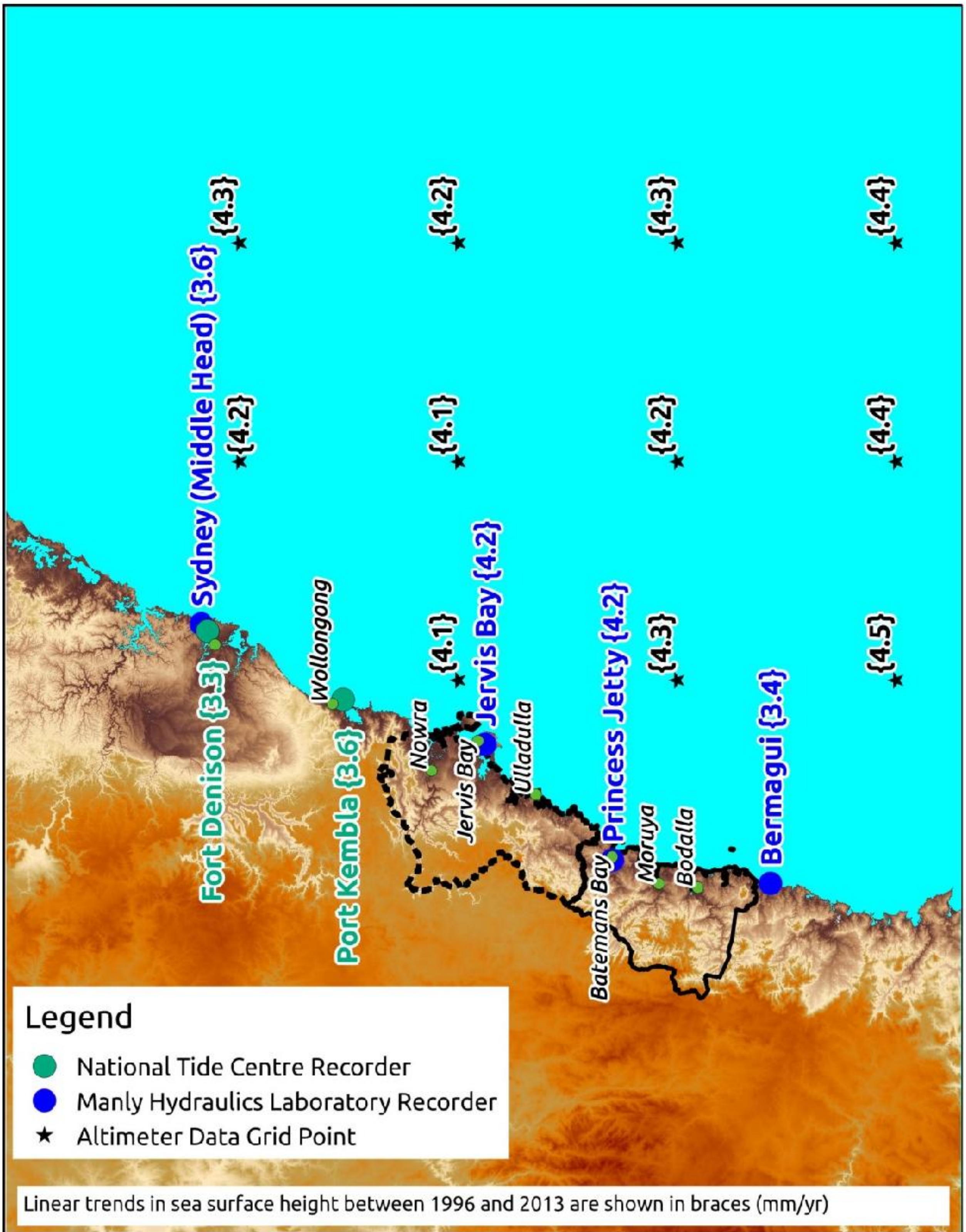

Figure 12:Data Locations and Short Term Linear Trends

South Coast Regional Sea Level Rise Planning and Policy Response Framework

Whitehead & Associates
Environmental Consultants

0 25 50 75 100 km
(Approx Scale)

Revision	A
Drawn	DJW
Approved	DJW

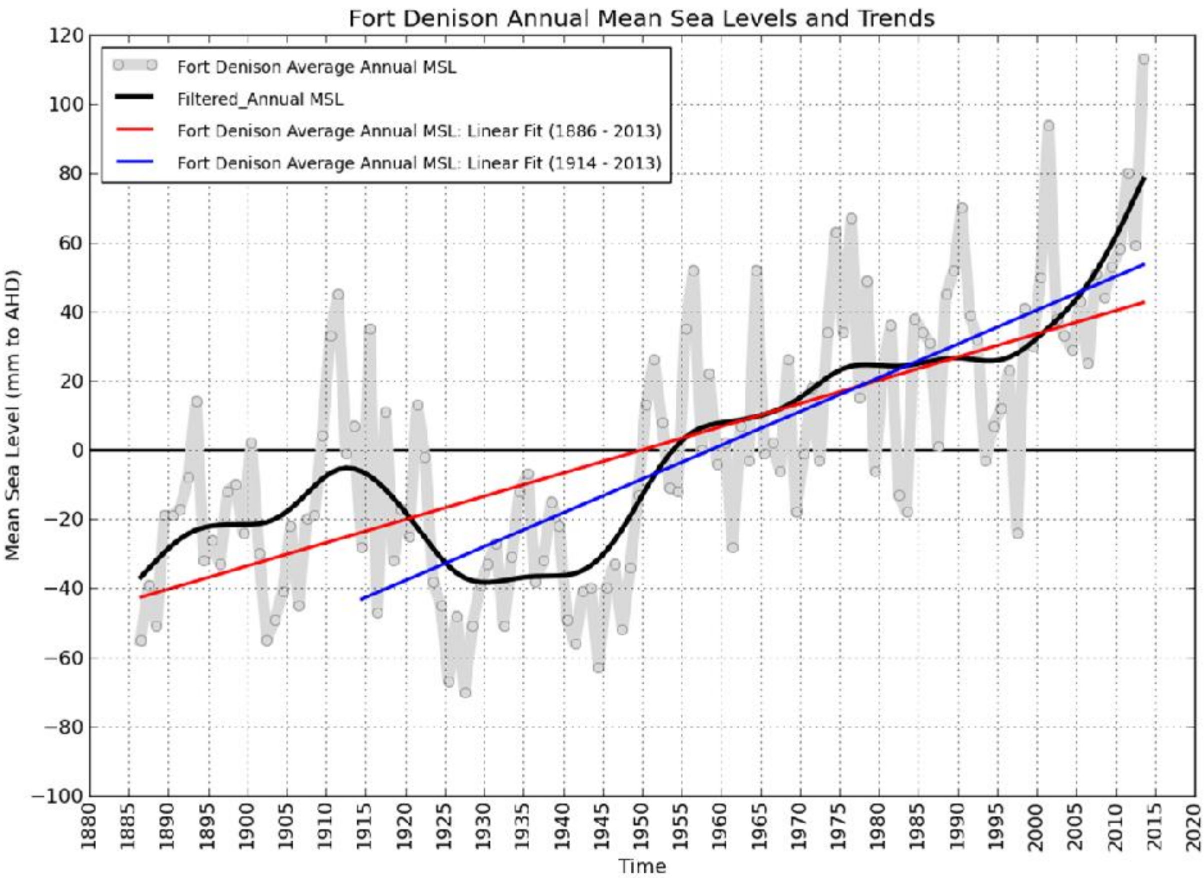

Figure 13 Fort Denison Annual Average Water Levels, Smoothed (filtered) trend and linear trends

Clearly, simply having a long time series (say > 60 – 75) is not in itself enough to guarantee robust estimates of sea-level rise from a single gauge. Closer examination of the record is called for. Comparison of the "filtered" time series and the linear fit indicates that the processes affecting mean sea level at Fort Denison are not particularly well captured by a simple, constant rise. One feature of particular note is the dip in mean sea level after 1910 and the subsequent rise following 1940.

One partial explanation for processes which appear to correlate to these longer term variations is the Interdecadal Pacific Oscillation (Modra and Hesse, 2011). The Interdecadal Pacific Oscillation (IPO) is a broad scale pattern of sea surface temperature and sea level pressure over both the North and South Pacific Ocean. A Positive IPO indicates that tropical sea surface temperatures are above normal and trade winds are weakened. When the IPO is negative, tropical sea surface temperatures are below normal and trade winds are intensified. The IPO has been linked to variations in broad scale weather patterns in Australia (Power et al., 1999), as well as coastal storminess on the Australian East Coast (Callaghan and Helman, 2008). By considering the effects of the IPO and different lengths of record, significantly greater or lesser rates of rise can be calculated.

The different ways and different values obtained from fitting linear trends to a clearly complex variation in mean sea level with time highlights the pitfalls of these analyses. And this is without even trying to fit a second order trend with "*acceleration*" (or deceleration) to the time series.

There is a notable upturn, following 1995, in the filtered signal shown in Figure 13. While this appears similar in nature to the sharp rise experienced at Fort Denison between 1940 and 1955, closer examination indicates:

- Thus far, the rise has been sustained for a longer period than in the 1940's and 1950's; and
- The amount of the apparent rise is now larger than that experienced during the 1940's and 1950's.
- Notably, the present rise was not preceded by a significant dip in the way that the rise of the 1940's and 1950's was. If patterns in mean sea level at Fort Denison are shown to relate to the same physical processes that govern the IPO, this would point towards a breakdown or masking of that correlation, by an accelerating global sea-level rise

This is of significant concern. Whether the increase in sea-level rise slows as it has in previous decades remains to be seen. There is not enough information here to be certain about the nature of the present rise in sea level. Monitoring over the next 5 years of data from Fort Denison and other data sets as appropriate will be crucial to determining whether this event is significantly anomalous and indicative of an accelerating rate of sea-level rise. At the present time, a cautious approach to planning is warranted until the nature of the latest rise is well understood.

Due to the length of record, Fort Denison is recommended as the most appropriate gauge on which to report changes to mean sea levels as they arise. The first step is to undertake robust filtering to remove the sub decadal oscillations, as presented in Figure 13. The resulting signal is a reasonable representation of mean sea level over time, and the final value (at 2013) is a good approximation of the present mean sea level.

It can be argued that processing in this way, without removing longer term effects such as those which are apparently related to the IPO, is inappropriate and not an accurate representation of mean sea level. However, it is important to consider the reasons for analysing and reporting the mean sea level.

Section 5 of this report regularly mentions updating the affected public on mean sea levels as they change in future. The fear with not removing effects such as the IPO is that we may "overshoot" in our estimation of present mean sea-level rise. In other words, we may reach a situation where the mean sea level calculated one year is lower than that calculated for the year before. However, examination of Figure 13 shows that the filtered time series does not indicate any significant period of a falling mean sea level since 1930 at Fort Denison, a period of over 80 years. It appears unlikely that this will change in the near future and it is expected that sea-level rise will, eventually if it hasn't already, dominate natural variability.

In summary, the calculation of up to date mean sea level and provision of that information to affected landholders, particularly those where exposure to coastal hazards is likely in the near future, is seen as an important way to make sure the public remain aware of the level of risk as it increases in future. The mean sea level information can also be used as a warning in the case of trigger based planning responses.

We consider it inappropriate, and do not envisage that any such reporting will be used for projecting sea-level rise into the future. Instead, the information could be used as supplementary information when Council updates long term projections. This would typically occur once every six years or so, normally when the IPCC releases a new assessment report.

3.5.7 Conclusions

The main points to note from this figure and the preceding discussion are:

- There are errors associated with the estimation of sea-level rise when using short time periods. However the short term trend from numerous data sources is a clear rise of between 3.2 and 4.5 mm/year over the past 20 or so years along the coastline of the Study Area and at Sydney. Due to the effects of natural variability over the period considered, the relationship of these rates to an underlying and ongoing sea-level rise cannot yet be clearly discerned;
- There is no consistent pattern of spatial regional variation between Sydney and the Study Area, particularly from the coastal tide gauges. This contrasts with the findings of the NSW Chief Scientist and Engineer (2012) which suggested that variations might occur in the rate of sea-level rise along the NSW Coast. It can be concluded that this assumption is not correct for the Study Area, or between the Study Area and Sydney;
- The values calculated are broadly consistent, but tend to be slightly higher than, the global average value calculated over a similar period in AR5 (3.2mm/yr.). The findings are also consistent with a recently published study by White et al. (2014)
- This indicates that future long term sea-level rise in the study area will not vary significantly from the global value; and
- From time to time, the future mean sea level in the study areas will vary from the global average, but this will be caused by oscillations of natural climate variability (e.g. due to ENSO and IPO).

In future, sea-level rise within the study area can be adequately assessed by examining behaviour at the Fort Denison gauge and adopting this gauge as a proxy. While Port Kembla may be equally suitable, Fort Denison has the advantage of a much longer record for teasing out longer term variability. The usefulness of other records will increase as the length and quality of the data improves with time.

4 Guidance for Choosing a Regional Sea-level rise Projection

4.1 Key Points

- **AR5 provides four "global mean" sea level rise projections, based on the effect of greenhouse gas emissions in the future.**
- **Of these scenarios, RCP2.6 (the lowest) is notably less plausible than the others;**
- **If a given projection is realised, there is still uncertainty relating to an incomplete understanding of the physical processes.**
- **Because of this uncertainty, each projection can be represented by 3 separate lines:**
  - **a "low" line which has around 85% chance of being exceeded;**
  - **a median line (50/50); and**
  - **a "high" line which has around 15% chance of being exceeded.**
- **The "high" line could still be exceeded if a given projection is realised.**
- **Adoption of the "high" line is considered to be suitably conservative for most purposes.**
- **For certain critical infrastructure, even larger projected values could be considered.**
- **The difference between all four projections over the next 15 years (to 2030) is insignificant and by 2050 is less than 3cm**
- **Projected differences become significant in the last two decades of the present century.**
- **Risk examination indicates the consequences of selecting a "too low" projection are more significant than selecting a "too high" projection**
- **Legal and planning information promotes a cautious approach when planning for sea level rise**
- **In Australia and overseas, the historical tendency has been to select projections that are close to the higher projections modelled by the IPCC, with even higher values being tested in some jurisdictions for extreme scenario analysis**
- **The maximum amount of sea-level rise that could physically occur offshore of the study area by 2100 is likely between 2.0 and 2.5m. These values seem extremely unlikely at present.**
- **There is still significant uncertainty as we look beyond 2050, and we advise a cautious approach in application of projections this far into the future.**
- **We recommend that RCP8.5 be adopted as a basis for decision making**
- **More recent research indicates that higher sea level rises are plausible. That research has not yet been through the rigorous IPCC review process. The evolving understanding needs to be monitored by the Partner Councils.**

4.2 Locally Relevant Projections

The four available projections for global sea-level rise (IPCC AR5) are presented in Table 3. Application of the regional effects outlined in Section 3.4 results in locally relevant versions of these projections, as presented in Table 10.

Table 10 Locally Adjusted Projections of Sea-level rise for Shoalhaven and Eurobodalla[1]

Year	RCP2.6			RCP4.5			RCP6.0			RCP8.5		
	Low	Middle	High	Low	Middle	High	Low	Middle	High	Low	Middle	High
2015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2020	0.02	0.02	0.03	0.02	0.02	0.03	0.02	0.02	0.03	0.02	0.02	0.03
2030	0.05	0.07	0.10	0.05	0.07	0.10	0.05	0.06	0.10	0.06	0.07	0.10
2040	0.10	0.12	0.16	0.09	0.12	0.16	0.08	0.12	0.15	0.11	0.14	0.17
2050	0.13	0.17	0.23	0.14	0.18	0.24	0.13	0.17	0.23	0.16	0.20	0.26
2060	0.15	0.21	0.30	0.18	0.24	0.32	0.16	0.22	0.30	0.21	0.29	0.37
2070	0.18	0.27	0.37	0.22	0.31	0.41	0.21	0.29	0.39	0.29	0.39	0.50
2080	0.21	0.31	0.44	0.25	0.38	0.51	0.25	0.36	0.50	0.35	0.49	0.64
2090	0.23	0.36	0.51	0.30	0.44	0.60	0.31	0.44	0.61	0.44	0.61	0.79
2100	0.25	0.41	0.58	0.34	0.50	0.69	0.36	0.53	0.72	0.53	0.74	0.98

[1]Derived by adjusting the Global Projections from Table 3 for regional effects from 2015

Before making a decision, it is important to consider how much variation there is between different projections at different points in time. The 'High' line from all four projections is presented in Figure 14.

Three relevant time frames are considered:

- 2030: There is no difference in the four local projections to 2030 (all show a rise of 10cm since 2015 for the "High" line), so the projection adopted becomes irrelevant when considering that time frame;
- 2050: Again, the difference is minor with a variation of 3cm in total between all four projections (23cm for RCP2.5 and 26cm for RCP8.5, considering the "High" line); and
- 2050 – 2100: Increasingly, there is a greater spread of the projections, with the RCP8.5 and RCP2.6 lines diverging from the two middle projections, particularly after 2080.

Therefore, the projection chosen will only impact significantly on planning decisions that consider time periods longer than 35 years post 2015. Even after 2050, the increased spread in projections is small year by year, but accumulates to make the difference between projections quite large by 2100.

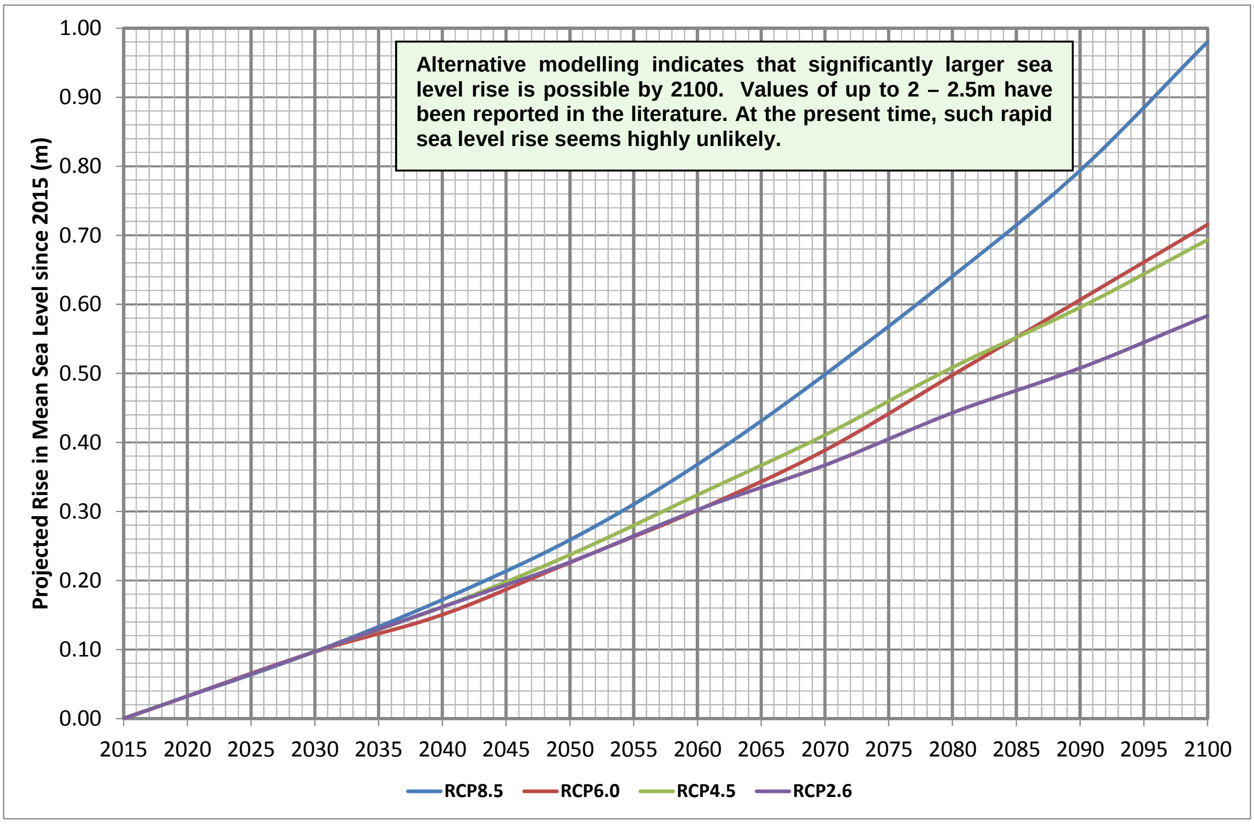

Figure 14 Comparison of "High" Lines for AR5 Projections, Adjusted for Local Conditions

AR5 only notes that all four projections are "*plausible*" and does not associate any likelihood with each. In making a decision about the appropriate future to adopt, it is worthwhile to understand the assumptions behind all four projections.

The following characterisations are based on summaries that can be found in Jubb et al. (2013) and Wayne (2013):

- **RCP2.6**: Very low greenhouse concentration levels. Emissions peak during the 2000's and reduce. Atmospheric $C0_2$ concentrations peak at 2050 and then modestly decline. Removal of $C0_2$ from the atmosphere using carbon capture and storage occurs. Greenhouse gas emissions reduce substantially over time. Drastic policy intervention would be required with greenhouse gas emissions being reduced almost immediately. Expected global population is around 8 billion and declining at 2100. RCP2.6 is more ambitions than any of the scenarios examined historically (i.e. previous IPCC reports). Requires early participation from all major emitters including developing countries;
- **RCP4.5**: Emissions (and radiative forcing) are stabilised shortly after 2100. Expected global population of above 8 billion and slightly declining at 2100. Most similar to SRESB1, which was the lowest emissions scenario used in previous IPCC assessments;
- **RCP6.0**: Emissions (and radiative forcing) are stabilised shortly after 2100 by the application of a range of technologies and strategies for reducing greenhouse gas emissions. Expected global population of over 9 billion and holding stable at 2100. Most similar to SRESB2 used in previous IPCC assessments; and
- **RCP8.5**: Characterised by increasing greenhouse gas emissions over time, leading to high concentration levels and a failure to curb warming by 2100. More or less unabated

emissions. This is representative of the "high range" of scenarios that assume no effective policy is adopted to stabilise or reduce global emissions by 2100. Expected global population of around 12 billion at 2100. Most similar to SRESA1FI used in previous IPCC assessments. A1FI was also the emissions scenario underpinning the previous NSW State Government policy on sea-level rise.

All of the RCPs include an assumption that air pollution control becomes more stringent over time. However, assumptions relating to air pollution control and climate policy vary across time and between global regions. All scenarios incorporate an increase in the use of non-fossil fuels (renewables) over time.

Based on the above characteristics we note that RCP8.5 involves a more or less "business as usual" approach to the future, resulting in an accelerating rate of sea-level rise. The two moderate scenarios (RCP4.5 and RCP6.0) represent quite different scenarios, but both require substantial efforts to reduce emissions and ultimately result in similar projections for sea-level rise through to 2100.

RCP 2.6 is very ambitious and appears to be an outlier, tracking below scenarios that have been considered for climate impact assessment before. It requires almost immediate and drastic cuts to emissions and assumes active removal of carbon from the atmosphere in the near future. Given the present underlying rate of economic growth with the rise of China, India and other emerging economies, and the ongoing accelerating rise of carbon dioxide in the atmosphere (refer Section 3.2.2), RCP 2.6 may be "*plausible*" but it is not considered a justifiable basis for projecting future sea-level rise for coastal planning.

4.3 Risk Assessment Outcomes

4.3.1 Introduction

The standard risk assessment process is outlined in Figure 2. The present study is constrained in undertaking a full analysis and subsequent evaluation of the risks, the main reason being that we cannot reasonably assign "likelihood" to any future emissions scenario that the world might follow. Accordingly, while we can examine the consequences of adopting a projection which turns out to be too high or too low, we cannot properly assign a risk level which involves prior assessment of both consequences and likelihood.

The risk assessment "context" is outlined in detail in Section 2, including the physical, statutory and planning environments, along with the objectives and scope of the present study. In this section, the identification of risks and assessment of consequences is detailed for further consideration.

4.3.2 Risk Identification

During the *Risk Preliminaries Workshops,* risks were identified in a formalised manner using the following word formula:

> **There is a risk that a *<u>cause</u>* will lead to an *<u>event (or chain of events)</u>* resulting in an *<u>outcome</u>* with a *<u>set of consequences/impact</u>***

The four components of the risk (cause, event, outcome, consequences) were identified and tabulated. The "causes" for the purpose of our study typically comprise a combination of policy decisions (over which we presently have some control) and a future sea-level rise (over which there is significant uncertainty and we presently have limited control). As the risk identification was undertaken at two separate workshops (both Shoalhaven and Eurobodalla) and participants were separated into groups, the full list of risks obtained from workshops has subsequently been rationalised to eliminate duplicates. The outcome of the process is presented as Appendix A1 to this report, with potential controls identified to deal with each individual risk. A total of 32 separate risks were identified by the participants.

These risks were taken to the *Planning Policy* workshop at which a consequences examination was undertaken. However to make this activity achievable within a single day's workshop, the risks were further rationalised into 11 groups, with cross referencing provided between the 32 separate risks and their risk groupings as detailed in Appendix A2.

Among the 11 groups, three overarching causes of risk were identified:

1. Risks associated with adopting a sea-level rise projection that is too high (3 rationalised groups);
2. Risks associated with adopting a sea-level rise projection that is too low (4 rationalised groups); and
3. Risks associated with poor implementation of a sea-level rise policy following adoption of a projection (4 rationalised groups)

The risks associated with poor implementation have been taken into consideration when developing the guiding principles for the policy and planning response presented in Section 5. Examination of the risks associated with adopting projections that are too high or too low are, of particular interest in making decisions about which projection to adopt.

4.3.3 Examination of Consequences

At the *Planning Policy* workshop, a presentation relating to each of the case study sites for the present study (Currarong, Calalla Beach, Lake Conjola and Mollymook for Shoalhaven Council; Surfside, Batemans Bay and Mossy Point/ Tomakin for Eurobodalla) was given to facilitate risk assessment. The presentation included background information from studies on past geomorphological behaviour, present zoning, presence of infrastructure and ground elevations. A summary of the information is included in Appendix B. Mapping in GIS was also provided to give an indication of the overall susceptibility of each location to sea-level rise and a qualitative assessment of future behaviour in response to sea-level rise was provided by study team members.

Attendees were presented with coarse assessments of erosion and inundation that would result from sea level rise up to and including 1.0m (i.e. close to the 2100 value for RCP8.5) and to assess the consequences of sea-level rise, at each case study site, with respect to the risk groupings provided in Appendix B2. As a guide, the consequences assessment table at the end of Appendix B2 was provided to attendees. That table identifies consequences on a five point qualitative scale (insignificant, minor, moderate, major, catastrophic). The number of responses indicating each point on the qualitative scale is summarised in Appendix B2, and a summary of those findings is presented in Table 11.

Table 11 Outcomes of Workshopped Consequences Assessment
(4 sites in Shoalhaven, 3 sites in Eurobodalla)

	Proportion of Responses: Shoalhaven Sites				
Consequence Rating → / Risk Type↓	Insignificant	Minor	Moderate	Major	Catastrophic
Projection Too High	6.1%	38.3%	43.9%	10.2%	1.5%
Projection Too Low	1.1%	3.1%	16.8%	63.9%	15.1%
Poor Implementation	0.6%	8.7%	37.3%	43.2%	10.2%

	Proportion of Responses: Eurobodalla Sites				
Consequence Rating → / Risk Type↓	Insignificant	Minor	Moderate	Major	Catastrophic
Projection Too High	13.5%	29.4%	29.4%	27.8%	0.0%
Projection Too Low	4.8%	13.7%	13.7%	50.0%	17.9%
Poor Implementation	23.6%	19.8%	19.8%	35.4%	1.4%

In interpreting this information, it is important to understand the composition of attendees at the workshops. Each workshop had between 10 and 15 attendees, with representatives from both Project Partners (including staff from planning, engineering, asset management, natural resource management and risk management), OEH and the Department of Planning. All attendees were professionals with some background experience in dealing with the issue of sea-level rise.

From the information presented in Table 11, it can be seen that both workshops considered that adopting a projection that was too high could result in Minor-Moderate consequences, and Poor Implementation could result in Moderate-Major consequences. The Eurobodalla workshop results tended towards more severe consequences overall and this is partly due to the inclusion of Batemans Bay, a major regional hub, as one of the case study sites. The issue of a too low projection is notable as both LGA's indicated a clear tendency (i.e. > 50%) towards selecting the major consequences option if too low a projection is adopted.

Overall, the workshop attendees and risk assessment have indicated a greater concern about the consequences of adopting a projection that is too low, than adopting a projection that is too high between the present and 2100.

4.4 Legal/Planning Considerations

The legal advice, legislation and state planning framework summarised in Section 2 leads to the following conclusions:

- A number of the legal advices indicate that, if a council does not adopt their own sea-level rise projections, adoption of the previous benchmark values seems a safe and defensible legal option;
- The present NSW coastal policy espouses the *principle of intergenerational equity*, namely that the natural and cultural character of the coast should be maintained for future generations, while continuing to provide suitable development and use opportunities for the present generation. This implies that the coast should be allowed to adapt in as natural a way as is feasible in response to sea-level rise*;*
- The NSW Coastal Policy also espouses a "*risk-averse*", but not a *"no-development"* approach, to decisions regarding land use planning and the siting of development
- Planning guidelines point towards a desire to avoid the intensification of land use in coastal areas and to minimise the exposure of development to coastal risks;
- The present NSW guidelines for coastal zone management plans indicate that a *"risk management hierarchy"* be adopted where risks are avoided where feasible, and mitigated if they cannot be avoided;
- The present NSW guidelines for coastal zone management plans indicate that councils should consider adopting projections widely accepted by competent scientific opinion;

Overall, the planning guidelines and legal advice encourage a cautious approach to planning for sea-level rise that is best achieved through the selection of a higher sea-level rise projection.

4.5 Other Considerations

Many local councils in New South Wales are continuing with the previous NSW Government sea-level rise benchmark values, awaiting further advice from the state government. This is unsurprising, as the assessment by the NSW Chief Scientist and Engineer stated that the scientific basis for those benchmark values was *"adequate"*. The primary concerns of the Chief Scientist were that:

- There were regional variations that needed to be taken into account. This study has found that regional variations in offshore mean sea level are not significant between different locations along the southern coast of NSW and Sydney; and
- That the full range of uncertainty was not being properly accounted for. This can be largely addressed by acknowledging that uncertainty and planning accordingly, either through detailed site specific risk based assessments and/or by adopting adaptive management strategies.

The Chief Scientist and Engineer investigated the projections that were being adopted both internationally and locally in Australia (NSW Chief Scientist and Engineer, 2012). At that time, there were a range of scenarios adopted internationally, including scenarios that were both lower and higher than the values typically adopted in Australia. Most jurisdictions included at least one projection that was significantly larger than those being adopted in Australia. This enables risk assessment with the consideration of extreme sea-level rise. In all other Australian states at that time, it was most common to adopt a sea-level rise of between 0.8 and 1.0m by 2100. In Australia, which is relatively stable geologically, this corresponded to adoption of the A1FI scenario with allowances for accelerated ice melt.

In Section 3.3, it was highlighted that recent (post AR5) research indicates that many sea-level rise scientists consider that the likely ranges of sea-level rise predicted by modelling presented by the IPCC may be on the low side (Horton et al., 2014). This aligns with some of the "semi-empirical modelling undertaken following the IPCC's fourth assessment report (Pfeffer et al., 2008; Rahmstorf, 2007; Sriver et al., 2012). While AR5 has concluded that there is low confidence in those models, there is a possibility that sea levels will rise higher and faster than projected within the IPCC AR5 report, due to uncertainties relating to the timing of changes to the West Antarctic Ice Sheet.

4.6 Recommended Sea-level rise Projection and Justification

In summary, the preceding four sections indicate:

- That RCP2.6 is not as plausible as the other projections and should not be used for coastal management and planning at this time (Section 4.2);
- That outputs from workshops involving professional staff from Shoalhaven and Eurobodalla Councils, OEH and the Department of Planning indicate that the future adverse consequences of adopting a sea-level rise projection that is too low are more severe than through adopting a projection that is too high. It must be cautioned that there are still potential negative consequences from adopting a projection that is too high (Section 4.3);
- That the planning guidelines and legal advices encourage a cautious approach that promotes the selection of a higher sea-level rise projection as appropriate (Section 4.4);
- That scientific analyses following release of the IPCC's AR5 indicated that many scientists with expertise in studying sea-level rise consider a rate and magnitude of sea-level rise which is significantly greater than that predicted by the modelling underpinning the IPCC projections is possible (Section 4.5);
- That there was a tendency around Australia, and Internationally, following the release of the IPCC's AR4 in 2007, to adopt projections based on the fossil fuel intensive scenario (A1FI) for planning purposes. That scenario is most similar to RCP8.5 in the most recent IPCC assessment (AR5) (Section 4.5). There are no widely supported arguments for a change from this approach.

For the reasons outlined in this chapter and summarised in the above dot points, we recommend at this time that RCP8.5 is a suitable basis for a sea-level rise projection. In the absence of detailed, rigorous and justifiable site specific risk assessments which use all three lines presented by that projection, the "High" projection line (with ~ 15% probability of exceedance) should be adopted for coastal management and planning at present. Having said that, we note the projections do not diverge significantly before 2050. Accordingly, the impact on *Current* and *Medium Term* coastal hazard planning (see Section 5.5.1. for discussion) will not be affected by selecting a different IPCC projection than RCP8.5. The choice of projection has more impact on existing and proposed developments over the long term. However the choice of a higher projection over the long term has been offset by a more flexible planning response (adaptable designs, trigger constrained consents etc.). These issues are detailed in Chapter 5.

Regardless, the opportunity remains to continuously examine changes in sea level, by analysing data from the existing tide gauge network, and reacting appropriately to any deviations from the selected projection as sea-level rises. A suitable analysis and reporting regime needs to be established. It is important to put the mechanisms in place now that will ensure regular review and updating of both contemporary mean sea level and future sea-level rise projections, as required, in the future.

Finally, a comparison is provided here between the adjusted RCP8.5 scenario and the "benchmark" values from the previous State government sea-level rise policy. The previous State Government policy values were provided relative to 1990. For this study, these values have been adjusted to the present by subtracting 50mm which is approximately equal to the apparent rise in mean sea level at Fort Denison, as shown by the "filtered" time series on Figure 13. We note that recent global average mean rise reported in AR5 (~3.2 mm/yr.) would imply an additional rise of around 30mm for the 25 year period since 1990. For the purposes of comparison, our adjustments will suffice. At present, we estimate that the mean sea level offshore of the Study Area is around 80 mm above Australian Height Datum.

Table 12 Comparison of Recommended Projection against Previous Policy Values

Time	Local Sea-level Rise Projection Based on RCP 8.5 (in (metres)[3]			Previous State Policy (approx.)[3]
	Low[2]	Medium[2]	High[2]	
2015	0.00	0.00	0.00	0.0[1]
2030	0.06	0.07	0.10	
2050	0.16	0.20	0.26	0.35[1]
2070	0.29	0.39	0.50	
2100	0.53	0.74	0.98	0.85[1]

[1]Values adjusted by subtracting 50mm to account for apparent rise at Fort Denison between 1990 and the beginning of 2014.

[2]In the absence of detailed, rigorous and justifiable site specific risk assessment which uses all three sets of values, the "High" projection values (with ~ 15% probability of exceedance) are recommended for coastal management and planning, providing that ongoing review of available science and water level data is undertaken to enable adaptation of the approach in future.

[3]To obtain the absolute projected mean sea level elevation relative to AHD, a further 0.08 metres would need to be added to these values.

5 Planning and Policy Response Framework

5.1 Key Points

- **Attention to careful implementation of the policy will be key to its success**
- **Six guiding principles for the policy and planning framework were identified, these being: Integrity, Responsibility(Custodianship), Flexibility, Consistency, Communication and Transparency, and Avoiding Complexity**
- **We recommend adoption of four coastal hazard planning areas (CHPA's)**
- **"Current Hazard" CHPA's that would be affected by coastal processes and flooding over a 0 to 15 year time frame**
- **"Medium Term Projected Hazard" CHPA's that would be affected within 15 to 35 years (this generation)**
- **"Strategic Projected" CHPA's that would be affected within 35 to 100 years (multigenerational)**
- **"Possible Maximum Strategic" CHPA's that would be affected by very high estimates of sea level rise by 2100.**
- **The CHPA's will be adjusted over time as new information and projections become available**
- **Areas already zoned for development should be treated differently from areas where rezoning to allow development is proposed.**
- **A more risk averse approach should be applied to new areas of development.**
- **Where development has already occurred, land should be utilised for as long as is feasible, but occupants should be regularly updated on the present state of the mean sea level and the level of hazard to which they may be imminently exposed.**

5.2 Introduction

The Sea-level rise Policy and Planning Framework was prepared following the high level risk identification and evaluation undertaken during the workshops held as part of the present study:

- At the *Risk Preliminaries Workshop* the objectives, scope and environment of relevance to the framework were defined. The outcomes of this process are encapsulated in our summary of "*Guiding Principles*" in Section 5.4;
- The *Guiding Principles* in Section 5.4 are provided as a skeleton from which we recommend the Study Partners should develop policy statements. Draft principles were presented at the *Planning Policy Workshop* and modified following feedback;
- On the basis of these principles and the risk evaluation process, we have identified a series of preferred options for risk treatment. A set of draft options were presented to the *Planning Policy Workshop*. At that workshop, the options were tested for performance against the case study sites investigated as part of this study. The case study sites and the outcome of that process are described in Appendix B.

- The preferred options were modified following feedback and used to develop the planning tables presented within this report chapter and in Appendix C.

The framework has also drawn upon background information from the preceding chapters. Importantly, this framework is not reliant upon any particular future sea-level rise projection being adopted. It is acknowledged that sea levels will rise over time and the forward projections of mean sea level will need to be adjusted regularly to accommodate those changes and prepare for the future.

For the framework to operate, regular analysis of mean sea level is required. Capacity to undertake this role presently exists within both the Federal Government (BoM's National Tide Centre) and the NSW state government (Manly Hydraulics Laboratory). Both of these organisations routinely collect tidal data from gauges in New South Wales. Ideally, one of these will undertake this ongoing role to provide some consistency in approach and prevent the need for the Project Partners to independently derive their own analyses of mean sea level as it rises. If this does not occur, the Project Partners could arrange for the task to be undertaken through private consultancy or by a suitably detailed review of new information published by the IPCC or CSIRO. However, it seems most appropriate that the Project Partners encourage one of these government facilities to take up this role.

5.3 Application of Sea-level rise Projections

The projections available at the time of writing were derived from the IPCC's AR5, modified as appropriate to represent expected local conditions and recalibrated to represent expected rise from 2015. These projections will need to be updated as new scientific information becomes available. Over the past 25 years, it has been customary to update the sea-level rise projections each time the IPCC releases a new assessment report, generally on a 6 yearly basis, and Council should ensure that such regular review continues.

From AR5, each of the provided projections is characterised by three separate projection lines:

- A "High" line which, if the underlying future emissions scenario is realised, is considered to have around a 15% chance of being exceeded;
- A "Middle" line which, if the underlying future emissions scenario is realised, is considered to have around a 50% chance of being exceeded; and
- A "Low" line which, if the underlying future emissions are realised, is considered to have around an 85% chance of being exceeded.

Out of these three, the line (or lines) adopted to determine the extents of physical hazards (flooding, erosion, inundation and the like) will ultimately be based on risk assessment or guidelines that may be issued by the State Government. We consider it reasonable to base decisions on a formal risk assessment which utilises all three lines to assess hazard likelihoods and consequences. Methods are emerging which will eventually allow for such an assessment (Woodroffe et al. 2012, Horton et al. 2013, Hunter et al, 2013, Preston et al. 2014) but these have not yet been implemented widely in New South Wales. Guidance regarding a preferred formal quantitative risk assessment approach has not been provided by the State Government. The option to use such methods is appropriate if it can be demonstrated that such methods will result in robust and suitably cautious planning outcomes although we note that such assessments are relatively complex and costly at the present time.

Two activities which rely heavily on hazard information are planning and engineering design. Best practice involves a cautious approach. For example, when designing a jetty, breakwater or other structure along the coast or inside estuaries, engineers will design so that the structure has only a small chance of failure over its design life. It would be irresponsible for an engineer to design a structure, for example, which has a 50% chance of failing during its design life, where the consequences are significant in cost or safety.

A similar argument can be adopted for strategic planning. It is irresponsible to enable development to be placed in an area where it is likely to be threatened during the course of its life and the impacts are significant. Accordingly, even if a full formal risk assessment is undertaken, a risk averse approach is recommended to minimise the chance that costly problems are caused for future generations. In the absence of a suitably detailed risk assessment and/or joint probability analysis, it is recommended that the “High” line for the selected projection be used to design for future conditions as a suitable level of caution.

Even so, uncertainty remains and the sea-level rise indicated by the “High” line (and the emissions scenario on which it is based) could be exceeded in future. Therefore, adaptability to accommodate future sea-level rise should be a core concern of strategic planning, development and structural design within the coastal zone. If these activities can proceed in a way that demonstrates capacity to easily adapt in future, initial implementation need not accommodate the full amount of projected sea-level rise over its design/expected lifetime. Temporary use of areas that will be at unacceptable risk in future may be permitted. In this way, a “wait-and-see” approach can be taken, whereby adaptation will occur once a suitable trigger point is reached. With time, the future hazard will become more obvious to communities, but it is important that the anticipated planning outcome is identified now. Regular analysis of mean sea level, as discussed above, is a key way in which occurrence of these trigger points will be identified.

The sea level projection information will need to be adjusted when deriving model boundary conditions for those detailed studies which define existing hazards and extrapolate future hazards in the coastal zone. For example:

- Coastal Hazard Studies: Depending on the analysis required, the projected sea level needs to be modified to incorporate climatic variability, storm surge, wave set-up, wave run-up and astronomical tide components. Industry standards exist to undertake such modifications, and a suitably qualified coastal engineering or science practitioner should be consulted;
- Flood Studies: Flood studies in the coastal zone typically adopt downstream tidal boundary conditions which include climatic variability, storm surge, astronomical tide and potentially wave set-up. As is standard practice, these components will need to be combined with the projected mean sea level used in flood studies.

Historically, sea-level rise has been incorporated in a way which ties a given amount of sea-level rise to a certain point in time. For example, common practice using the previous state government benchmarks would relate a 0.4m sea-level rise (relative to 1990) to the year 2050 and a 0.9m sea-level rise to the year 2100.

Within the framework presented here, we recognise uncertainty in the time frames at which a particular rise in sea level would be reached but accept that sea level will continue to rise at accelerating rates. The framework incorporates the flexibility to adapt if the rise experienced at a future time significantly exceeds or falls short of that originally planned for.

We consider that flood and coastal hazard studies should focus on determining the hazards associated with a number of future potential rises in sea level, so that up to date planning maps

/ hazard zones can be generated easily in accordance with the sea-level rise experienced, without commissioning a new study.

5.4 Guiding Principles

A. Integrity

Council recognises that sea levels, both globally and along the New South Wales coast, have been rising for more than a century, and that some research indicates that the rate of rise is accelerating.

The Intergovernmental Panel on Climate Change (IPCC), the leading international body for assessing climate change science, has stated that this sea-level rise is likely related to global warming caused by greenhouse gas emissions. Computer modelling adopted by the IPCC also indicates that the rate of rise is going to accelerate in the coming decades.

In the short term (the next decade or two), the predicted impacts are relatively small. However, we need to plan for development over longer time frames and consider the impact of any decisions made now on future generations.

It is unfair for us to ignore the prevailing views of science if they indicate our decisions, or lack of present action, will create substantial problems for future generations.

We recognise that the scientific understanding about the timing and quantity of sea-level rise is neither "settled" nor "certain". There are genuine sceptical voices in the scientific community, but our assessment is that these voices are presently in the minority.

Even so, it is important that we remain active in accessing and interpreting both global research and locally relevant data so that we can modify our regulations over time, as our understanding of the expected amount and impacts of sea level change improves.

B. Responsibility (Custodianship)

Council remains committed to responsibly managing the ongoing development and use of our coastline for both the present and future generations. At a local level, Council has minimal control over policies that will impact on atmospheric concentrations of greenhouse gases. However, we remain responsible for appropriately adapting to a climate which we acknowledge is changing.

In the face of considerable uncertainty regarding future sea levels, flood risk and coastal erosion and inundation, we consider it prudent to adopt a cautionary, risk-averse approach. Through this we hope to minimise any burden that may be carried forward to future generations. Even so, our approach needs to be balanced, and the livelihood and well-being of today's community is also of great importance.

In areas where development already exists, we are committed to allowing land owners continued use of their land for as long as they can, without adversely affecting the enjoyment of their neighbours, placing unnecessary strain on emergency services during floods and storms, or reducing the general public's right to access our beaches and coastline.

We hope to reduce the level of local uncertainty over time. One area of particular uncertainty is the way and rate at which beaches will respond to a rising sea level. We will continue to encourage the state government's efforts in monitoring our coastline. Where feasible, council will consider undertaking its own monitoring, utilising emerging technologies, to ensure that our policy remains workable. We will remain in contact with state government and bodies such as CSIRO, who collect and interpret information on the sea levels around Australia.

C. Flexibility

We expect that the planning levels and controls accompanying our policy, and potentially the policy itself, will require modification from time to time. This is essential as the future sea levels are uncertain and we will need to recognise that our level of certainty may change over time.

While we don't expect to regularly change the nature of the controls, we do expect that the areas over which they apply will vary as sea levels rise. For example, the zones within which we would allow critical community services may expand if improved science shows that the original upper levels of expected sea-level rise can be reduced.

Due to the present level of uncertainty, however, we deem it necessary to be cautious about the areas where we allow critical infrastructure. Similarly, as sea levels rise and/or the coastline recedes, the controls at a given coastal location are likely to become more stringent.

We have undertaken to formally review our policy at least once every six years, in line with the release of new information from the Intergovernmental Panel on Climate Change (IPCC). However, we are committed to ongoing examination of contemporary science and the emergence of credible, and dramatically different scientific information may also trigger a formal policy review.

D. Consistency

Council is committed to consistent application of our policy. Not only will this apply to maintaining fairness between private land owners, but also maintaining a consistent application between private and public land owners.

Inevitably, there will be differences in the way that the policy will be applied to different land uses (zonings), but any differences will be based on the net benefit to the whole community. Council will invest in staff training to ensure that there is a suitable and consistent understanding of the policy and the underpinning science.

E. Communication and Transparency

The community will be kept informed regarding Council's decision making relating to planning for sea-level rise. We will endeavour to include the community in the decision making process but will necessarily rely on the expert opinions of suitably qualified professionals that practice in this field when projecting sea-level rise.

We will involve the community in decisions relating to the application of that scientific information to effective and fair planning through regular, ongoing consultation.

It is not possible to make decisions that will please everyone. Council is constrained by both funding and legal requirements and these, combined with available scientific advice, will influence the decisions that are ultimately made. However, we undertake to clearly outline the reasons for our decisions at any given point in time and will make that information readily available to the community.

F. Avoiding Complexity

We will endeavour to make planning for sea-level rise as simple as possible. Perhaps the two simplest approaches are the adoption of very relaxed controls, or the adoption of very stringent controls. Both of these approaches have unacceptable consequences, and a balance needs to be struck.

In striking that balance and ensuring there is adequate flexibility, it is necessary to introduce some complexity, which is amplified through the uncertainty associated with processes of storms, tides and a changing sea level along our coast.

While there is some complexity associated with our proposed planning controls, we wish to make their application as clear as possible. Information outlining the application of our policy will be made readily available to the public.

5.5 Preferred Strategy for Risk Treatment

5.5.1 Coastal Hazard Planning Areas

The approach proposed will be governed by Coastal Hazard Planning Areas (CHPAs). These coastal planning areas will be determined by studies that model coastal processes and flooding to determine the extents of hazards. It is expected that the results from existing flood and coastal hazard studies will be broadly consistent with the requirements of this planning framework, although assessment should be undertaken on a case by case basis. There are four key physical hazards that will be impacted by sea-level rise and their extents are typically derived as follows:

- Coastal Erosion Hazard: This comprises the area affected by predicted coastal erosion and/or recession of the coastline, using the methods that are commonly applied in NSW for this purpose, along with an appropriate allowance for sea-level rise.
- Flooding Inundation Hazard: This comprises the area affected by the 1 in 100 year flood event from both catchment and ocean in accordance with the normal methods applied in NSW, along with an appropriate allowance for sea-level rise.
- Regular or Recurrent Inundation Hazard: This comprises the area inundated by normal astronomical tides more than three or four times a year using an appropriate allowance for sea-level rise.
- Groundwater Hazard: rising water tables in coastal aquifers will affect buried infrastructure, road pavements and other infrastructure. Eventually permanent water pooling in some low lying areas is likely. Dedicated studies of this hazard have not been undertaken historically in New South Wales, even though there are a number of locations where they could potentially be of great importance as sea-level rises.

We have specified four CHPAs for these hazards. The CHPAs will increase in geographical extent (i.e. move inland) as the considered sea-level rises. A broad description of each CHPA is outlined in Table 13. The extent of each CHPA would be determined from the results of hazard definition studies that obtain their outputs by either:

- Undertaking a rigorous, justifiable risk analysis that examines the likelihood and consequences associated with values from the “High”, “Middle” and “Low” projections for the future time period in question; or
- Adopting the corresponding “High” projection of sea-level rise for the future time period in question.

The subsequent coastal zone management plan will identify and discuss the planning options for these areas.

Table 13 Coastal Hazard Planning Areas and Appropriate Strategy

Coastal Hazard Planning Area[3]	Time Period	Lifespan Covered	Description	Recommended "High" Sea-level rise Projection[2]
Current Hazard <u>Response</u>: Imminent Actions	0 to 15 years	Current Community	Considering the projection adopted by Council, use mean sea level at Fort Denison projected 15 years from present with an additional allowance of 5cm[1] for normal variability when planning for hazards. Within this area, redevelopment is inappropriate without very strict controls, and up to date plans are required to effectively handle emergencies. Landholders must be advised by Council if their property exists within this area, along with the nature of the hazard (or hazards) that are deemed to affect their land, including extents. Notification to be provided on s149 certificates[4] following adoption of the relevant coastal zone or floodplain management plan.	0.1
Medium Term Projected Hazard <u>Response:</u> Plan, monitor and respond	15 to 35 years	Current Generation	Considering the projection adopted by Council, use mean sea level at Fort Denison projected 35 years from the present when determining hazards. Controls on redevelopment are required here. Landholders should be advised if they are within this area, and a broad estimate (5-10 year precision) of when Council's adopted projection would cause their land to fall within the "Current Hazard" Area. Notification to be provided on s149 certificates[4] following adoption of the relevant coastal zone or floodplain management plan. No rezoning to allow development of previously undeveloped areas should be allowed here.	0.26
Strategic Projected Hazard Planning <u>Response</u>: Plan and monitor	35 to 85 years	Multiple Future Generations	Considering the projection adopted by Council, use projected mean sea level at Fort Denison 85 years from present (initially set at 2100) when determining future hazards. Rezoning to enable development is allowed, but steps must be taken to ensure that any long-term land use is fully adaptable to future sea-level rise. Council may choose to inform existing land owners of the future potential for exposure to sea-level rise in this area. However, it is not considered necessary to inform these land owners of a time frame more specific than "*more than 35 years*".	0.98
Possible Maximum Strategic Hazard <u>Response</u>: Plan accordingly	85 + years	Impacts on future Generations Critical Infrastructure	This is for application in strategic sea-level rise planning, and is provided as an appropriate level for consideration when planning critical infrastructure. The value significantly exceeds the projection adopted by Council at 2100, and can be considered to represent the expected physical upper limit of global mean sea level rise by 2100, or the maximum IPCC modelled value of sea level rise, under RCP8.5, by 2200. It appears highly unlikely that this value would be reached by 2100. Refer to Section 3.2.5 for discussion.	2.0

[1]The allowance of 5cm is based on fluctuations of the year to year mean sea level values around the filtered trend line which can be inspected on Figure 13

[2]These values are a sea-level rise relative to the beginning of 2015. To convert to absolute projected mean sea level elevation relative to AHD, a further 0.08 metres would need to be added to these values. These values are initial values only and can be considered relevant for at least 5 years, in the absence any new and substantially different scientific discoveries regarding the physical processes affecting sea-level rise. This does not negate the need to keep residents within the "Current Hazard" area more regularly informed of the way in sea which mean level is evolving with time.

[3]The extent of coastal hazard planning areas will be determined through detailed studies carried out during the preparation of coastal zone and floodplain risk management plans.

[4]Notifications on s149 certificates will be subject to a review by Council following advice from the State Government.

5.5.2 Areas Presently Zoned for Development

The general approach within areas presently zoned for coastal development is to enable existing land owners to continue use of their land for as long as possible, without exposing them to undue health or safety risk. However, to enable this to occur, Council must be committed to regularly updating residents within these areas, so that the community is aware of the increasing risk as it evolves. This is of particular importance to residents of the "Current Hazard" area, who should be updated every year or two.

Within the Current Hazard area, location specific community consultation is highly recommended to encourage residents to think about adaptation. This consultation should broadly discuss what adaptation options might or might not be acceptable. For example, protective coastal structures that adversely affect adjacent properties are unlikely to be acceptable. In comparison, the Regular Inundation hazard, probably of most importance around estuaries, is a "creeping" hazard which does not have the immediate disaster like character of floods and coastal storms, and for which effective adaptation options may not exist.

Retreat will eventually become the only viable option at many locations. Consideration needs to be given to when habitation of hazard affected areas will no longer be possible. Planning for the possible removal of buildings and infrastructure, and a means for funding that removal should be undertaken for the "Current Hazard" area.

We note that the practicalities of planning for retreat make it very difficult to adopt a pro-active planned retreat policy. Changes to the governing NSW legislation to enable strong enforcement of a planned retreat policy will most likely be required before such a strategy becomes viable. Both Project Partners do not presently allow buildings to be constructed on vacant land in areas already exposed to coastal hazards. It is not expected that this will change.

5.5.3 Areas of Proposed Rezoning to allow Development

Rezoning to allow development should not occur within *Current Hazard* or *Medium Term Projected Hazard* areas. If rezoning is to occur within the *Strategic Projected Hazard Planning* area, covenants that require the development to be consistent with future adaptation, such as lightweight and/or relocatable buildings and the adaptation aware layout of subdivisions (e.g. shore normal service corridors that can be shortened as foreshore erosion progresses). Where possible, the land title and associated covenants should be formed such that no guarantee of future habitation or the right to protect the land from the effects of sea-level rise and an increase in the severity of coastal processes is implied.

Council may consider constraints related to the "*Possible Maximum Strategic Hazard*" area when considering rezoning.

5.5.4 Areas of Critical Community Utility

It is recognised that certain localities are of particular importance to the economy and functioning of the broader community. In this instance, such areas of importance relate to areas where facilities that exist are commonly used by community members that do not reside in the immediate vicinity. These areas can be considered as 'focal' points for the community. Such localities may include the central business districts of regional centres and/or focal points for the local tourism industry and will likely include major trunk roads, national highways, community owned facilities and existing coastal protection works. These areas may be subjected to special planning conditions and/or relaxation of the principles outlined in Section 5.5.2 and 5.5.3. This should only occur following detailed studies to determine that:

- Proposed development intensification, redevelopment or other modifications, allowed as part of plans for those areas, do not create unacceptable impacts relating to coastal processes, flooding and/or inundation of the surrounding area; and
- That the plans for those areas, including consideration of any negative impacts will provide a demonstrable net benefit to the broader community.

In determining appropriate conditions for these special areas, consideration must be given to how the area may adapt in future and/or what physical triggers would apply to determine when development within those areas needs to be abandoned and infrastructure removed.

5.5.5 Strategic Response to Different Development Types

The strategic requirements where various types of development (Existing, Proposed or Critical Community) occur inside the different CHPA's are presented in Table 14.

5.6 Development Assessment Guidance Tables

Section 5.5 describes the overarching strategy and approach recommended to adequately plan for future sea-level rise. In a number of locations, reference is made to suitable "controls" that should be implemented to ensure development is compatible with the level of physical risk at the development location and over the expected life of the development.

These controls are typically applied as requirements for development consent, or as conditions applied upon granting the consent. Example controls for combinations of development type (i.e. the physical form / purpose of the development) and different coastal hazard planning areas are tabulated in Appendix C.

5.7 Policy Review

The policy and planning framework is to be thoroughly reviewed and updated every 5-6 years. This should be timed to coincide with the release of new assessment reports by the IPCC.

However, the information relating to coastline change and changes in mean sea level will need to be made available on a yearly basis. Furthermore, information should be promptly delivered to those land owners with property inside the "current hazard" area, so that they are aware of the changing profile of risk to their property as it evolves.

Table 14 Planning Guidelines in Coastal Hazard Planning Areas

Coastal Hazard Planning Area	Areas Already Zoned for Development	Areas where Rezoning is Proposed to Allow Development	Critical Community Utility
Current Hazard	-Up front landowner notifications required where an appropriate coastal zone management plan or floodplain management plan has been adopted by Council; -Create/Update Emergency Management Plans -Create/Update Coastal Zone Management and adaptation Plans -Minor additions and alterations to existing development allowed -Redevelopment only allowed with a funded, appropriate management plan -No Subdivision	- Up front landowner notifications required where an appropriate coastal zone management plan or floodplain management plan has been adopted by Council; -No rezoning to allow development -No new residential, commercial or industrial development	-Up front landowner notifications required where an appropriate coastal zone management plan or floodplain management plan has been adopted by Council; -Undertake studies to demonstrate critical community utility -instigate adaptation or relocation planning; -avoid expansion or intensification within current and adjacent medium term projected hazard areas; -no rezoning to allow development; -no new residential, commercial or industrial development.
Medium Term Projected Hazard	-Up front landowner notification required where an appropriate coastal zone management plan or floodplain management plan has been adopted by Council -Create/update coastal zone management and adaptation plans -New development possible with appropriate controls -No subdivision -No net increase in residential densities -Redevelopment to demonstrate adaptive capacity throughout the proposed design life and a suitable end-of-life plan; -Funding for retreat/adaptation plans for private development to be met by private funding sources	-Up front landowner notifications required where an appropriate coastal zone management plan or floodplain management plan has been adopted by Council -No rezoning to allow development -Proponents to demonstrate adaptive capacity throughout the proposed design life and a suitable end of life plan. -Appropriate building standards to accommodate/withstand hazards are required. -Structural materials/methods to facilitate easy removal upon decommissioning with minimal site rehabilitation. -Proponent to demonstrate capability of funding removal operations as these become necessary. -Moveable dwellings will be considered on merit. -Funding for retreat/adaptation/ decommissioning plans for private development to be met by private funding sources	-Up front landowner notifications required where an appropriate coastal zone management plan or floodplain management plan has been adopted by Council -Undertake studies to demonstrate critical community utility -develop adaptation or relocation plans; -Proponents to demonstrate adaptive capacity throughout the proposed design life and a suitable end of life plan.

Table Continued on Following Page

Coastal Hazard Planning Area	Areas Already Zoned for Development	Areas where Rezoning is Proposed to Allow Development	Critical Community Utility
Strategic Projected Hazard Planning	-Landowner notification recommended, however the expected long time frame and uncertainty in the time frame should be communicated -Redevelopment/subdivision allowed with appropriate controls to ensure sea-level rise can be accommodated/adapted to over design life of the development	-Notification recommended at development application stage -Rezoning is allowed with the imposition of appropriate covenants only -Infill, new residential and commercial development assessed on merit; -Appropriate building standards to accommodate/withstand hazards are required if the design life is to extend beyond 35 years. -Structural materials/methods to facilitate easy removal upon decommissioning with minimal site rehabilitation	-Develop long term adaptation or relocation plans; -Proponents to demonstrate a suitable adaptation strategy -Appropriate building standards to accommodate/withstand hazards are required if the design life is to extend beyond 35 years. -Structural materials/methods to facilitate easy removal upon decommissioning with minimal site rehabilitation
Possible Maximum Strategic Hazard	-location of critical infrastructure to be assessed in accordance with the maximum sea-level rise to 2100 values	-Rezoning is allowed with the imposition of appropriate covenants only	-Avoid the establishment of areas of critical community utility within this area

6 Conclusions and Recommendations

6.1 Planning and Legislation

Sea-level rise has been recognised and planned for in NSW for at least the past 25 years. Over time, the legislation, regulations and guidelines applicable to planning for sea-level rise have become more complex. s733 of the *Local Government Act, 1993* aims to provide local councils with exemption from liability relating to coastal planning, providing that a genuine attempt is made (in *"good faith"*) to comply with a relevant gazetted manual. At the present time, that manual is the New South Wales CZMP guidelines (OEH, 2013c). That manual requires that councils should consider sea-level rise, indicating that councils should adopt projections that are "*widely accepted by competent scientific opinion*".

The present *Environmental Planning and Assessment Act, 1979* requires that the New South Wales Coastal Policy be taken into account. The Coastal Policy indicates that (i) actions should be taken to prevent problems for future generations; and (ii) a "risk-averse" approach should be taken regarding land use planning for sea-level rise.

Our review of the applicable legislation and a range of legal advice made available to us during the course of this study indicates that, to take advantage of the s733 of the *Local Government Act, 1993*, local councils cannot ignore future sea-level rise. Underpinning our study and its outcomes is the assumption that both Project Partners wish to genuinely attempt to plan for sea-level rise.

6.2 Assessment of Science and Available Projections

Raw tidal time series were obtained from the National Tide Centre (NTC) and Manly Hydraulics Laboratory (MHL). The data were processed to remove erroneous records, and to calculate the average water level recorded at each location, for each calendar year. In addition, processed altimeter data from offshore of NSW were obtained from CSIRO. Analysis of all records over approximately the past 20 years found that:

- There has been a continuing upward trend in mean sea level over the past 20 years, with a (straight line) trend of between 3.3 and 4.5 mm/yr., calculated depending on the location and data set considered;
- Short term variability, which correlates well with ENSO, can cause local water levels to deviate markedly from year to year;
- The upward trends are similar to trends reflected in globally averaged estimates reported in the IPCC's latest report (AR5);
- There was no discernible spatial variation in mean sea level trends between Sydney and the study area.

Given that mean sea level at all sites examined have adjusted quickly and in a similar manner; in response to local ENSO related variability, we can find no reason why there would not be an almost equivalent adjustment to longer, underlying sea-level rise. Accordingly, we expect that sea levels offshore of the study area will rise at a similar rate to sea levels at Sydney. We advise that monitoring and analysis of the contemporary mean sea level at Fort Denison will provide results that are directly applicable to the study area.

A range of scientific reports and papers were reviewed. Arguments relating to the outcomes of the previous and most recent IPCC reports (AR4 and AR5 respectively) were examined and considered. Information relating to the methods of modelling to “project” future sea-level rise was also examined and considered.

The level of scientific understanding is acknowledged to be imperfect in AR5 even though there have been significant improvements since AR4. We note that there is genuine scepticism relating to the reality of climate change, but among scientists that have an established track record in climate science and directly related fields, this point of view is apparently only held by a small minority. Having reviewed the IPCC’s AR5 report, we have found it to provide a balanced representation of the present state of the science, including discussions relating to uncertainty and possible errors in assessment. We consider that the modelled projections from the IPCC’s AR5 report are *“widely accepted by competent scientific opinion”* as required by the CZMP guidelines (OEH, 2013c). The AR5 projections form a suitable basis for deriving local projections of relevance to the study area.

As with all computational models of uncertain physical processes, the models which are used by the IPCC are not perfect. However, the approach of the IPCC is to use many different models to reach a range of results. This process helps to encapsulate the range of uncertainty associated with those model results. To acknowledge this uncertainty, each projection presented by the IPCC can be interpreted as a series of 3 individual future possibilities, which we have designated as “High” (around 15% chance of being exceeded), “Medium” (around 50% chance of being exceeded) and “Low” (around 85% chance of being exceeded).

There are four projections presented in AR5, referred to as *Representative Concentration Pathways*, or RCP’s. RCP2.6 is a very low emissions scenario; RCP4.5 and RCP6.0 are mid-range emissions scenarios; and RCP8.5 is a high range emissions scenario. Considerations of importance are outlined in the following section.

6.3 Advice Regarding Projection Selection

Considering a range of issues associated with selecting a projection, we came to the following conclusions:

- That RCP2.6 is not as plausible as the other projections and should not be used for coastal management and planning at this time;
- That outputs from workshops involving professional staff from Shoalhaven and Eurobodalla Councils, OEH and the Department of Planning indicate that the future adverse consequences of adopting a sea-level rise projection that is too low are more severe than through adopting a projection that is too high. It must be cautioned that there are still potential negative consequences from adopting a projection that is too high;
- That planning guidelines and legal advice encourage a cautious approach that promotes the selection of a higher sea-level rise projection as appropriate;
- That scientific analyses following release of the IPCC’s AR5 indicated that many scientists consider a rate and magnitude of sea-level rise which is significantly greater than that predicted by the modelling underpinning the IPCC projections is possible;
- That there was a tendency around Australia, and internationally, following the release of the IPCC’s AR4 in 2007, to adopt projections based on the fossil fuel intensive scenario (A1FI) for planning purposes. That scenario is most similar to RCP8.5 in the most recent IPCC assessment (AR5). There are no widely supported arguments for a change from this approach.

For these reasons, we have advised that RCP8.5 is a suitable basis for a sea-level rise projection. “Low”, “Medium” and “High” values are presented for the RCP8.5 projection. In most situations, we recommend use of the “High” line.

6.4 Relevance of the Projection and Application within a Planning Framework

While a projection based on RCP8.5 has been recommended, it is important to recognise that all four of the available projections do not differ appreciably before 2050. Bearing this in mind, the projection adopted will not have a significant impact on planning for development that will have reached its end of life by 2050.

In many locations, detailed studies will be required to translate offshore water levels into hazards at the shoreline or within estuaries. Such studies include flood studies, coastal hazard studies and tidal propagation studies. In some locations, suitable studies have already been undertaken, but may need to be augmented.

We consider that much of the angst generated by the previous State Government sea-level rise policy related to implementation issues. These typically related to blanket application of the 2100 “benchmark” value and a lack of communication regarding an appropriate context within which to apply the benchmark values. Projected sea-level rise at 2100 is of minimal relevance to many short term, relocatable or expendable development / redevelopment activities. Conversely, it is important to ensure that the possibility of sea-level rise is communicated in affected areas, while appropriately acknowledging the significant uncertainty associated with sea-level rise projections leading up to 2100 and beyond.

From our review of the science, the majority opinion is that sea levels will eventually reach the RCP8.5 values, but the time frame over which this might occur is significantly uncertain. In comparison, projections for sea-level rise by 2050 sit within a much tighter range, and planning for sea-level rise within that time frame can be undertaken with relative confidence.

Considering these things, we believe the following Coastal Hazard Planning Areas (CHPA’s) should be adopted by council:

- **Current Hazard**: Areas that are **presently, or will become imminently threatened** by the ‘design’ hazards (e.g. design coastal storm, design flood) over the next 15 years. In this area, immediate actions are required to advise, prepare and prevent harm;
- **Medium Term Projected Hazard**: Areas that are projected to be **impacted within the next 15 to 35 years**. In this area, plan sensibly, monitor changes and respond to any unexpected changes;
- **Strategic Projected Hazard Planning**: Areas containing development that are projected to be impacted within the next 35 to 100 years. In this area, forward planning is called for along with monitoring to inform future actions;
- **Possible Maximum Strategic Hazard**: Areas of existing or proposed critical infrastructure that are projected to be impacted over the next 100 years if a very high sea-level rise scenario (greater than RCP8.5) occurs.

Different responses are required for development depending on its nature. Areas of existing development should be allowed to remain as long as it is feasible from both practical and safety perspectives, without adversely impacting on neighbours or the broader community. Proposed development should be subject to controls that ensure the development is safe for the course of its expected life and can be decommissioned with relative ease or suitably adapted. Areas of importance to the functioning of the broader community (e.g. Critical Community Utility) are subject to special conditions but will require detailed studies to justify the viability and worth of the development.

Finally, successful management of sea-level rise will only be achievable if a consistent, fair, open and well communicated approach is adopted. We have recommended that council develop a policy based on the guiding principles dealing with:

- Integrity;
- Responsibility;
- Flexibility;
- Consistency;
- Communication and Transparency; and
- Avoiding Complexity.

Of these, the final principle will be the most difficult to achieve. By its nature, processes along the coast are highly uncertain, and this introduces complexity into planning when the desire is to achieve balanced long-term use of a changing coastline. To assist with achieving this balance we recommend regular review of the policy, framework and future sea-level rise projections, followed by adjustment of practices based on experiences and updated information.

7 References

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Appendix A Workshop Outcomes

Appendix A1: Risk Register

Identifier	Cause	Event	Outcome	Impact/Consequences	Controls (Preventative)	Controls (Mitigative)
A	No sea level rise or very low sea-level rise after adopting a sea level rise policy that limits development	Unnecessary expenditure + limitation of development	Unnecessarily impact on economic growth	Loss of council credibility reduction in income/rates	Do not adopt a policy.	Adopt a policy that is flexible.
B	Unplanned for sea-level rise with climate change and policy levers too low	Moderate sea level rise above present	Assets are increasingly exposed	-Increased impact and cost of maintenance -Community impact, failing infrastructure	Be conservative with planning levels adopted	Adopt a policy that is flexible.
C	Sea level rise far exceeds expectations and policy inflexible	Significant impacts on infrastructure	Unplanned and unforeseen impacts that community is not ready for	-Potentially enormous impacts on peoples individual finances -Individuals seek to sue council through inability to act -Inability to spread costs equitably over time -Economically catastrophic in future	Be conservative with planning levels adopted	-Adopt a policy that is flexible -Keep the community informed
D	Adopt a policy that defers action. Sea level rise continues as projected	Lack of preparation and finances for adaptation	Business as usual now, but causes problems that need to be dealt with in future	Substantial burden on ad-hoc, emergency management as the default approach in future		-Identify funding sources early -Keep the community informed of hazards -Make sure the policy is suitably flexible
E	Sea level rise policy + lack of consultation and engagement	Political pressure	Poor and inadequate policy outcomes	Ineffective policy, indefensible	-Keep the community informed throughout the process	-Ensure that the policy is ultra-defensible through ongoing research and documentation -Ensure that there is thorough internal education regarding the policy, so that it is accepted internally, and uniformly applied.
F	Develop policy, but don't implement consistently	Ad-hoc management	Lack of fairness, inequitable outcome	-Council successfully sued -Uncertainty may make strategic planning more difficult	-Keep staff well informed educated and policy aware to ensure consistency	
G	Policy is not sufficiently clear	Ad-hoc management	Confusion	-policy ineffective -undesirable outcomes -loss of credibility	-Ensure that the policy is clearly constructed, documented and gives definitive guidance -Ensure that staff are educated such that they understand the policy and its underpinning assumptions	

Identifier	Cause	Event	Outcome	Impact/Consequences	Controls (Preventative)	Controls (Mitigative)
H	Policy developed, but lack of communication internally. Failure to define roles appropriately (note present restructure of Shoalhaven Council)	Poor coordination in adaptation activities	Poorly targeted asset expenditure	-Unnecessary expenditure loss of face -potentially catastrophic failure with unexpected outcomes -higher than expected maintenance -health risk (sewer / stormwater)	-Ensure adequate education is provided across Council, noting that sea-level rise is an issue for asset planning as well	-Establish a system that ensures communication shortcomings are identified and promptly rectified.
I	Policy developed undervalues public assets (e.g.) beaches	Protection of beaches with hard structures + beach erosion	Complete loss of sub-aerial beach in some areas	-whole area seen as undesirable location -reduction in rates base	-Ensure that public recreation and access to the shoreline is balanced against private interests in developing policy	-Identify suitable funding sources to facilitate property buy back -Ensure that the policy retains the majority of popular beaches as publicly accessible, even under sea level rise so that the entire LGA does not gain an undesirable reputation
J	Too high a sea-level rise benchmark (more easily modified but community backlash immediately)	Referral of DA on beachfront	Land and Environment challenge	Financial costs, impact on policy effectiveness	-Ensure that the sea level rise planning levels are legally defensible (not too stringent) -Ensure that the Community is kept informed and engaged during policy development	
K	Too high a sea-level rise benchmark (more easily modified but community backlash immediately)	Freeze on land through zoning	Development constrained	Loss of council revenue and impact on budget	-Ensure that policy levels represent a defensible balance between science and economic effects	-Make sure that the policy is flexible so that an overestimate based on the best science at the time can be modified in future
L	Too high a sea-level rise benchmark (more easily modified but community backlash immediately)	Approve DA with unnecessary restriction	Increased construction costs, creates future problem for adaptation (e.g. Planned retreat)	Development may not proceed. Deferring implementation of long term strategy, potential litigation	-Ensure that flexible, relocatable building options are adopted in areas potentially at risk.	-Ensure that the adopted policy is defensible legally and scientifically. -Ensure that the community is kept informed and engaged during policy development.
M	Too high a sea-level rise benchmark (more easily modified but community backlash immediately)	Protection of public assets unnecessarily	Impact beach amenity waste of resources	Budget impacts	-Base policy on the best available science subject to legal constraints -Maintain consistency with rules between public and private assets	-Avoid protective structures which are not adaptable and inflexible -Adopt a monitoring strategy which doesn't take action until physical triggers (water levels / erosion extents) are reached

Identifier	Cause	Event	Outcome	Impact/Consequences	Controls (Preventative)	Controls (Mitigative)
N	Too high a sea-level rise benchmark (more easily modified but community backlash immediately)	Council underinvestment in assets	Loss of services	Unhappy residents planning / designing unnecessary services	-Base policy on the best available science subject to legal constraints -Maintain consistency with rules between public and private assets	-Ensure Policy is flexible and updated regularly -Adopt a monitoring strategy which doesn't take action until physical triggers (water levels / erosion extents) are reached
O	Too low a sea-level rise benchmark (difficult to modify but less community backlash).	Approval of ill sited DA's impacted by coastal hazards	Asset lost / damaged third party appeal	Council sued approval overturned, possible damage / replacement policy	-Base policy on the best available science subject to legal constraints -Implement suitable caution into the benchmarks adopted	-Condition all DA's that might be affected by sea level rise within planning time frames such that they are flexible (relocatable) or robust; -Adopt a flexible approach to policy development, enabling and expecting change in the future due to uncertainty.
P	Too low a sea-level rise benchmark (difficult to modify but less community backlash).	Public infrastructure ill-site	Failure / loss of infrastructure	Public health impacts	-Ensure Asset management people are aware of the expectations of Sea Level Rise -Ensure that Policy is based on the best available science subject to legal constraints -	-Continued monitoring in the vicinity of critical infrastructure within the coastal zone to ensure that problem areas are identified early -Identify funding options for the relocation / replacement of affected infrastructure, with rapid response once physical triggers are reached.
Q	Too low a sea-level rise benchmark (difficult to modify but less community backlash).	Inappropriate zoning for future development	Creates expectation of continued use for purpose	Creates future DA assessment problems	-Adopt policy levels that are appropriately conservative but in line with legal requirements and present scientific understanding	-Maintain flexibility in any newly zoned areas that could potentially be impacted by coastal processes in the foreseeable future -Appropriately condition any rezonings to ensure adaptability is built into development
R	Inadequate flexibility in policy	Approval / refusal of application without considering type of development	Inhibit development unnecessarily court action	Economic impact on local area loss of return???, budget implications, review of policy	-Make sure that policy considers each development type appropriately with respect to design life and the risks involved	
S	Inadequate flexibility in policy	New scientific information	Trigger review of policy and planning - obsolete	Economic cost community backlash legal challenges	-Inform the community early and well regarding uncertainty -Build an expectation that the policy and trigger levels will be reviewed regularly and in light of new information	

Identifier	Cause	Event	Outcome	Impact/Consequences	Controls (Preventative)	Controls (Mitigative)
T	No policy on future sea level rise	Sea level rise not considered in planning and development	Business as usual (no sea-level rise) development impacted in future	Minimal impact initially, 3rd party appeals -loss of life, loss of property, -litigation council and residents, public health, loss of amenity etc.	-Adopt a well considered, balanced and defensible policy and benchmark levels	-Keep an open mind and remain flexible with regards to future policy adoption -Monitor rigorously -Plan thoroughly for emergency management
U	No policy on future sea level rise	Merits based approval of applications	Substantial increased cost to applicant and council inconsistency in approach (visual impacts, costs)	-Increased litigation as decisions contested -loss of investment due to uncertainty	-Adopt a well considered, balanced and defensible policy and benchmark levels	
V	General policy too focussed on private property	Loss/impact on public land from property development	Loss of land loss of habitat loss of amenity & access	-Reduction in tourism/recreational use -community angst -loss of mitigation impacts -water quality impacts -cost of maintaning infrastructure to residential.	-Ensure that the policy is uniformly applicable and appropriate for public and private -Consider the rights of public access to the foreshore and value of coastal assets to the general public	-Adopt a flexible approach that enables alteration of policy in future. -Encourage the removal of development from areas at risk
W	Sea-level rise perception too low	'Radical' policy implemented - e.g. No allowance for sea level rise	Large number of residents affected	Class action against council financial losses say 1000 landowners * $12,500 each = $12.5M = financial failure of council. =failure to provide services	-Adopt a conservative approach, in line with legal advice and the best available science. -Acknowledge that sea level rise must be planned for -Avoid opening up new areas for development where they could be foreseeably affected by sea-level rise	-Monitor and ensure that the community are kept aware of information as it becomes available.
X	Sea-level rise perception too low	'Radical' policy implemented - e.g. No allowance for sea level rise	Council assets affected, failure of infrastructure	Budget safety issues community angst	-Adopt a conservative approach, in line with the best available science -Acknowledge that sea level rise must be planned for	-Identify assets located in “at-risk” areas and monitor -As appropriate, plan for relocation, protection, continued use of critical assets as sea levels rise
Y	Sea-level rise perception too low	'Radical' policy implemented - e.g. No allowance for sea level rise	Health and safety	Failure of infrastructure safety issues	-Adopt a conservative approach, in line with the best available science -Acknowledge that sea level rise must be planned for	-Identify assets located in “at-risk” areas and monitor -As appropriate, plan for relocation, protection, continued use of critical assets as sea levels rise
Z	Sea-level rise perception too low	'Radical' policy implemented - e.g. No allowance for sea level rise	Environmental/amenity impact	Loss of tourism creation/loss of habitat community backlash towards council	-Adopt a conservative approach, in line with the best available science -Acknowledge that sea level rise must be planned for	-Avoid future adaptation options which adversely affect foreshore access or accentuate impacts on valuable habitats.

Identifier	Cause	Event	Outcome	Impact/Consequences	Controls (Preventative)	Controls (Mitigative)
A1	Sea-level rise occurs but policy doesn't adequately promote forward planning	Recession of shorelines and ad-hoc protection works	Loss of beach width	No access to beach, reduction in amenity	-Ensure that the policy adequately considers future impacts in a changing climate -Promote flexible adaptation options which can be reversed in future	
A2	Overly conservative sea-level rise policy	Incorrect professional advice to council	Overly conservative policy	Council sues consultant	-Do not take advice on face value. Undertake a detailed internal review -Employ suitably qualified consultants -Seek peer review if deemed necessary	-Promote a flexible policy that can be altered if and when more/better information is uncovered
A3	Policy plans for sea-level rise which doesn't occur	Unnecessary implementation of policy	-Unnecessary resources -Implementation of policy that is not required	Opportunities lost	-Ensure that Policy is based on the best available science subject to legal constraints	-Promote monitoring to gain a local understanding of ongoing processes -Adopt a flexible policy that is able to be changed over time.
A4	Unrealistic developer constraints	Not supported by court	Development approved without reasonable controls	Failure of policy potential precedent set costs	-Ensure adequate review of development control planning framework and any development control plans thus developed -Seek legal opinion regarding any development control plans -Ensure consent conditions are applied evenly and equitably across the LGA and in accordance with a well communicated and clear policy.	-Ensure policy and development controls are designed to be flexible and able to be changed over time in response to changing information and legal conditions.
A5	Inadequate/ Unclear advice for DA preparation	DA inadequate for assessment	Unnecessary expense for client	Community angst potential claim	-KISS Policy, wherever possible, particularly for smaller developments, -however acknowledge the uncertainties of coastal processes and provide a clear pathway for applicants to follow. -Undertake the necessary studies to provide necessary information to applicants and reduce expense	
A6	No policy and climate change occurs	Replacement of assets at too low a level	Won't perform for design period	Increased cost and or reduced level of service.	-Take a conservative approach for critical assets -Base policy on the best available science subject to legal constraints -Implement suitable caution into the benchmarks adopted	-Identify assets located in "at-risk" areas and monitor -As appropriate, plan for relocation, protection, continued use of critical assets as sea levels rise -Continued monitoring in the vicinity of critical infrastructure within the coastal zone to ensure that problem areas are identified early

Appendix A2 Rationalised Consequences Assessment Table (Shoalhaven)

Rationalised Risk Group	Cause	Event / Outcome	Risks (refer to Risk Register for Detailed Description)	Currarong Consequence Rankings Occurance Values					Callala Beach Consequence Rankings Occurance Values					Lake Conjola Consequence Rankings Occurance Values					Mollymook Beach Consequence Rankings Occurance Values				
				Insignificant	Minor	Moderate	Major	Catastrophic	Insignificant	Minor	Moderate	Major	Catastrophic	Insignificant	Minor	Moderate	Major	Catastrophic	Insignificant	Minor	Moderate	Major	Catastrophic
1	Policy adopts too high sea level rise	Land Sterilisation / Development Constraint, potential legal challenge	A, J,K, L, R, A3, A4	1.5	5.0	4.5	0.0	0.0	0.0	1.0	8.0	1.5	0.5	0.0	1.5	7.0	2.0	0.5	1.5	3.5	5.0	1.0	0.0
2	Policy adopts too high sea level rise	Unnecessary Expenditure	A, L, M, A2, A3, A4	0.0	7.0	4.0	0.0	0.0	1..0	3.5	4.5	2.0	0.0	1.0	3.5	4.5	2.0	0.0	0.0	4.0	6.0	1.5	0.5
3	Policy adopts too high sea level rise	Act too Early / under supply (or lack of maintenance) assets	J, N	1.0	7.5	2.5	0.0	0.0	0.0	5.5	3.5	1.5	0.5	1.0	4.5	4.5	1.0	0.0	1.0	4.0	4.0	1.0	0.0
4	Policy adopts too low sea level rise	Assets Exposed to Hazards	B, C, O, P, Q, T, V, W, X, Y, Z, A1	0.0	1.0	3.5	6.0	0.5	0.0	0.0	0.5	8.0	2.5	0.0	0.0	1.0	8.5	1.5	0.0	0.0	0.5	7.5	3.0
5	Policy adopts too low sea level rise	Poor forward Planning / Funding	C, D, P, Q, A1, A6	0.0	1.0	2.5	7.0	0.5	0.0	0.0	1.5	7.5	2.0	0.0	0.0	1.0	7.5	2.5	0.0	0.0	0.5	9.5	1.0
6	Policy adopts too low sea level rise	Increased reliance on reactive “Emergency” actions	C, D, X	2.0	0.0	3.5	5.5	0.0	0.0	0.0	2.5	5.5	3.0	0.0	1.5	1.5	5.0	3.0	0.0	1.0	1.5	8.0	0.5
7	Policy adopts too low sea level rise	Funding/Legal Burden on Future Generations	B, C, D, O, R, S, T, U, V, W, X, A6	0.0	1.0	3.5	5.0	1.5	0.0	0.0	2.5	7.0	1.5	0.0	0.0	2.0	6.5	2.5	0.0	0.0	1.5	8.5	1.0
8	Poor Implementation	Lack of Communication / Engagement	E	0.0	3.0	5.0	1.5	0.5	0.0	0.0	4.0	5.5	0.5	0.0	4.0	5.5	0.5	0.0	0.0	0.0	3.0	6.5	0.5
9	Poor Implementation	Inconsistency in Application / Unfair or Unclear	F, G, A5	0.0	3.0	4.0	2.5	0.5	0.0	0.0	5.0	4.5	1.5	0.0	3.0	5.0	2.0	0.0	0.0	1.0	3.0	5.5	0.5
10	Poor Implementation	Poor Internal targeting of funds poor valuation of assets (incl. Natural)	D, H, I, A1, A6	0.0	3.0	3.0	3.5	0.5	0.0	0.0	3.0	5.0	2.0	0.0	4.0	4.0	2.0	0.0	0.0	0.0	4.0	5.0	1.0
11	Poor Implementation	Inflexible Policy	R, S, A1	1.0	3.0	3.0	2.5	0.5	0.0	0.0	4.0	4.5	1.5	1.0	4.0	3.5	1.5	1.0	0.0	0.0	4.0	5.0	1.0

Rationalised Consequences Assessment Table (Eurobodalla)

Rationalised Risk Group	Cause	Event / Outcome	Risks (refer to Risk Register for Detailed Description)	Surfside Consequence Rankings Occurance Values					Batemans Bay Consequence Rankings Occurance Values					Mossy Point/Tomakin Consequence Rankings Occurance Values				
				Insignificant	Minor	Moderate	Major	Catastrophic	Insignificant	Minor	Moderate	Major	Catastrophic	Insignificant	Minor	Moderate	Major	Catastrophic
1	Policy adopts too high sea level rise	Land Sterilisation / Development Constraint, potential legal challenge	A, J,K, L, R, A3, A4	0.00	3.50	3.50	0.00	0.00	0.00	1.25	1.25	4.50	0.00	1.00	3.00	3.00	0.00	0.00
2	Policy adopts too high sea level rise	Unnecessary Expenditure	A, L, M, A2, A3, A4	1.00	2.50	2.50	1.00	0.00	0.00	2.00	2.00	3.00	0.00	1.50	2.25	2.25	1.00	0.00
3	Policy adopts too high sea level ris	Act too Early / under supply (or lack of maintenance) assets	J, N	1.50	1.75	1.75	2.00	0.00	1.00	1.00	1.00	4.00	0.00	2.50	1.25	1.25	2.00	0.00
4	Policy adopts too low sea level rise	Assets Exposed to Hazards	B, C, O, P, Q, T, V, W, X, Y, Z, A1	0.00	0.50	0.50	5.00	1.00	0.00	0.00	0.00	3.00	4.00	0.00	1.25	1.25	3.50	1.00
5	Policy adopts too low sea level rise	Poor forward Planning / Funding	C, D, P, Q, A1, A6	0.00	1.50	1.50	3.00	1.00	0.00	0.50	0.50	3.00	3.00	0.00	2.25	2.25	2.50	0.00
6	Policy adopts too low sea level rise	Increased reliance on reactive "Emergency" actions	C, D, X	1.00	0.50	0.50	5.00	0.00	0.00	1.00	1.00	3.00	2.00	1.00	1.25	1.25	3.50	0.00
7	Policy adopts too low sea level rise	Funding/Legal Burden on Future Generations	B, C, D, O, R, S, T, U, V, W, X, A6	0.00	1.50	1.50	4.00	0.00	0.00	0.50	0.50	3.00	3.00	2.00	0.75	0.75	3.50	0.00
8	Poor Implementation	Lack of Communication / Engagement	E	2.00	1.25	1.25	1.50	0.00	2.00	0.75	0.75	2.50	0.00	2.00	1.75	1.75	0.50	0.00
9	Poor Implementation	Inconsistency in Application / Unfair or Unclear	F, G, A5	0.00	1.25	1.25	2.50	1.00	0.00	1.00	1.00	4.00	0.00	0.00	2.25	2.25	1.50	0.00
10	Poor Implementation	Poor Internal targeting of funds poor valuation of assets (incl. Natural)	D, H, I, A1, A6	2.00	0.75	0.75	2.50	0.00	2.00	0.00	0.00	4.00	0.00	3.00	0.75	0.75	1.50	0.00
11	Poor Implementation	Inflexible Policy	R, S, A1	2	1.75	1.75	0.5	0	1	1	1	3	0	1	1.75	1.75	1.5	0

Notes: At the Eurobodalla Workshop, attendees assigned a "risk" level (Low, Medium, High, Extreme) based on a possible likelihood, and a standard risk assessment table. These rankings were subsequently back factored to Consequence rankings as follows: Insignificant = Low, Minor = 0.5 * Medium, Moderate = 0.5 * Medium, Major = High, Catastrophic = Extreme.
This has resulted in a peculiarity that the "Minor" counts are identical to the "Moderate" counts, and this follows through in the assessment.

Consequences Assessment (after AGO, 2006)

Consequence Rating	Performance Categories and Criteria: Public Safety	Local Economy and Growth	Community and Lifestyle	Environment and Sustainability	Public Administration
Catastrophic	Large numbers of serious injuries or loss of lives	Regional decline leading to widespread business failure, loss of employment and hardship	The region would be seen as very unattractive moribund and unable to support its community	Major widespread loss of environmental amenity and progressive irrecoverable environmental damage	Public administration would fall into decay and cease to be effective
Major	Isolated instances of serious injuries or loss of lives	Regional stagnation such that businesses are unable to thrive and employment does not keep pace with population growth	Severe and widespread decline in services and quality of life within the community	Severe loss of environmental amenity and a danger of continuing environmental damage	Public administration would struggle to remain effective and would be seen to be in danger of failing completely
Moderate	Small numbers of injuries	Significant general reduction in economic performance relative to current forecasts	General appreciable decline in services	Isolated but significant instances of environmental damage that might be reversed with intensive efforts	Public administration would be under severe pressure on several fronts
Minor	Serious near misses or minor injuries	Individually significant but isolated areas of reduction in economic performance relative to current forecasts	Isolated but noticeable examples of decline in services	Minor instances of environmental damage that could be reversed	Isolated instances of public administration being under severe pressure
Insignificant	Appearance of a threat but no actual harm	Minor shortfall relative to current forecasts	There would be minor areas in which the region was unable to maintain its current services	No environmental damage	There would be minor instances of public administration being under more than usual stress but it could be managed

Appendix B Case Study Assessments

Appendix B: Case Study Assessments

B.1 Currarong

B.1.1 Site Description

The study area incorporates that section of Currarong Beach to the west of the Currarong Creek entrance on the northern side of Beecroft Peninsula (Figure B.1). The study area extends approximately 1km west from the creek entrance along the beach to a small creek inlet and exposed bedrock outcrop just north of Lighthouse Road. The area is bound by the western bank of Currarong Creek and Nowra Road, approximately 300m to 450m landward of the Beach and encompasses residential development and the caravan park adjacent to the creek.

The beach is sandy with a substantial single foredune. It is aligned east–west and is sheltered from the dominant south and south-east swells by the northern point of Beecroft Peninsula which extends some 2km north-east from the creek entrance. Ocean swells reaching the beach are modified by refraction, diffraction and shoaling/breaking which results in a sheltered wave climate under most swell conditions. The beach is exposed to an unrestricted wind fetch from north to north-east which would result in significant short period waves at the shoreline during local storm events. For both swells and local seas, the sand movement at the shoreline is predominantly from east to west, although infrequent events may result in some sand moving from west to east.

Over recent years the beach has been experiencing erosion and recession of the dune face, posing concerns for the future safety of Warrain Crescent and the existing development landward. The residential development south of Warrain Crescent extends behind the Beach and is separated from the Beach by a public reserve with a minimum width of 15m near the eastern end to a maximum of 50m adjacent to Worrigee Road to the west. Extensive bedrock comprises the northern outstand of Beecroft Peninsula to the west and north east of the study area. Bedrock is exposed at the shoreline and on the seabed at both the eastern and western end of the study area, dipping seaward in a north east direction. This bedrock is currently affecting the alignment of the shoreline and is reflected in the shape of the original subdivision and the alignment of Warrain Crescent. The onshore extent of the bedrock and its potential future impact on the shoreline alignment is currently unknown.

B.1.2 Determining an Appropriate Planning and Policy Response

<u>Existing hazards</u>

Current concerns are limited to the erosion of the beach and dune face which affects the existing beach access ways and has the potential to undermine the eastern end of Warrain Crescent should a major erosion even occur. The dune height is sufficient to prevent significant wave inundation of the road or landward development. Flooding risk from the creek and ocean is minimal.

<u>Future hazards from sea level rise</u>

To facilitate identification of risks, the likely impacts resulting from a sea level rise of 1m above present sea level are considered. It is assumed that no action is taken to address those hazards over the intervening period. The future hazards include:

- Potential erosion of the foreshore – sea level rise will result in erosion of the foreshore and dune during storms with progressive recession of the dune face as sea level rise continues. For this purpose a recession of the shoreline of 50 metres for a sea level rise of 1m has been assumed. This will be modified should bedrock outcrops exist landward of the present shoreline.

- Reduction in foundation capacity of existing development located landward of the dune escarpment
- Increased risk of wave overtopping and inundation initially to the road
- Changes in creek entrance conveyance and location

<u>Assets potentially affected</u>

The following assets could be affected by a sea level rise of up to1m:

- Potential loss of Warrain Crescent from Peel Street to Eastern toilet block (approximately 700m)
- Reduction in foundation stability of residential development along Warrain Crescent
- Erosion and loss of residential development along Warrain Crescent south of Cambewarra Road
- Loss of eastern toilet block and services
- Changes to the Creek entrance and conveyance, affecting tidal and flood levels adjacent to the Creek
- Loss of facilities along the western foreshores of the creek including the existing boat ramp

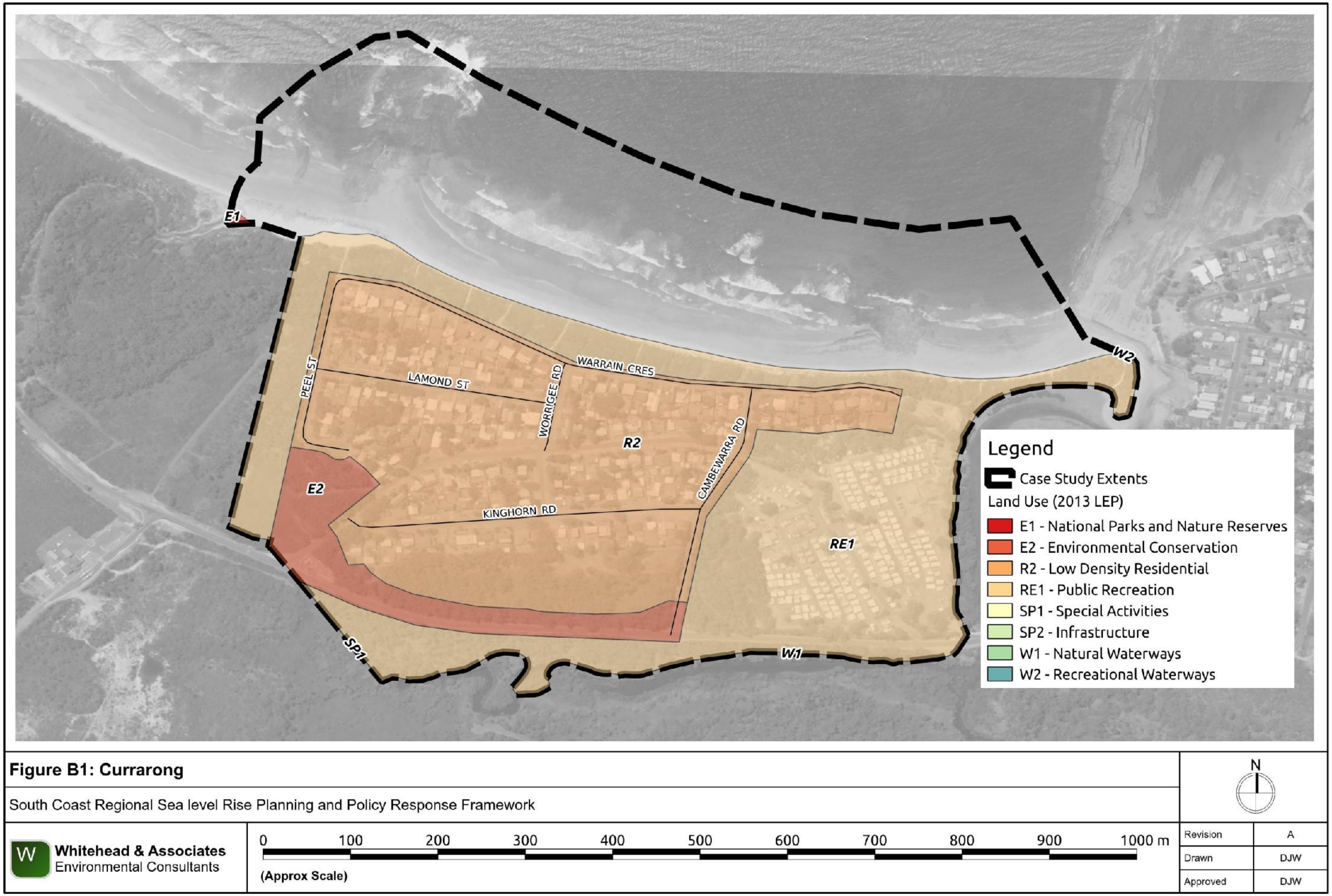

Figure B1: Currarong

South Coast Regional Sea level Rise Planning and Policy Response Framework

Whitehead & Associates
Environmental Consultants

Revision	A
Drawn	DJW
Approved	DJW

B.2 Callala Beach

B.2.1 Site Description

The study area incorporates that section of Callala Beach within Jervis Bay to the south of the Callala Creek entrance on the south side of Callala Point (Figure B2). The study area extends approximately 3.5km south-west from the creek entrance along the beach, including the development fronting and adjacent to Callala Beach and a section of the undeveloped reserve east of the Myola township. The area is bound to the north by the western bank of Callala Creek and incorporates all the development behind Callala Beach, including the golf course approximately 1.5km from the beach.

The beach is sandy with a substantial single foredune remaining. Development is located on the reformed dune ridges adjacent to the Beach. The area west of the township is low lying and forms part of the catchment and waterway of Callala Creek. The beach is aligned north-east to south–west and while sheltered from much of the ocean swells by the northern and southern headlands of Jervis Bay, is exposed to the predominant south-easterly swells passing through the entrance to the Bay some 12km to the south-east. Ocean swells reaching the beach are modified by refraction, diffraction and shoaling and result in a sheltered wave climate under most normal swell conditions. The beach is exposed to a 14km wind fetch from the south to south-east which would result in significant short period waves at the shoreline during local storm events. The Beach is well aligned to the swell and sea conditions.

Over many years the Beach has been experiencing infrequent erosion and recession during major storm events, posing ongoing concerns for the future safety of existing development along Quay Road to the south of Callala Beach Road. The residential development north of Callala Beach Road is landward of Greenway Road which extends behind and parallel to the beach for approximately 550m to the north. The road is separated from the beach by a public reserve with a minimum width of 25m. There is extensive bedrock exposed both onshore and on the seabed adjacent to Callala Point. However there is no evidence of significant bedrock exposure on the Beach seaward of the dwellings along Quay Road or seaward of Greenway Road. There is no identified bedrock within or landward of the currently developed area that may impact on future beach realignment.

B.2.2 Determining an Appropriate Planning and Policy Response

<u>Existing hazards</u>

Current concerns relate to erosion of the Beach and dune face which separates the existing development south of Quay Road and adjacent to the beach. While there is a dune buffer 20m to 30m wide seaward of the individual dwellings at present, existing development southwest of the Callala Beach Road intersection and along the south side of Quay Road is potentially at risk. Recorded erosion events have resulted in erosion to the front of existing dwellings, requiring emergency protection works to protect the buildings. This risk increases to the south-west where the remaining dune is narrowest.

Greenway Road is separated from the Beach by a dune buffer approximately 45m wide.

<u>Future hazards from sea level rise</u>

To facilitate risk assessment, the likely impacts resulting from a sea level rise of 1m above present are considered. It is assumed that no action is taken to address these hazards over the intervening period. The future hazards include:

- Potential erosion of the foreshore – sea level rise will result in increasingly frequent erosion of the foreshore and dune during storms with progressive recession of the dune face as sea level rise continues. For this purpose a recession of the shoreline of 50 metres for a sea level rise of 1m has been assumed. This allowance would be modified should bedrock outcrops exist landward of the present shoreline or at shallow depth under the beach.
- Reduction in the foundation capacity of existing development located landward of the dune escarpment
- Increased risk of wave overtopping and inundation.
- Changes in flood and inundation levels adjacent to watercourses and low lying areas landward of the beach.
- Changes to groundwater levels.

Assets potentially affected

The following assets could be affected by a sea level rise of up to 1m.:

- Potential loss of all residential and community development seaward of Quay Road (approximately 1.4km)
- Reduction in foundation stability of Quay Road and potential periodic inundation of the road during storms.
- Undermining and potential loss of Greenway Road and access to those properties immediately landward.
- Loss of the seaward ends of Callala Beach Road, Parkes Crescent, Centre Street, Sir Henry Crescent and Princess Street, including facilities, beach front parking and community buildings.
- Potential changes to the northern creek entrance, increasing tidal conveyance to the creek.
- Increased risk of flooding and costal inundation to low lying areas behind the Beach.

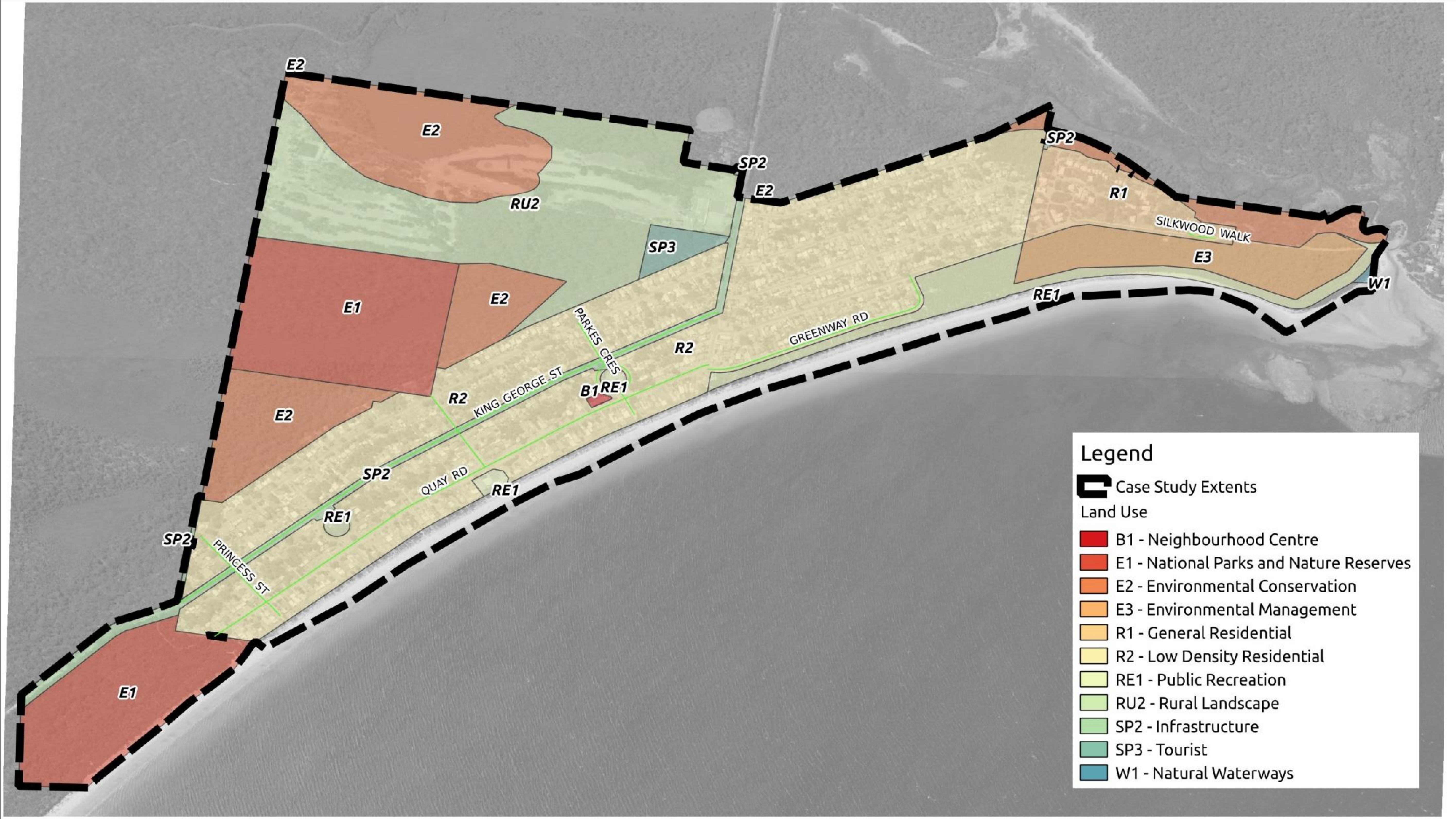

Figure B2: Calalla

South Coast Regional Sea level Rise Planning and Policy Response Framework

Whitehead & Associates Environmental Consultants

Revision	A
Drawn	DJW
Approved	DJW

B.3 Lake Conjola

B.3.1 Site Description

The study area incorporates the southern foreshore of the Lake Conjola entrance channel, at the northern end of Conjola Beach and immediately south of Cunjurong Point and Green Island (Figure B.3). The entrance channel is approximately 3.3km long from the landward face of the flood tide shoal to the ocean entrance, and is aligned approximately east west. The study area extends approximately 2.5km west from just inside the ocean entrance along the southern foreshore to the western edge of the demountable village located at the eastern end of the Lake. The area encompasses the foreshores and development south of the channel and extends up to 700m south of the channel foreshore.

The channel foreshore is fixed with protection works of varying standards. Development varies and the land is covered by a range of zonings. Existing development includes residential (village) development on large blocks, residential development, canal type development along the canal joining Pattimores Lagoon to the entrance channel, caravan and demountable village development and public recreation facilities (including boat launching ramp and carpark). The channel bed is sandy with large mobile tidal shoals, more permanent islands and deeper channels. The channel width is 200m to 400m with a 500m width at the ocean entrance.

The Lake Conjola catchment is approximately 145km^2 and the lake surface area is approximately 4.3km^2 with a maximum depth around 10m. The study area is prone to flooding from both catchment rainfall and/or ocean storm surges at present. Peak measured flood levels within the lake are recorded for flood events in 1971, 1975 and 1972 between 2.0m AHD and 2.5m AHD through the study area with the highest flood hazard occurring between Pattimores Lagoon and the entrance channel. Flood levels above 1.8m AHD result in significant loss of access to existing development. Flood levels for individual flood events will vary, depending on the weather conditions (including ocean level), and the condition of the entrance channel.

B.3.2 Determining an Appropriate Planning and Policy Response

Existing hazards

Current concerns relate to the stability of the estuary foreshore and to the lower estuary flooding during both rainfall and elevated ocean events. Much of the low lying land adjacent to the Estuary is flooded infrequently (particularly the section between Pattimores Lagoon and the entrance channel). In addition to isolation and damage to individual development, higher flood levels can impact emergency access by road to the entrance area, exacerbating issues associated with resident safety and evacuation. The entrance is currently managed through dredging and dune works to maintain an open channel and floodway..

Future hazards from sea level rise

To facilitate risk analysis, the likely impacts resulting from a sea level rise of up to 1m above present sea level are considered. It is assumed that no action is taken to address these hazards over the intervening period. The future hazards include:

- Changes to the entrance configuration and potential erosion of the estuary channel foreshores and channel shoals. Sea level rise will result in increased water depths and flow velocities on existing stabilisation structures. Flow paths and channel locations may realign.
- Generally, an increase in water surface levels within Lake Conjola, Pattimores Lagoon and Berringer Lake of approximately 1m will occur. This can increase the water surface area of each storage and potentially increase tidal flows along the entrance channel as the tidal

prism gradually increases. Corresponding flood levels will increase by approximately 1m inundating additional foreshore areas during floods and potentially, changing current flood storage areas to high hazard flood areas. Some presently low lying foreshore areas may be permanently inundated

- Erosion of the entrance channel foreshores during storms with potential failure of existing protection works and damage or loss of waterfront structures.
- Increasing frequency in loss of road access.
- Failure of stormwater drainage in low lying areas.
- Changes to groundwater levels.
- Permanent inundation of existing intertidal habitat areas.

<u>Assets potentially affected</u>

The following assets could be affected by a sea level rise of up to 1m:

- Potential flood inundation to 1.0 m above existing flood levels. Low lying development may need to be relocated or abandoned. Development that is currently flood free may become flood prone.
- Damage to low lying road surfaces from frequent inundation and high groundwater levels.
- Failure of bank stabilisation works.
- Failure of services.
- Loss of existing intertidal habitat.

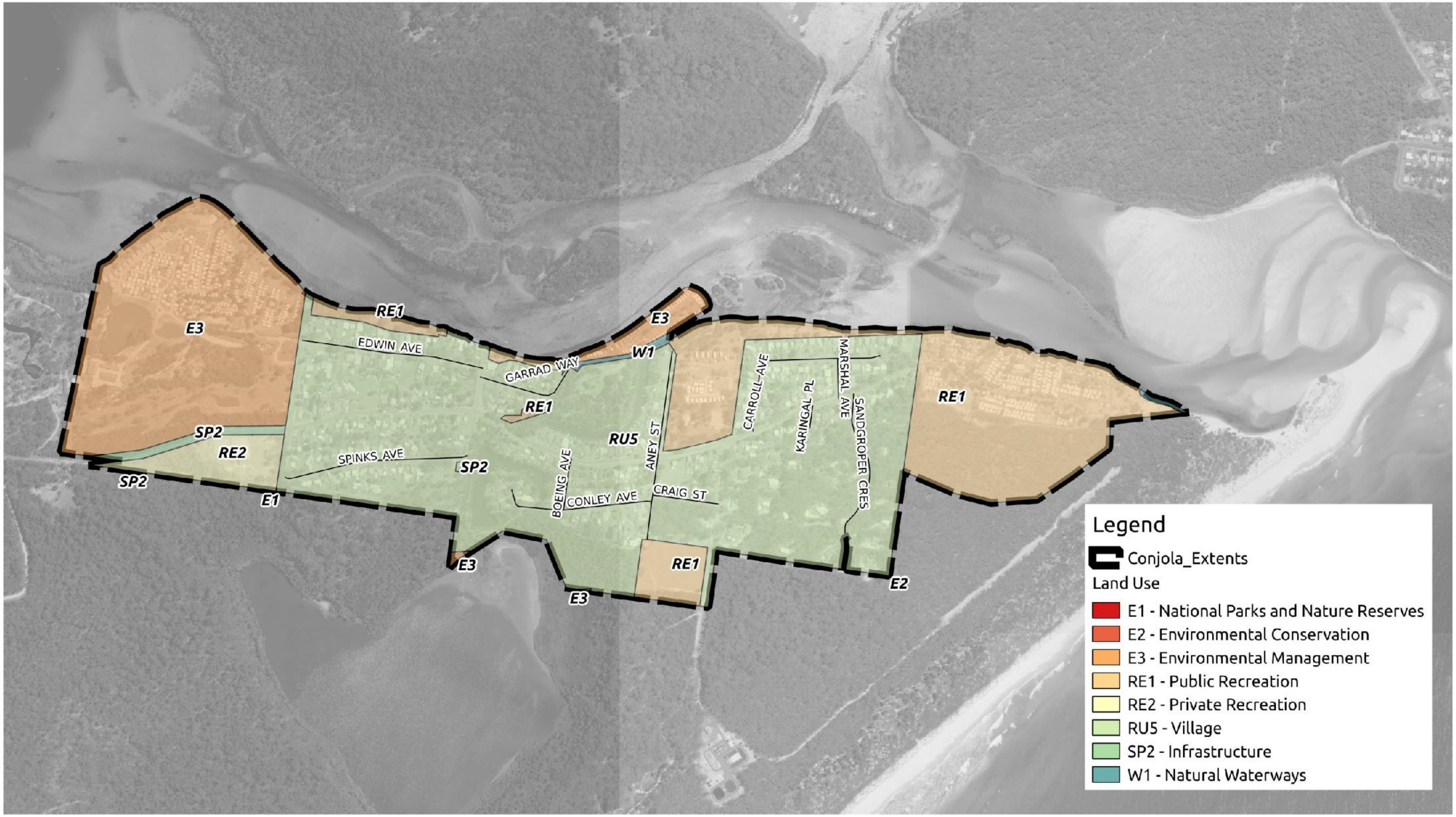

Figure B3: Conjola

South Coast Regional Sea Level Planning and Policy Response Framework

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Environmental Consultants

0 250 500 750 1000 1250 1500 1750 2000 m

(Approx Scale)

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Revision	A
Drawn	DJW
Approved	DJW

B.4 Mollymook

B.4.1 Site Description

Mollymook Beach is a sandy beach approximately 2 kilometres long extending north from the rocky headland at the north end of Collers Beach to the south side of Bannisters Point (Figure B.4). The beach is aligned NNE to SSW and is an exposed ocean beach, facing the predominant south-east swell direction. At the northern end of the beach, the exposed bedrock cliffs of Bannisters Point extend approximately 0.5 kilometres south east from the north end of Mollymook Beach. This shelters the northern end of the Beach from swells approaching from the east to the north. The southern end of the Beach receives some shelter from the bedrock headland and rock shelves that extend north east from the headland separating Mollymook from Collers Beach. Extensive outcrops of rock reef on the seabed are visible off both headlands and patches of reef appear seaward of the surf zone at two locations along the beach. There is no available information on bedrock outcrops landward of the Beach which may control future beach recession.

At the southern end of the Beach the Mollymook Beachside Golf Clubhouse is located immediately adjacent to the back beach escarpment. The clubhouse is protected a by a gabion and reno mattress sea wall and the recent extension to the building incorporates deep foundations. South of the protection structure there is an informal rock wall tying the structure to the bedrock of the headland. North of the golf clubhouse, the recently redeveloped intersection of Golf Avenue and Ocean Street is immediately behind the Beach. There is a vertical retaining wall separating the road and development behind from the Beach. To the north of Ocean Street the Mollymook Surf Life Saving Club is separated from the Beach by a grassed park approximately 30 metres wide. This park extends along the foreshore approximately 370 metres from Ocean Street to Backwater Creek and is bounded to the west by Mitchell Parade. The central section of the park incorporates a large sealed carpark, separated from the back of the Beach by approximately 40 metres of grassed foreshore reserve.

There are two creeks that cross the beach which are intermittently open. Blackwater Creek which is one third of the way from the southern end, drains the central catchment behind Mollymook, including the Mollymook Golf Club. Where Blackwater Creek flows under Mitchell Parade, the creek is constrained by the bridge pylons and by rip rap protection. The seaward 100 metres of the creek is unconstrained and the entrance moves to the north during storms when the Creek flows strongly. Major sewerage trunk lines are located close to the back beach with pumping stations located near the Golf clubhouse and on the northern side of Blackwater Creek entrance. The other small creek at the north end of the beach is piped under Mitchell Parade and again is free to migrate north along the beach during high flow events. There is no residential development immediately north or south of either creek entrance.

To the north of Blackwater Creek there is residential development on the seaward side of Mitchell Parade (south of Donlan Road) which is separated from the beach by a well vegetated dune 30 metres to 50 metres wide. This development is identified as an approved location for placing emergency erosion works and beach access under the Coastal Protection Act 1979 and is an identified erosion hotspot.

Along the central section of the Beach residential development is restricted to the western side of Mitchell Parade which in places is only 10 metres from the back of the beach. Rock reef can be seen on the seabed offshore from this section of the beach and Mitchell Parade deviates closer to the beach, occupying the landward section of the salient formed by this reef. Where Mitchell Parade deviates landward again to the northern intersection with Donlan Road, there is again residential development seaward of Mitchell Parade. These properties are separated from the beach by a narrow, vegetated dune/reserve. The houses are between 30 metres to 50 metres from the back of the Beach. At the northern end of the Beach there is further residential development separated from the Beach by Beach Road and a steeply grassed embankment. At the closest location, the seaward side of Beach Road is only 10 metres from the back of the Beach. At the northern end of Beach Road there is a toilet block and sewage pumping station at a low level immediately behind the beach.

B.4.2 Determining an Appropriate Planning and Policy Response

<u>Existing hazards</u>

Current concerns relate to the erosion of the Beach and dune face which separates the existing development and beachfront roads along Mollymook Beach.

At the southern end of the Beach the Golf clubhouse and sewage pumping station are protected by an engineered revetment at the back of the beach. Further north, the Ocean Street redevelopment is fronted by a vertical beach retaining wall. The development behind the Beach to the north of Ocean Street and south of Blackwater Creek entrance is generally more than 30 metres landward of the Beach and not at immediate threat. The sewer mains are located seaward of this development.

Residential development north of Blackwater Creek and seaward of Mitchell Road is separated from the Beach by a dune buffer and is not currently affected by erosion or inundation but is recognised as a potential erosion hotspot.

North of Donlan Road, Mitchell Parade veers towards the Beach and at its closest location is only 10m to 20m from the back beach, potentially at risk of being undermined during a severe storm event. Further residential development is located seaward of Mitchell Street around the northern intersection with Donlan Street and north to the northern creek entrance. At present there is a dune buffer of 30m to 50m wide seaward of the individual dwellings. Further north, development is landward of Beach road and elevated.

<u>Future hazards from sea level rise</u>

To facilitate analysis of risks, the likely impacts resulting from a sea level rise of up to 1m above present are considered. It is assumed that no action is taken to address these hazards over the intervening period. The future hazards include:

- Potential erosion of the foreshore – sea level rise will result in erosion of the foreshore and dune during storms with progressive recession of the dune face as sea level rise continues. For this purpose a recession of the shoreline of 50 metres for a sea level rise of 1m has been assumed. This allowance could be modified should bedrock outcrops exist landward of the present shoreline or at shallow depth under the Beach.
- Failure of protection works at the south end of the beach and seaward of Ocean Street as the beach width reduces and water depths increase, resulting in altered design conditions.
- Increased risk of wave overtopping and inundation.
- Erosion and recession of the back beach threatening sewerage infrastructure, roads and residential development

- Changes in entrance conditions and inundation levels adjacent to the two watercourses and low lying areas landward of the beach.
- Changes to groundwater levels.

Assets potentially affected

The following assets could be affected by a sea level rise of up to 1m:

- Failure of existing beachfront protection works (southern end)
- Erosion damage to seaward portion of Ocean Road and Surf Club
- Loss of residential development seaward of Mitchell Parade north of Blackwater Creek (300m) and at the northern intersection with Donlan Road (275m).
- Loss of sewerage infrastructure immediately behind the beach.
- Reduction in foundation capacity of existing development located landward of the dune escarpment.
- Loss of toilet block at the northern end of the beach.
- Potential loss of sections of Mitchell Street and Beach Road.
- Increased risk of flooding and costal inundation to creek structures and low lying areas landward of the Beach.
- Failure of stormwater infrastructure

Figure B4: Mollymook

South Coast Regional Sea Level Planning and Policy Response Framework

Whitehead & Associates
Environmental Consultants

Revision	A
Drawn	DJW
Approved	DJW

B.5 Batemans Bay – Surfside

B.5.1 Site Description

The study area incorporates that beach section extending from the Princes Highway Bridge over the Clyde River and along the northern foreshore of Batemans Bay for approximately 2km. (Figure B.5). The shoreline is seaward of Wharf Road, McLeod Street, Timbara Crescent and Myambla Parade and is the northern landward margin of the mobile entrance shoals at the Clyde River entrance. The section of shoreline is at the western end of Batemans Bay, approximately 8km from the open coast at the Bay mouth. The study area includes low lying areas of recreational land at the centre (landward of Timbara Crescent) and at the northern end of Myambla Parade which extend inland approximately 700m from the shoreline.

From the Clyde River Bridge, the shoreline is aligned approximately south-east to east for 400 metres and is protected by a rock foreshore wall. Seaward of Wharf Road the area is zoned public recreation open space and private recreation with a caravan park adjacent to the foreshore. Residential development is located on low lying land on the landward side of Wharf Road.

From the end of the rock wall seaward of McLeod Street is a 575m section of shoreline zoned Environmental Living with a single dwelling and associated buildings. At the western end of this beach section Wharf Road is located within a few metres of the beach face. This section of the shoreline has eroded over recent decades as the sand shoal seaward of the shoreline shifts, reducing the protection at the shoreline and allowing wave erosion of the foreshore. An old subdivision exists seaward of the shoreline on the seabed at this location where the sand shoals were once more prominent. There is a small creek entrance at the end of this beach section on the eastern side of Mundara Way which drains the catchment and low lying recreational land to the north.

There is a short (200m) section of curved sandy beach between the creek entrance and the rock outcrop on the western end of Myambla Parade. This beach section faces south west. and is low lying with recent erosion and recession of the shoreline an ongoing concern. The 6 residential properties along this beach section are seaward of Timbara Crescent, and the dwellings themselves are only 10m to 15m from the shoreline. Further residential development is sited north of Foam Street, along TImbara Crescent on low lying land adjacent to the small creek.

The final shoreline section extends from the end of Timbara Crescent approximately 900m on the seaward d side of Myambla Parade. This curved section of sandy beach faces south-east and includes the small rocky headland at the eastern end of Myambla Parade. Residential development extends along the Beach on the south-east side of Myambla Parade. This development is separated from the Beach by a low foredune and reserve approximately 30m wide. Further residential development is located in the low lying area to the west of Myambla Parade.

While located in the upper reaches of the Bay, the shoreline of the study area is exposed to ocean swells entering the bay during storms. Under most conditions the shoreline is quite sheltered but this can be deceptive. Stability and protection of the foreshore is dependent on the nearshore sand shoals and the supply of sand to maintain these shoals which reduce the wave impact. The foreshore stability is in a delicate balance with predominant sand transport at the shoreline occurring to the north-west and into the river while flows from the river scour sand and renourish the entrance shoals effectively recycling the available sand.

The shoreline at this location is also exposed to locally generated wind waves from the south-east sector.

B.5.2 Determining an Appropriate Planning and Policy Response

Existing hazards

Current concerns relate to erosion of the Beach and dune face which separates the existing row of residential development seaward of Timbara Crescent (6 properties) and the single residence seaward of Wharf Road. There is also residential development seaward Of Myambla Parade (approximately 38 dwellings) which will be at increasing threat from erosion as sea level rises and the beach retreats.

Along the southern portion of the study area, rock protection works have been placed to stabilise the foreshores on the north side of the Highway Bridge and incorporating the caravan park behind the foreshore. The current risk to development along this section of the foreshore is low.

Future hazards from sea level rise

To facilitate identification of risks, the likely impacts resulting from a sea level rise of 1m above present sea level are considered. It is assumed that no additional action is taken to address those hazards over the intervening period. The future hazards include:

- Potential erosion of the foreshore – sea level rise will result in erosion of the dune (Myambla Parade) during storms with progressive recession of the dune face and loss of foreshore reserve as sea level rise continues. Potentially recession of the shoreline up to 50 metres for a sea level rise of 1m has been assumed. This allowance may be modified should bedrock outcrops exist landward of the present shoreline or at shallow depth under the beach. The changes in foreshore alignment will also depend on the evolution of the entrance shoal which currently protect the shoreline and the rate of available sand supply from those shoals.
- Potential failure of existing protection works at the south end of the area as sea level rises and wave impact and overtopping increases resulting in altered design conditions.
- Increased risk of wave overtopping and inundation of foreshore reserves, roads and low lying development.
- Erosion and inundation of the back beach threatening sewerage and stormwater infrastructure.
- Changes in entrance conditions and inundation levels adjacent to the two minor creeks.
- Changes to groundwater levels.

Assets potentially affected

The following assets could be affected by a sea level rise of up to 1m:

- Failure of existing beachfront protection works (southern end)
- Increasing frequency of loss of access due to road inundation.
- Erosion of unprotected foreshores with potential permanent loss of road access along Wharf Road and McLeod Streets.
- Loss of residential development seaward of Wharf Road, Timbara Crescent and Myambla Road).

- Damage/failure of stormwater services to low lying areas landward (north) of Myambla Parade.
- Reduction in foundation capacity of existing development located landward of the receding dune escarpment.
- Potential inundation of existing development seaward of Timbara Crescent and Myambla Parade during storms.
- Elevated groundwater levels as sea level rises.

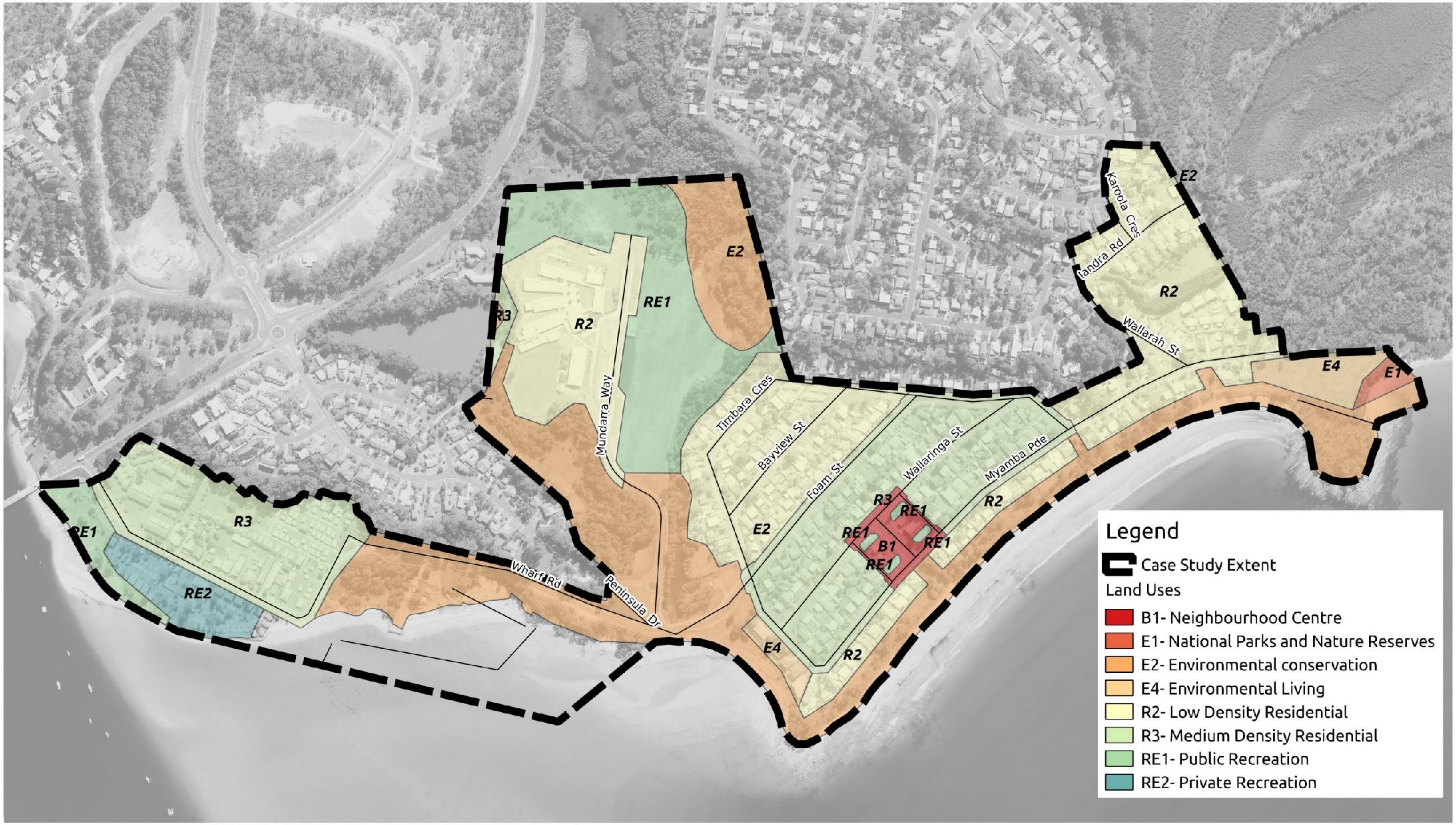

Figure B5: Batemans Bay Surfside

South Coast Regional Sea Level Planning and Policy Response Framework

N

Whitehead & Associates
Environmental Consultants

0 250 500 750 1000 1250 m
(Approx Scale)

Revision	A
Drawn	DJW
Approved	DJW

B.6 Batemans Bay Central Business District

B.6.1 Site Description

This study area includes the southern Batemans Bay foreshore and recreational waterway on the east side of the Princes Highway Bridge over the Clyde River. It extends approximately 3.3km along the southern foreshores of the Bay and incorporates the riverside portion of the CBD, residential development and recreational areas including the waterway, jetties, a marina and beach area (Figure B.6). It extends approximately 100m seaward of the rock wall into the river channel. The channel foreshore faces north-east before turning at 90 degrees where the Bay widens east of Catalina, forming a sandy beach (Corrigans) facing to the east.

The section of shoreline between the Clyde River Bridge and High Street is the commercial centre of Batemans Bay. The foreshore faces north-east and is lined by rock protection adjacent to the main river channel. South from the bridge there is a carpark along the foreshore seaward of Clyde Street for approximately 300m. Commercial development is located landward of Clyde Street. Between North Street and High Street (375m) the commercial development is adjacent to the foreshore with only a narrow recreational pedestrian path separating commercial development from the waterway. The area landward of the foreshore is mainly low lying with an increase in heights occurring closer to High Street.

For approximately 350m south-east of High Street to Pacific Street, the foreshore is backed by Beach Road and is protected by a rock seawall. Residential development is located on the western side of Beach Road on higher ground.

South-east of Pacific Street, the foreshore continues in a straight line while Beach Road curves inland and to the south, leaving a broader foreshore area zoned for public recreation and tourist uses. This includes the current marina development. Medium density residential development is located west of Beach Road and on the eastern side of Beach Road landward of the tourist zoning. This area is all low lying.

At the end of the rock training wall at Hanging Rock Place, the shoreline swings to the south forming the east facing Corrigans Beach, backed by private and public recreation areas. The boundary of the study area is the northern shoreline of a small lagoon and creek entrance approximately 600m south of the end of the river training wall.

While the shoreline along the rock training wall is dominated by estuarine processes, it is still overtopped by ocean swell from time to time. The area landward is in the main low lying and susceptible to infrequent inundation. It is largely protected from local wind waves with exposure limited to a small fetch to the north. The sandy beach area south of Catalina is directly exposed to ocean swell waves approaching through the Batemans Bay entrance. It is also exposed to local wind waves generated from the east to south east. Sand movement along this Beach is predominantly from south to north.

B.6.2 Determining an Appropriate Planning and Policy Response

<u>Existing hazards</u>

The CBD of Batemans Bay (western end of the study area) is low lying having been constructed on a section of infilled estuary/shoals. At present there is occasional nuisance flooding from the Bay due to wave overtopping during high tides and strong winds. There is also infrequent river flooding of the CBD and commercial buildings. The CBD river foreshores are protected by a seawall with low crest level along its entire length.

To the east of the CBD, the Beach Road is immediately landward of the foreshore and provides the main road access to the southern foreshores of the Bay. The road is low lying and increasingly at risk of inundation from the ocean. The foreshore is stabilised with protection works.

At Catalina the foreshore area is allocated to tourism and open space with the marina development adjacent to the foreshore. There is little hazard at present to these open space areas or to the low lying residential development at Catalina to the north east of Beach Road.

Future hazards from sea level rise

To facilitate identification of risks, the likely impacts resulting from a sea level rise of 1m above present were considered. It is assumed that no action is taken to address these hazards over the intervening period. The future hazards mainly relate to inundation from the ocean, flooding or a combination of the two and include:

- The current foreshore is protected by seawalls along the study area to Hanging Rock. The southern sandy shoreline, while exposed, is open space with limited development adjacent to the shoreline. Provided the sea wall is maintained/upgraded as required, there will be manageable hazard from foreshore recession.
- Changes to the entrance shoal configuration and potential relocation of the navigation channel and shoals – sea level rise will result in increased water depths, wave and flow velocities on existing stabilisation structures.
- Inundation of the CBD will continue to increase in frequency and intensity as sea level rises. Road access may increasingly be compromised and stormwater infrastructure will cease to function as tail water levels rise.
- Wave overtopping of seawalls will reduce the ambience and functionality of present water front open spaces landward of the seawall.
- Inundation of Beach Road will increase in frequency and volumes, potentially compromising its serviceability as a major distributor road.
- Tourism infrastructure will need to be upgraded to continue functioning (e.g. higher crest levels, longer boat ramps, stormwater drainage upgrades).
- Increased frequency of inundation across roads and low lying residential development at Catalina (north of Hanging Rock Place to the marina) potentially affecting over 100 residences and tourist/commercial properties..
- Increasing frequency in loss of access to individual dwellings due to inundation.
- Failure of stormwater drainage in low lying areas.
- Changes to groundwater levels.
- Recession of the shoreline and open space areas seaward of Hanging Rock Place.

Assets potentially affected

The following assets could be affected by a sea level rise of up to 1m.:

- Potential for river flood inundation to 1.0 m above existing flood levels. Low lying development may need to be relocated or abandoned. Development that is currently flood free may become flood prone.

- Increasing frequency and severity of ocean flooding during storms, cutting roads and backing up stormwater drains in low lying areas.
- Need for upgrade of existing seawalls and shoreline infrastructure (walkways, jetties, outfalls etc.) as sea level rises and depths increase.
- Damage to low lying road surfaces from frequent inundation and high groundwater levels.
- Inundation of commercial and residential property during more frequent coastal inundation events.
- Failure of some services in low lying areas.

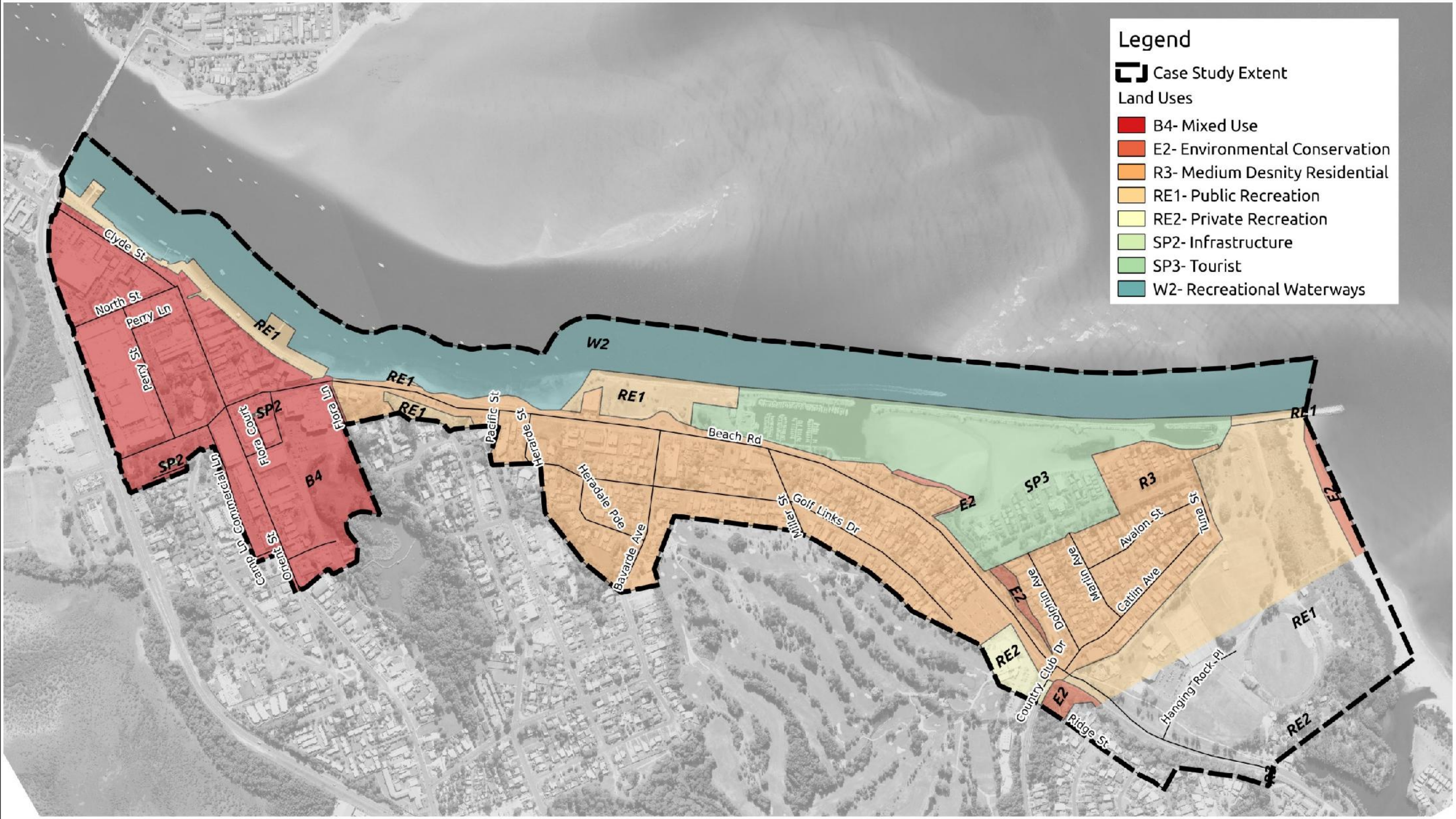

Figure B6: Batemans Bay Central Business District

South Coast Regional Sea Level Planning and Policy Response Framework

Whitehead & Associates
Environmental Consultants

0 250 500 750 1000 1250 1500 1750 m
(Approx Scale)

N

Revision	A
Drawn	DJW
Approved	DJW

B.7 Mossy Point / Tomakin

B.7.1 Site Description

The study area includes a section of coastline bound to the south by Mossy Point and including a small small semi-circular sandy beach to the north (approximately 1km long) and the rocky reef extending offshore from the southern end of Tomakin. The area of interest is approximately 1.6km in diameter and bounded by Annetts Parade to the south and George Bass Drive to the north-west (Figure B.7). It includes the south-western section of Tomakin village to the west of Ainslie Parade. It also includes the lower reaches of the Tomaga River and the ocean entrance. The river catchment covers approximately 98km^2 and the waterway area is 1.6km^2. It is presently tidal for approximately 11km upstream of the ocean entrance.

The ocean coastline is deeply embayed between the elevated rocky headland at Mossy Point to the south and the reef to the north. The short section of sandy beach is very sheltered with only a small number of dwellings located at the southern end of Tomakin, seaward of Reid Street and Kingston Place. The closest of these residences is approximately 40m from the Beach. The Tomaga River entrance is at the southern end of this beach, hard against the northern face of the Mossy Point headland. It is constrained by bedrock and only approximately 50m in width at the entrance (depending on the state of the tide). The entrance and channel face to the north east, extending around 500m landward from the beach before curving to the north. The river channel is separated from the ocean by a long sand spit extending 900m south-east from Tomakin township, almost to Mossy Point. This spit at its narrowest point is approximately 10m in width and is susceptible to breaching during storm events either from river scour on the western side or wave action on the eastern side.

Upstream from the entrance, the river channel meanders and widens to a maximum width of 225m adjacent to the Tomaga Tourist Park, south of the George Bass Drive Bridge.

The foreshores of the lower River are predominantly undeveloped with low density residential development restricted to two locations along the western foreshore at Mossy Point and the eastern foreshore at Tomakin. The front row of development in both locations abuts the river shoreline. There is also a small area of private recreational zoning for the Tomaga Tourist Park at the northern end of the study area, The Estuary is of high conservation value with much of the foreshore area zoned Environmental Conservation.

B.7.2 Determining an Appropriate Planning and Policy Response

Existing hazards

The extent of existing and future flood hazard within the estuary is currently being defined through a detailed flood study commissioned by Eurobodalla Shire Council.

Present concerns from erosion of the coastal and estuary foreshores are minimal with residential development located well back from the foreshore at Mossy Point and Tomakin. The open coast beach areas are undeveloped

Infrequent flooding of the lower estuary during ocean and catchment runoff events, potentially affects infrastructure along the foreshore (small jetties and two boat ramps.) There are also low-lying sections of road providing access to some residences along the western foreshore at Tomakin. The majority of the study area is undeveloped and in low lying areas includes high value ecosystems dependent on intermittent inundation.

The Tomaga Tourist Park at the western end of Tomakin is low lying with approximately 200 residential units adjacent to the estuary foreshore, There is a potential risk for breaching of the sand spit to the south of Tomakin which separates the Estuary from the ocean. At its narrowest section this spit is vulnerable to breaching during storm events. A breach of the spit would result in relocation of the entrance and realignment of the navigation channels until the spit re-establishes. This could impact navigability within the Estuary, particularly along the Mossy Point foreshore, if the existing entrance was to temporarily close.

Future hazards from sea level rise

The potential impact on the Estuary following a sea level rise will be clearer following the completion of the present flood study. The major impacts are likely to be to higher flood levels, resulting in permanent inundation of large areas of the current estuarine habitat, and increasing frequency and severity of both catchment and ocean flooding to low lying foreshores. The tidal exchange through the entrance may increase and the tidal effects will extend further up the catchment than at present. The ongoing evolution of the entrance and sand spit configuration is uncertain, currently being controlled by the bedrock outcrops seaward of the beach, the extent and level of these are not presently well defined. The future hazards include:

- Potential erosion of the estuarine foreshores as water depths and wave/currents change in response to sea level rise. Existing infrastructure may be at risk (jetties, boat ramps, stormwater).
- Inundation of low lying development, including the western foreshores of Tomakin and the Tomaga Tourist Park.
- Permanent inundation of existing intertidal estuarine habitat with longer term impacts on the ecology of the Estuary
- Potential changes to both the channel location within the estuary and the entrance configuration over time.
- Increased risk of wave overtopping/tidal inundation and the inundation of low lying accesses.
- Failure of existing foreshore infrastructure including stormwater drainage, jetties and boat ramps.
- Changes to groundwater levels.

Assets potentially affected

The following assets could be affected by a sea level rise of up to1m:

- Failure of existing foreshore infrastructure
- Loss of highly valued intertidal habitat areas
- Potential for inundation of low lying access, reserves and potentially some development along the Western Tomakin foreshore.
- Impacts from increasing groundwater levels and saline intrusion further into the Estuary
- Localised failure of stormwater drainage.

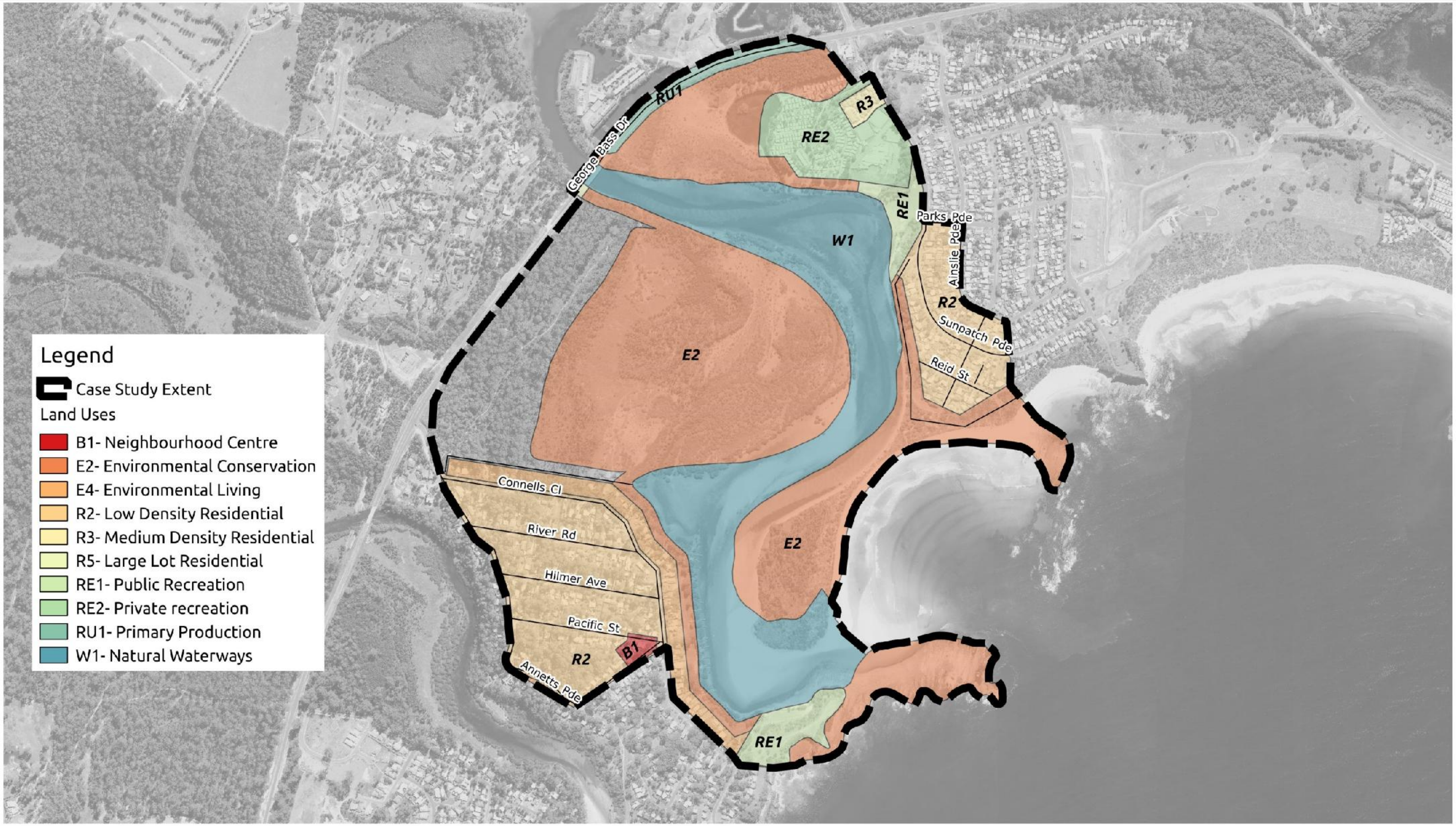

Figure B7: Mossy Point and Tomakin

South Coast Regional Sea Level Rise Planning and Policy Response Framework

Whitehead & Associates
Environmental Consultants

0 250 500 750 1000 1250 1500 1750 2000 m
(Approx Scale)

N

Revision	A
Drawn	DJW
Approved	DJW

Appendix C Framework Tables

Appendix C South Coast Regional Sea Level Rise Planning and Policy Response Framework: Guidance for Development Assessment Controls

The framework provided herein is not a prescriptive set of rules that must be adopted. It is provided as a guide for each of the Project Partners to assist with applying the sea level rise policy to their local planning needs. The guidelines must be used in conjunction with the recommendations from individual coastal zone and coastal floodplain management plans.

It is expected that land use planning and the preparation of development control plans will rely on the guidance herein but that local knowledge, the prevailing risk environment and judgement by Council staff will be required to make sound decisions.

Table C-1 Sea Level Rise Planning Framework: Example Development Controls for Varying CHPA and Development Type Combinations

Development Purpose	Current Hazard	Medium Hazard	Strategic	Possible Maximum Strategic
Single residential/habitable dwellings e.g. Medium Density Residential, Low Density Residential, Large Lot Residential	**Constraint Level:** Maximum -No Development Allowed -Minor Additions / Alterations allowed subject to strict controls	**Constraint Level** Severe • Adaptable Designs • Trigger Constrained Consent • Lightweight, easily removed or deconstructed designs • Floor levels set in accordance with triggers and expected life	**Constraint Level** High • Adaptable Designs • Trigger Constrained Consent • Lightweight, easily removed or deconstructed designs • Floor levels set in accordance with triggers and expected life	**Constraint Level** Low • Merit based assessment • Documented adaptability according to expected design life and nature of expected hazards • Otherwise, normal development assessment processes will apply
Residential Flats / Dual Occupancy e.g. Medium Density Residential, High Density Residential	**Constraint Level** Maximum No Development Allowed	**Constraint Level** Maximum No Development Allowed	**Constraint Level** High • Adaptable Designs • Trigger Constrained Consent • Lightweight, easily removed or deconstructed designs • Floor levels set in accordance with triggers and expected life	**Constraint Level** Low • Merit based assessment • Documented adaptability according to expected design life and nature of expected hazards • Otherwise, normal development assessment processes will apply
Residential Subdivision	**Constraint Level** Maximum No Development Allowed	**Constraint Level** Maximum No Development Allowed	**Constraint Level** High • Adaptable community layouts, e.g. shore normal roads and alignment • Trigger constrained consents • Detailed demonstration of adaptability over design life	**Constraint Level** Low • Merit Based • Design long term and major infrastructure to be outside of the maximum planning area

Development Purpose	Current Hazard	Medium Hazard	Strategic	Possible Maximum Strategic
Retail / Commercial / Industrial e.g. Neighbourhood Centre, Local Centre, Mixed Use, Business Development, General Industrial	**Constraint Level** Maximum **Development Controls** No Development Allowed	**Constraint Level** High **Development Controls** • Adaptable Designs such as triggered floor raising • Core infrastructure lifted above current flood levels with consideration of additional freeboard • Design for short design life • Lightweight, easily removed or deconstructed materials.	**Constraint Level** Moderate **Development Controls** • Adaptable Designs such as triggered floor raising • Core infrastructure lifted above current flood levels with consideration of additional freeboard • Design for short design life • Lightweight, easily removed or deconstructed materials.	**Constraint Level** Low **Development Controls** • Development Considered on Merit
Tourism	**Constraint Level** High **Development Controls** • Low Key tourist facilities allowed • Warning and Evacuation plans required • No hard infrastructure (e.g. toilet blocks or ancillary buildings)	**Constraint Level** Moderate **Development Controls** • Moderate scale tourist facilities allowed • Tents Caravans and Cabins • Ancillary Buildings allowed, but designed for adaptability and appropriate short life • Trigger based Consent	**Constraint Level** Low **Development Controls** • Development Considered on Merit	**Constraint Level** Low **Development Controls** • Development Considered on Merit