

Q8: Which topics generated the most productive discussion for the reference group:

Answered: 41 Skipped: 5

CC results

Northern Beaches Hospital Missed
Bus Rapid Transit
Pittwater Draft Public Space
Road Upgrades Mona vale Hospital

Other feedback that you would like to contribute?

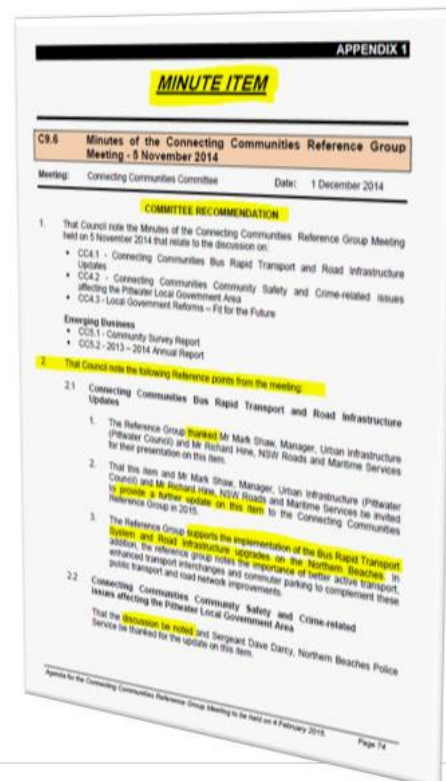
"It has been a privilege to be part of the group and strengthen my commitment to Pittwater."

"I would like to say that I do enjoy being given the opportunity to meet other members of our community and hear their point of view on the subjects chosen for our meetings and also being given correct information about vital subjects so that when challenged by our own members we can give them a more informed answer."

"It is important that the agendas and accompanying information are received early enough, so that there is opportunity to discuss items with the groups that we are representing. Voluntary groups do not meet so frequently that items can be discussed in a short time and if the information is not available early the group members are only able to represent their own point of view."

Existing Processes & Discussion

- Existing processes
 - Reference points
 - Agenda items
- Group Discussion
 - Report back



Overview

Reference Group Evaluation Survey
Upcoming term of Reference Groups
Reference Points
Existing process
Table Discussion Future improvements

Natural Environment Committee

10.0 Natural Environment Committee Business

C10.1	Draft Pittwater Estuary Mapping of Sea Level Rise Impacts Study - Community Engagement
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Meeting: Natural Environment Committee

Date: 2 March 2015

COMMUNITY STRATEGIC PLAN STRATEGY: Beach & Coastal Management Strategy
Land Use & Development

COMMUNITY STRATEGIC PLAN OBJECTIVE:

- To responsibly manage the risks associated with the coastal environment, including any exacerbated by global warming
- To ensure development responds to hazards and climate change
- To effectively respond to state and regional planning initiatives

DELIVERY PROGRAM ACTION:

- Consider the impacts of climate change and sea level rise into Council's policies, strategies and plans.
 - Develop, review and implement flood and coastal storm risk studies and plans in accordance with NSW Government guidelines
 - Monitor legislative and regulatory reforms relating to land use planning and respond and advocate on behalf of Council.
-

1.0 EXECUTIVE SUMMARY

1.1 SUMMARY

Pittwater Council has relied upon mapping prepared in 2004 as a part of the Pittwater Estuarine Planning Level Mapping Study in order to determine the extent of the estuarine inundation hazard for affected properties around the Pittwater foreshores and to inform development controls and hazard disclosures on s149 planning certificates.

The mapping was prepared without the benefit of spatial data developed from more recent Airborne Laser Scanning (ALS) and included an allowance for sea level rise of 0.2m over a 50 year planning horizon based upon the best scientific data available at that time.

Guidance in planning for sea level rise was provided by the NSW Government through a suite of documents including the *NSW Sea Level Rise Policy Statement (2009)* which included sea level rise planning benchmarks of 0.4m by 2050 and 0.9m by 2100. The Policy and benchmarks have since been repealed following a change of government in NSW.

Council independently adopted the state government's benchmarks for strategic planning purposes and commenced a review process to incorporate provisions for sea level rise in all relevant planning and management documents.

The Draft Pittwater Estuary Mapping of Sea Level Rise Impacts Study (2015) has undergone a lengthy process of revision and amendment in response to policy and legislative changes by successive NSW Governments and as a result the document now:

- amends the Draft Pittwater Foreshore Floodplain Mapping of Sea level Rise Impacts Study (2011);

- incorporates additional information following a review of the Mapping and Responding to Coastal Inundation Project (2012) prepared by the CSIRO for the Sydney Coastal Councils Group (SCCG);
- is consistent with the legislative and policy changes introduced as a result of the NSW Government's Stage 1 Coastal Management Reforms; and
- classifies coastal hazard risks such that Council is better able to comply with the disclosure requirements of Planning Circular PS 14-003 Coastal Hazard Notations, released in November 2014.

In light of the policy changes and following incorporation of new information and amendments as a result of statutory and policy requirements, the Draft Study provides:

- mapping of the extent by which all foreshore land around the Pittwater estuary is affected by the 100 year ARI estuarine inundation hazard for planning horizons of 2010, 2050 and 2100 utilising Council's adopted sea level rise benchmarks;
- classification of the subsets of properties in Pittwater subject to the 100 year ARI estuarine inundation hazard for the 2010, 2050 and 2100 planning horizons utilising Council's benchmarks; and
- calculations for new estuarine planning levels (EPLs) that will help determine the minimum floor level controls for all properties subject to an estuarine inundation risk.

2.0 RECOMMENDATION

1. That the Draft Pittwater Estuary Mapping of Sea Level Rise Impacts Study (2015), including the complete inundation mapping set and Estuarine Planning Level dataset, be placed on public exhibition for a period of six (6) weeks, from Friday 6 March 2015 to Friday 17 April 2015 with submissions invited from the community.
2. That the outcomes of the community engagement process and any proposed amendments to the Draft Study be reported to Council at the conclusion of the public exhibition period.
3. That Cardno (ACT/NSW) Pty Ltd, as the project consultant, be retained under Local Government Procurement contract to assist Council during the community engagement phase.

3.0 BACKGROUND

3.1 PURPOSE

To seek the approval of Council to undertake community engagement in regard to the draft Pittwater Estuary Mapping of Sea Level Rise Impacts Study (Draft Study) for a minimum period of 28 days and in accordance with the Community Engagement Plan prepared for the project.

3.2 BACKGROUND

In 2004, the Pittwater Estuarine Planning Level Mapping Study was prepared for Pittwater Council by Lawson & Treloar using 1% AEP storm tide data developed by the Estuary Processes Study (2003) and has been used to inform Council's Pittwater 21 Development Control Plan (P21 DCP) as well as s149 disclosures on planning certificates for properties affected by tidal inundation and wave action hazards.

The project also established Estuarine Planning Levels (EPLs) for 37 locations around the Pittwater foreshore. These EPLs were then used to calculate appropriate floor level controls for proposed new development on any of the affected properties. The EPLs included an allowance of 0.20m for projected sea level rise over a 50 year planning horizon based upon the best available scientific data at that time.

Subsequent to the release of the NSW Sea Level Rise Policy Statement and associated Sea Level Rise Planning Benchmarks by the NSW Government, Council engaged Cardno (ACT/NSW) Pty Ltd to review and updated the 2004 mapping and EPLs consistent with the NSW Governments Policy and benchmarks. Council had also independently adopted the SLR Planning Benchmarks for strategic planning purposes.

In accordance with the resolution of Council (Item C9.1, NEC 2/05/11), the revised mapping and new EPL database contained in the draft Foreshore Floodplain Mapping of Sea Level Rise Impacts Project were publicly exhibited for a period of 5 weeks community engagement during May and June in 2011. After the conclusion of the community engagement phase of the project, Council was made aware of the Mapping and Responding to Coastal Inundation Project which was undertaken by the CSIRO on behalf of the SCCG. Council resolved (Item C9.6, NEC 7/5/12) to engage Cardno to review the CSIRO mapping once it was finalised and released by SCCG.

At the end of 2012, the NSW Government reviewed the Stage 1 Coastal Management Reforms and announced that the NSW Sea Level Rise Policy Statement and associated Sea Level Rise Planning Benchmarks would be repealed. Coastal Councils were advised by the new state government to consider adopting their own local sea level rise projections that were widely accepted by competent scientific opinion in order to minimise their potential liability. On the basis of legal opinion provided by its insurance broker, Council continues to utilise the now repealed SLR Planning Benchmarks for strategic planning purposes.

As one of the outstanding tasks to complete the Stage 1 Coastal Management Reforms, the NSW Department of Planning & Infrastructure released *Planning Circular PS 14-003 Coastal Hazard Notations on section 149 planning certificates* on 13 November 2014. The planning circular requires councils to make a clear distinction between properties with a current exposure and those with a future exposure to a coastal hazard when making disclosures on s149 planning certificates.

A long and thorough process of review of Council's 2011 draft Foreshore Floodplain Mapping of Sea Level Rise Impacts Project has now been completed in response to policy and legislative changes introduced by the NSW Government. The resulting draft Pittwater Estuary Mapping of Sea Level Rise Impacts Study has been favourably assessed against coastal inundation mapping prepared by the CSIRO and now incorporates updated data from the most recent NSW cadastre.

3.3 POLICY IMPLICATIONS

- Estuarine Risk Management Policy for Development in Pittwater
- Pittwater Estuary Management Plan (2010)

As a consequence of adopting the hazard mapping and EPL database associated with the Study, it may be necessary to review the Estuarine Risk Management Policy for Development in Pittwater and amend related development controls and conditions of development consent contained in P21 DCP.

It will also be necessary to amend the list of affected properties that will require a relevant hazard disclosure on planning certificates issued under s149 of the *Environmental Planning & Assessment Act 1979* (EP&A Act).

3.4 RELATED LEGISLATION

- *Coastal Protection Act 1979* (CP Act) – An objective of the CP Act is to encourage and promote plans and strategies for adaptation in response to coastal climate change impacts, including projected sea level rise.
- *NSW Coastal Policy 1997* – An objective of the Policy is to ensure that climate change is recognised and considered.
- Planning Circular PS 14-003 Coastal Hazard Notations on Section 149 Planning Certificates – The Circular aims to ensure information on coastal hazards is relevant and clearly articulated.
- *Local Government Act 1993* – Section 733 of the Act provides councils with certain indemnities if coastline hazards are managed in good faith and in accordance with the provisions of a manual relating to the management of the coastline.

3.5 FINANCIAL ISSUES

3.5.1 Budget

- The costs associated with the preparation of the Draft Mapping Study prepared in 2011 were met in part by a grant contribution under the NSW Floodplain Management Program.
- Subsequent reviews and amendments of the Draft Study have been funded under Council's Delivery Program
- Council's consultant for the project, Cardno (ACT/NSW) Pty Ltd has estimated the cost of their professional services to complete the relevant tasks listed in the Community Engagement Plan to be \$17,390 ex GST.
- An allocation for all the proposed actions listed in the community engagement plan has been included in the current delivery plan.

3.5.2 Resources Implications

- Council will also be obliged to consider the potential impacts of estuarine inundation when developing new infrastructure and managing existing assets and infrastructure around the foreshores of the Pittwater estuary.
- An Estuarine Planning Level Request Service will be introduced to provide the applicable Estuarine Planning Level if required by landowners or other members of the public. Similar to the existing Flood Information Request Service operated by Council, the EPL Request Service will be a fee based service.

4.0 KEY ISSUES

4.1 Pittwater Estuarine Planning Level Mapping Study (2004)

Council adopted the Estuarine Planning Level Mapping Study in September 2004. The key outcome of the 2004 EPL Mapping Study was to determine an Estuarine Planning Level (EPL) for each property around the foreshore of the Pittwater waterway, which was calculated as a combination of:

- 100 Year Average Recurrence Interval (ARI); plus
- wind setup; plus
- wave setup; plus
- wave run-up (which is dependent upon the type of foreshore edge type or structure and the distance from the foreshore edge; plus
- an allowance of 0.2m for sea level rise; plus
- freeboard (which is generally 0.3m, but may vary from 0.0m to 0.3m at some locations)

Some 1,602 properties around the foreshore of the Pittwater estuary were identified by the 2004 EPL Mapping Study as having an estuarine risk and are currently subject to estuarine hazard notations on their s149 (2) Planning Certificates.

At the time LiDAR or Airborne Laser Scanning (ALS) topographical data was not available to the consultant.

4.2 Pittwater Estuary Mapping of Sea Level Rise Impacts Study (2015)

The key aims of the Pittwater Estuary Mapping of Sea Level Rise Impacts Study are to:

- review, update and expand the current Estuarine Planning Level Mapping to:
 - incorporate the Council's adopted sea level rise planning benchmarks (0.4m by 2050 and 0.9m by 2100);
 - utilise the more detailed topographical information from Council's ALS (2007) to determine the extent of inundation;
 - utilise the most up-to-date cadastral information to determine the properties that are affected by estuarine inundation;
 - develop more representative foreshore types that better define the foreshore localities of Pittwater to assist with the calculation of more accurate EPLs;
- update the Estuarine Planning Level database and associated mapping to inform the Estuarine Risk Management Policy for Development in Pittwater, Pittwater 21 Development Control Plan (DCP) and appropriate notations on Planning Certificates issued under s149 of the EP&A Act; and
- provide information about the likely current and future impacts of inundation exacerbated by sea level rise around the foreshores of the Pittwater estuary and convey this information to affected landowners in accordance with the requirements of Planning Circular PS 14-003 Coastal Hazard Notations.

Some 1,898 properties around the Pittwater estuary foreshores have been identified by the 2015 Draft Study as having an estuarine risk up to the year 2100. Of these 1,898 properties, 1,501 have been identified as having an estuarine inundation risk since 2004.

The 2015 Draft Study therefore identifies 397 more properties than the 2004 Study as having an estuarine risk up to 2100; however, 101 properties identified as having an estuarine risk by the 2004 Study have not been so identified by the 2015 Draft Study and will be removed from the database.

Consequently, an additional 296 properties around the Pittwater foreshores are now identified as subject to an estuarine inundation risk up to 2100 by the 2015 Draft Study when Council's adopted sea level rise benchmarks are applied.

4.3 Development of Affected Properties

The only significant change for properties affected by an Estuarine Inundation Risk will be the likelihood of higher floor levels being required for all new development to take account of projected sea level rise i.e. higher minimum floor level controls for all habitable structures. This change will affect new development only and will include alterations and additions.

As is currently the case, where development is proposed to be located on a property with an Estuarine Risk, an Estuarine Risk Management Report may be required in support of the Development Application depending upon the type, location and finished floor levels of the development proposed.

4.4 Public Exhibition and Community Engagement

Following Council's endorsement to place the Draft Study on public exhibition, the following community engagement activities will be undertaken to disseminate information and provide opportunities for community consultation and feedback:

- Public exhibition will run for a period of six weeks from Friday 6 March 2015 to Friday 17 April 2015. Copies of the Draft report and information sheets will be available at the Mona Vale and Avalon Customer Service Centres;
- On-line information including an electronic copy of the Draft Study report and mapping will be provided on Council's website. A link will be provided to an on-line comment form to enable the public to provide feedback to the project team.
- An on-line booking form will enable interested stakeholders to book a telephone call-back service or to book to attend one of two community information sessions that will include opportunities for individual face-to-face consultation with members of the project team;
- All affected property owners will also be directly contacted by letter which will include an information sheet and outline how they may take advantage of the available community engagement activities and feedback opportunities.

4.5 Actions Following Completion of Public Exhibition

Following the public exhibition phase, all submissions received will be considered and if required the Draft Study will be amended accordingly. The outcomes of the community engagement process and the final project report, mapping and estuarine planning level database will then be reported to Council for formal adoption.

Once adopted, the new mapping and database will be utilised to determine properties that are affected by an estuarine inundation risk and should be the subject of development controls under P21 DCP. These properties will also receive estuarine hazard notations on s149 Planning Certificates.

Information about the Inundation Risk Mapping and Estuarine Planning Level for an individual property will be made available upon application and after payment of the applicable fee via a new Estuarine Planning Level Request Service that will be similar to Council's existing Flood Information Request Service.

Feedback received during the public exhibition phase will also be utilised to inform a review of the Estuarine Risk Management Policy for Development in Pittwater and the relevant controls in P21 DCP. Any amendments that may be made to the Policy and P21 DCP will be reported and exhibited separately in accordance with the applicable statutory regulations.

Letters will be sent to all landowners whose properties were not identified as having an estuarine risk in the 2004 Study, but are identified as having an estuarine risk in the 2015 Study, to advise that their properties will now receive the relevant hazard disclosures on Planning Certificates issued under s149 of the EP&A Act.

Those landowners whose properties were identified as having an estuarine risk in the 2004 Study, but are not identified as having an estuarine risk in the 2015 Study, will also be advised by letter that their properties will no longer receive estuarine hazard disclosures on Planning Certificates issued under s149 of the EP&A Act.

5.0 ATTACHMENTS / TABLED DOCUMENTS

Attachment 1 - Pittwater Estuary Mapping of Sea Level Rise Impacts Study (Revised Draft Report, February 2015)

6.0 SUSTAINABILITY ASSESSMENT

6.1 GOVERNANCE & RISK

6.1.1 Community Engagement

- A community engagement plan has been prepared and costed for the current project and a précis of the main community engagement actions proposed has been included under the 'Key Issues' section of this report.
- Extensive consultation with affected stakeholders and interested members of the community has already taken place during and following the public exhibition in 2011 of an earlier version of the current Draft Study.
- The consultation included mail-outs to affected property owners, on-line information, on-line feedback to the project team, information and fact sheets as well as community information sessions with one-to-one consultation available.

6.1.2 Risk Management

- Given that additional foreshore properties have been identified in the Draft Study as subject to estuarine inundation hazards up to 2100, there is potential for greater than anticipated interest from affected stakeholders which could increase the cost of the community engagement process proposed.
- The Draft Study, once adopted by Council, will help to manage the identified risks associated with sea level rise and will inform other planning and management documents that Council is obliged by statute to prepare and administer.

6.2 ENVIRONMENT

6.2.1 Environmental Impact

- Nil impact.

6.2.2 Mitigation Measures

- The Draft Study has been prepared to specifically identify the potential impacts of sea level rise for foreshore lands located around the Pittwater estuary and will inform policy and actions that will help to mitigate those impacts.

6.3 SOCIAL

6.3.1 Address Community Need & Aspirations

- Amendments to the Estuarine Risk Management Policy for Development in Pittwater and associated development controls in Pittwater 21 DCP in response to new information developed by the Draft Study will help to reduce the vulnerability of new development to estuarine inundation hazards.

- Once adopted by Council the Draft Study will also inform disclosures on s149 Planning Certificates as to whether the land in question has a current or future exposure to coastal hazards.
- Greater community knowledge and awareness of the risks associated with estuarine inundation exacerbated by climate change impacts, particularly sea level rise, will also stem from the abovementioned actions.

6.3.2 Strengthening local community

- Once adopted the Draft Study will inform other plans and policies that will help to reduce risks associated with sea level rise for residents and businesses around the Pittwater estuary. As a consequence the community's resilience to sea level rise impacts is likely to be increased and the potential for social dislocation reduced.

6.4 ECONOMIC

6.4.1 Economic Development

- Nil impact.

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Pittwater Estuary Mapping of Sea Level Rise Impacts

**LJ2882/R2658v7 – Revised Draft Report
Prepared for Pittwater Council
February 2015**



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Cover Photo Source: View of Mackerel Beach foreshore, looking north-west. Cardno (June 2010)

Document Control

Version	Status	Date	Author		Reviewer	
1	Draft	July 2010	Shani Archer	SCA	Emma Maratea	ERM
			Sean Garber	SJG		
2	Draft	September 2010	Shani Archer	SCA	David van Senden	DvS
			Emma Maratea	ERM		
3	Draft	March 2011	Shani Archer	SCA	Louise Collier	LCC
			Emma Maratea	ERM		
4	Revised Draft	January 2012	Shani Archer	SCA	Louise Collier	LCC
5	Revised Draft	August 2013	Shani Archer	SCA	Emma Maratea	ERM
6	Revised Draft	January 2015	Shani Archer	SCA	Emma Maratea	ERM
7	Revised Draft	February 2015	Shani Archer	SCA	Emma Maratea	ERM

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- Appendix D Photo Log of Foreshore
- Appendix E Community Engagement Information and Results Summary

Glossary

Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
Average recurrence interval (ARI)	The long-term average number of years between the occurrence of a flood as big as or larger than the selected event. For example, floods with a discharge as great as or greater than the 20 year-ARI flood event will occur on average once every 20 years. ARI is a way of expressing the likelihood of occurrence of a flood event.
Barometric Setup	Mean sea level (MSL) rises in areas of low atmospheric pressure and falls in areas of high pressure.
Benchmarks	A standard by which something can be measured or judged. For example, predicted amounts of sea level rise to incorporate into planning considerations.
Cadastre, cadastral base	Information in map or digital form showing the extent and usage of land, including streets, lot boundaries, water courses etc.
Catchment	The land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.
Crest level	The level in metres Australian Height Datum (mAHD) of the top of a particular foreshore type.
Coastal inundation	The flooding of coastal lands by ocean waters. Severe coastal inundation is an infrequent event and is normally of short duration (peak flooding usually persists for several hours). In the case of the Pittwater Estuary, flooding may be caused by a combination of processes including high tides, storm surge and wave run-up onto the foreshore.
Coastal processes	Coastal processes are the set of mechanisms that operate at the land-water interface. These processes incorporate sediment transport and are governed by factors such as tide, wave and wind energy.
Coastal Zone	The coastal zone is the interface between the land and ocean. In NSW the coastal zone is defined by mapping prepared under the <i>Coastal Protection Act 1979</i> (Greater Metropolitan Region Maps 10, 11, 12 and 13).
Design storm event	A significant event to be considered in the planning process.

Development	<p>As defined in the <i>Environmental Planning and Assessment Act 1979</i> (EP&A Act).</p> <p>New development refers to development of a completely different nature to that associated with the former land use, e.g. the urban subdivision of an area previously used for rural purposes. New developments involve re-zoning and typically require major extensions of existing urban services, such as roads, water supply, sewerage and electric power.</p> <p>Infill development refers to the development of vacant blocks of land that are generally surrounded by already developed properties and is permissible under the current zoning of the land. Conditions such as minimum floor levels may be imposed on infill development</p> <p>Redevelopment refers to rebuilding in an area, e.g., as urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large scale. Redevelopment generally does not require either re-zoning or major extensions to urban services.</p>
El Niño-Southern Oscillation (ENSO)	<p>The term El Niño-Southern Oscillation (ENSO) describes a climatic cycle which oscillates between El Niño and La Niña conditions. It occurs due to changes in the strength of the Walker Circulation over the equatorial south Pacific. During El Niño conditions, which occur every three to eight years, drier conditions prevail, and average sea surface temperatures and sea levels are both lower. During La Niña conditions in Australia are generally wetter, and sea surface temperatures and average sea levels are both higher.</p>
Estuarine Flood Risk	<p>Also, referred to as estuarine or foreshore inundation risk. Foreshore inundation from a very high tide, combined with the effects of a storm event.</p>
Estuary Planning Level	<p>The combinations of elevated estuary levels (derived from significant historical ocean events or ocean levels of specific ARIs) and freeboards selected for estuarine inundation risk management purposes.</p>
Fetch	<p>The horizontal distance over which a wind blows in generating waves.</p>
Foreshore	<p>For the purposes of identifying the 40m setback from the foreshore, it has been assumed that the foreshore crest/edge is located at the 0.5mAHD contour.</p>

Foreshore type	The nature of the foreshore at any given location, e.g. retaining wall, sandy beach, rocky foreshore.
Flood	A general and temporary condition of partial or complete inundation of normally dry land areas, including inundation as a result of ocean storms and other coastal processes or catchment flows.
Flood damages	Potential damages associated with defined flood event expressed as monetary losses.
Flood hazard	The occurrence of a flood event with a defined exceedance probability.
Flood planning area	The area of land below the flood planning level and thus subject to flood related development controls.
Flood planning levels	The combinations of flood levels (derived from significant historical flood events or floods of specific ARIs) and freeboards selected for floodplain risk management purposes.
Flood risk	<p>Potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk is divided into three types, existing, future and continuing risks as described below:</p> <ul style="list-style-type: none"> ▪ Existing flood risk is the risk a community is exposed to as a result of its location on the floodplain. ▪ Future flood risk is the risk a community may be exposed to as a result of new development on the floodplain. ▪ Residual flood risk is the risk a community is exposed to after floodplain risk management measures have been implemented.
Freeboard	<p>Provides reasonable certainty that the risk exposure selected in deciding on a particular flood chosen as the basis for the EPL is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. Freeboard is included in the flood planning level.</p> <p>As a component of the EPL, a freeboard of 0.3m is added to the local (still) water level. For the purposes of the 'Estuarine Planning Level Request Service' the freeboard allowance will be included in the base EPL and would not be added separately.</p>
Geographical information system (GIS)	A system of software and procedures designed to support the management, manipulation, analysis and display of spatially referenced data.

Hazard	A source of potential harm. A situation that poses a level of threat to life, health, property, or the environment.
High Tide	The maximum height reached by a rising tide. The high water is due to the periodic tidal forces and the effects of meteorological, hydrologic, and/or oceanographic conditions.
Highest astronomical tide (HAT)	The highest level of water which can be predicted to occur under any combination of astronomical conditions.
Joint Occurrence	The occurrence of two or more processes at any given point in time. With respect to coastal processes, joint occurrence could include the simultaneous occurrence of high astronomical tides, storm surges and wind-waves which would lead to highly elevated water levels.
Mean High Water Springs (MHWS)	The MHWS is the highest level which spring tides reach on the average over a period of time (usually several years).
Mean Low Water Springs (MLWS)	The MLWS is the lowest level which spring tides reach on the average over a time period (usually several years).
Mean Sea Level (MSL)	MSL is a measure of the average height of the ocean's surface such as the halfway point between the mean high tide and the mean low tide. At present, mean sea level is approximately equivalent to 0mAHN.
Probability	A statistical measure of the expected frequency or occurrence of flooding.
Risk	The chance of something happening that will have an impact on objectives, usually measured in terms of a combination of the consequences of an event and their likelihood
Sea level rise (SLR)	A rise in the level of the ocean surface that is projected to occur in the future.

Section 149 Certificate	Under Section 149 of the <i>Environmental Planning and Assessment Act 1979</i> (EP&A Act), a local council will, upon application, issue a certificate providing information about planning controls or property affectations relating to any piece of land within the council area. A certificate issued under Section 149(2), which is compulsory in the sale of the property, provides information about the zoning of the property, the relevant state and local planning controls and other property affectations such as land contamination, road widening and whether or not flood-related development controls apply to the property. A Section 149(5) certificate provides additional advisory information that Council may be aware of on that land.
Tidal Flood Risk	Potential danger to personal safety and potential damage to property resulting from tidal inundation from a waterway onto surrounding areas within a floodplain.
Tidal flooding	The flooding of foreshore areas due to higher than average tidal levels.
Topography	A surface which defines the ground level of a chosen area.
Wave breaking	As waves increase in height through the shoaling process, the crest of the wave tends to speed up relative to the rest of the wave. Waves break when the speed of the crest exceeds the speed of the advance of the wave as a whole. Waves can break in three modes: spilling, surging and plunging.
Wave run-up	The vertical distance above mean water level reached by the uprush of water from waves across a beach or up a structure.
Wave set-up	The increase in water level within the surf zone above mean still water level caused by the breaking action of waves.
Wind set-up	The increase in mean sea level caused by the "piling up" of water on the coastline by wind.

1 Introduction

The foreshore areas of the Pittwater Estuary within the Pittwater Local Government Area (LGA) are subject to periodic inundation by coastal and estuarine processes.

Pittwater Council established the Estuarine Planning Level Mapping (Lawson and Treloar, 2004) using the best available shoreline terrain data and estimates of extreme ocean water levels at that time. These adopted planning levels incorporated an estimate of sea level rise of 20cm, which was considered appropriate in 2004.

In October 2009, the NSW Government adopted the Sea Level Rise Policy Statement (DECCW, 2009) which incorporates two sea level rise planning benchmarks for the NSW coast, namely 40cm by 2050 and 90cm by 2100. This has since been repealed, however Council have adopted the same approach to sea level rise in terms of these benchmarks.

Cardno (NSW/ACT) Pty Ltd was engaged by Pittwater Council to update the 2004 Estuarine Planning Level Mapping in accordance with adopted benchmarks for future sea level rise. In addition, the 2004 shoreline terrain mapping has been updated with Council's Airborne Laser Scanning (ALS) survey data (2007) validated through a field ground-truthing exercise. This updated terrain mapping, coupled with an understanding of the coastal and oceanographic conditions that lead to extreme water levels within the Pittwater Estuary have been used to derive estimates of inundation levels and extents for the Pittwater Estuary Foreshore for the updated Estuarine Planning Level Mapping (this report).

This study also includes mapping of the shoreline terrain of the fortnightly, monthly and six monthly high tide water levels as well as the 100 Year Average Recurrence Interval (ARI) ocean storm level under the existing (2010) conditions together with two sea level rise scenarios of 40cm by 2050 and 90cm by 2100.

1.1 Historical Planning Context

Appropriate building floor levels for the purposes of design and construction can often be obtained from NSW councils that are estimated from best available information on extreme water levels (i.e. occurring very infrequently) associated with catchment flooding and ocean processes. The floor levels are set to seek to minimise the potential for inundation during extreme flood events.

Pittwater Council previously commissioned Lawson and Treloar (now Cardno) to undertake the Pittwater Estuary Processes Study (2003) and the Estuarine Planning Level Mapping Study (2004). The Estuary Processes Study (Lawson and Treloar, 2003) described the general oceanographic, near-shore and beach processes influencing extreme water levels around the Pittwater shoreline. Water levels with an average recurrence interval (ARI) of 100 years were calculated around the foreshore of Pittwater. The estimates included the combined effects of the following processes:

- 100 Year ARI ocean storm tide;
- Wind setup; and
- Wave setup.

The storm tide level associated with oceanographic processes on a regional scale of hundreds of kilometres was assumed to be a constant level across the whole of Pittwater while the wind and wave setup estimates were assumed to vary with location around the Pittwater foreshore. These 100 Year ARI water level estimates were then used to inform Pittwater Council's 2004 Estuarine Planning Level Mapping Study. This study (Lawson and Treloar, 2004) established an Estuarine Planning Level (EPL) for each property around the Pittwater foreshore and adjacent low lying areas. EPLs were determined from estimates of the combined effects of the following processes and allowances:

- 100 Year ARI storm tide;
- Wind setup;
- Wave setup;
- Wave run-up, which is dependent on the type of foreshore or structure and the distance from the shoreline;
- An allowance of 0.2m for sea level rise; and
- A freeboard allowance of 0.3m.

Based on the results of the 2004 mapping, approximately 1,500 properties around Pittwater were identified as having an "Estuarine Risk" and were notated accordingly on their Section 149(2) Planning Certificates.

1.2 Project Scope of Current Study

This current study aims to update the previous (2004) mapping with more detailed terrain information provided by the recent ALS survey data (2007) and to incorporate the adopted benchmarks for future sea level rise.

The key aims of this study were to:

- Review, update and replace the current Estuarine Planning Level Mapping, established in 2004 to incorporate the sea level benchmarks of 0.4m by 2050 and 0.9m by 2100 (previously adopted in *NSW Government's Sea Level Rise Policy Statement*) (2009), within the framework of the NSW Floodplain Risk Management Process;
- Engage with the community to provide information about the likely existing and future impacts of tidal and extreme water level inundation due to sea level rise around the foreshore of Pittwater; and
- Update the Estuarine Planning Levels and associated mapping as an input to the Pittwater 21 Development Control Plan (DCP), which involves appropriate notations on Section 149(2) and Section 149(5) Planning Certificates.

1.3 Sea Level Rise Policy Context

This study was commenced in 2010 in accordance with the State Government's Sea Level Rise Policy Statement (DECCW, 2009) and the *Flood Risk Management Guide: Incorporating Sea Level Rise Benchmarks in Flood Risk Assessments* (DECCW, 2010a). Policy benchmarks were identified based on the findings of investigations undertaken by the Intergovernmental Panel on Climate Change (IPCC).

In late 2012, the NSW State Government repealed its sea level rise policy and benchmarks as part of its 'Stage One Coastal Management Reforms'. It was announced that councils would now determine their own sea level rise projections to suit their local conditions.

In response to this position by State Government, a recent paper by Whitehead & Associates Environmental Consultants (2014) was undertaken to develop regionally relevant sea-level rise projections for the NSW South Coast. The Whitehead & Associates report stated that based on their investigation, sea levels offshore of the NSW South Coast are expected to rise at a similar rate to the global average, and that any difference between the study area and Sydney will be minimal. Although not undertaken for the Pittwater Estuary itself, the results of the report considers that the modelled projections from the IPCC AR5 (2013) report are "widely accepted by competent scientific opinion", and therefore form a suitable basis for deriving local projections.

Council has adopted the State Government's former *Sea Level Rise Policy Statement* and the sea level rise planning benchmarks contained therein. As such, Pittwater Council will continue to utilise the former SLR planning benchmarks for strategic planning purposes until such time as SLR projections at a local scale are developed and supported by competent scientific opinion. The methodology employed in this study therefore remains unchanged.

2 Development in the Coastal Zone

The coastal zone is the interface between the land and ocean. These zones are important because the majority of the Australian population inhabits such zones. The coastal zone of Pittwater is no exception, with the foreshore (excluding that within the Ku-ring-gai Chase National Park) being dominated by urban development. Inundation of the coastal zone (and subsequent impacts on the urban development within this zone) can be caused by large waves and elevated water levels associated with a range of coastal and oceanographic process responses to severe storms. Within this study this is referred to as 'Estuarine Flood Risk'. The nature and extent of the inundation is dependent on the interactions between the ocean and the land. Thus, an understanding of the interactions of the ocean and the land is essential to identify the hazards within coastal zones.

In order to protect future development within the coastal zone from the identified hazards, it is necessary to ensure appropriate development controls are incorporated into proposed developments. Estuarine Planning Levels (EPLs) are applied as a method for managing risk along the foreshore of Pittwater. EPLs are applied under the *Environmental Planning and Assessment Act 1979*. More specifically, Pittwater Council's approach to managing this risk is set out in the *Estuarine Risk Management Policy for Development in Pittwater* (within the Pittwater Development Control Plan (DCP) 2009).

Estuarine Planning Levels calculated as part of the current study reflect the likely extreme water levels along the Pittwater foreshore that generally occur during an intense ocean storm (that may occur, on average, once in a lifetime or longer). Estimates of extreme water levels are based on the current understanding of the coastal processes.

2.1 Coastal Processes

To calculate appropriate EPLs it is necessary to understand the oceanographic and coastal processes impacting the foreshore. The following coastal processes have been considered in the determination of EPLs for Pittwater:

- Regional Processes (ocean scale of hundreds of kilometres);
- Local Processes (within Pittwater - scale a few kilometres); and
- Site Specific Processes (scales of tens of metres).

These processes are outlined schematically in **Plate 2.1** and described in more detail in the following sections.

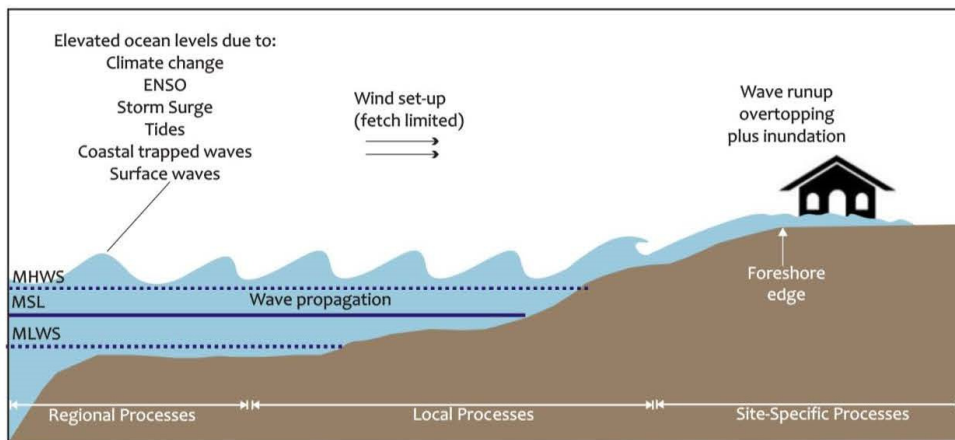


Plate 2.1 Coastal Processes Affecting Estuarine Planning Levels

Note: MHWS = Mean High Water Springs
MSL = Mean Sea Level
MLWS = Mean Low Water Springs

2.1.1 Regional Processes

Regional oceanographic processes relate to those ocean processes that are influenced by energy inputs causing sea level fluctuations over the larger scales of the NSW coastal waters and essentially affect coastal waters between Wollongong and Newcastle simultaneously (i.e. hundreds of kilometres of coastline). Coastal water levels in the study area region can be influenced by the following oceanographic processes:

- Astronomic Tides;
- Meteorological / Oceanographic Processes:
 - Storms Surge:
 - Barometric Setup.
 - Wind Setup.
 - Ocean Waves.
 - Coastal Trapped Waves.
 - El Niño-Southern Oscillation (ENSO).
 - Meteorological Oscillations.
 - Climate Change.
- Tectonic Processes.

Further details on these processes can be found in **Appendix A**. Tectonic processes are not considered in this assessment as they play a very minor role (and hence low risk) in the study area.

At times, these individual factors interact in complex ways to elevate water levels significantly above normal tidal levels. Storms with low central atmospheric pressure (barometric setup), strong onshore winds (resulting in wind setup) and large waves superimposed on spring (or king) tides, are the most common cause of elevated water levels (NSW Government, 1990). This is shown diagrammatically in **Plate 2.2**.

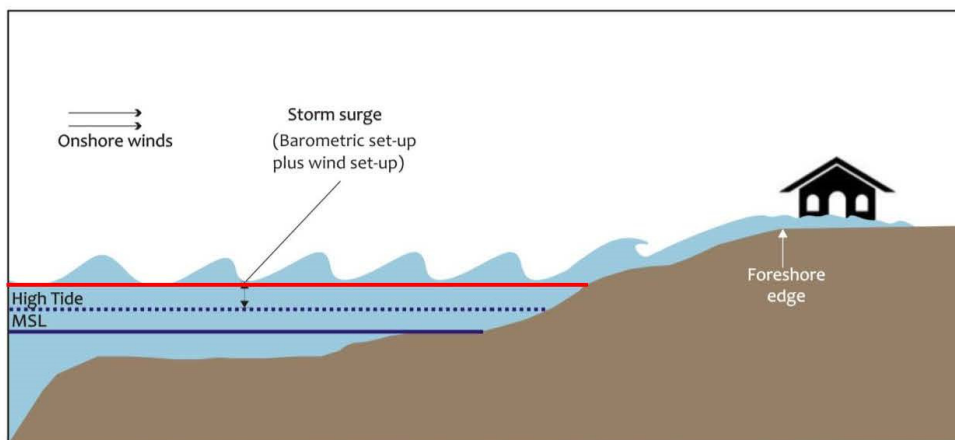


Plate 2.2 Regional Processes

Determining a regional elevated water level for planning purposes depends on the probability of that level occurring and the risk associated with it. Planning benchmarks are generally determined on the basis of an average recurrence interval (ARI), which relates the probability of a particular water level occurring. Department of Planning (2007) advises that for flood prone land unless there are exceptional circumstances, councils should adopt the 100 Year ARI flood levels for planning of residential development. This relates to the water level associated with a storm event that has the probability of occurring once every hundred years.

Sea level rise is likely to have an impact on flood levels in the future.

2.1.2 Local Processes

Local processes within the context of this study relate to the processes that cause variations in 'elevated local water levels' within the Pittwater Estuary. Water levels within the Pittwater Estuary will be influenced by local variations as a result of both wind strength and direction and waves.

Local Wind Setup

The same wind that adds to the regional storm surge in the form of wind setup will also cause further variation in the water level through wind setup developed over the Pittwater Estuary. This wind setup, however, is much smaller and is limited by the distance of water (fetch) over which the wind blows.

Wave Height

As discussed in **Section 2.1.1** ocean storms can contribute to elevated water levels along the coastline. Within the vicinity of the Pittwater Estuary, these ocean storms generally come from the east-north-east to south sector. Local wind generated waves can contribute to the elevated water levels as a result of ocean storms. The highest local wind generated waves will occur during storms that have south to easterly winds that 'push' water onto the coast. In this way the two processes (regional and local) are correlated and the likelihood the highest ocean water levels and highest local wind-generated waves occurring together

(joint occurrence) will be very rare on the westward and northward-facing shorelines of the study area.

Numerical wave modelling of the area (Lawson and Treloar, 2003) has shown that at the northern end of the Pittwater Estuary, swell penetration from the Tasman Sea will dominate wave climate, whereas in the southern portion of the Pittwater Estuary, wave climate will be dominated by local waves generated within the estuary itself.

Wave heights will vary depending on the location along the Pittwater foreshore. This is because as waves propagate from the deeper ocean into shallow water within Pittwater, the waves may undergo changes caused by refraction, shoaling, bed friction, wave breaking and, to some extent, diffraction.

2.1.3 Site Specific Processes

Site specific processes within the context of this study relate to the processes at the foreshore. The physical factors that will impact the elevated water level will be the nature of the foreshore (e.g. retaining wall or sandy beach, referred to in this report as “foreshore type”) and the height of the foreshore.

As a wave reaches the foreshore an ‘uprush’ of water onto the foreshore will occur, this is called wave run-up. The height of wave run-up is affected by the nature of the foreshore. Should wave run-up be large, wave overtopping may occur, which results in the temporary inundation of the foreshore area. The inland extent of the wave inundation is assumed to be 40m from the foreshore crest.

Site-specific processes are shown below in **Plate 2.3**. Detailed discussion of possible wave run-up mechanisms and their calculation is provided in **Appendix B**.

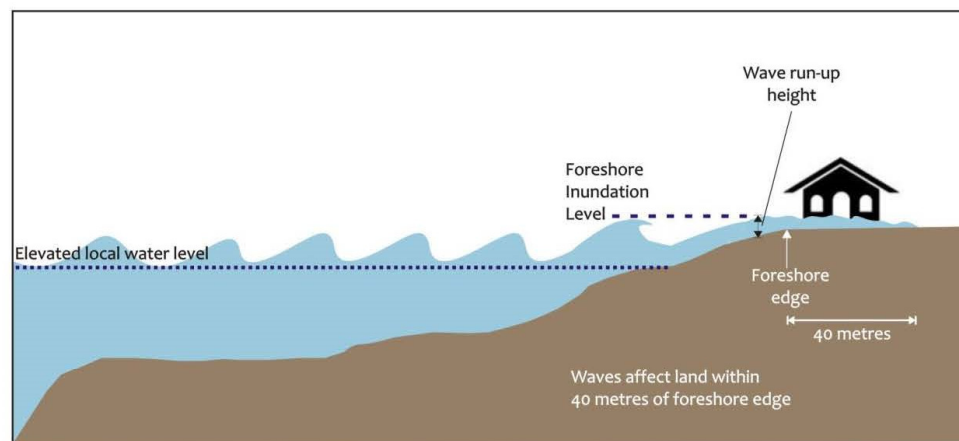


Plate 2.3 Site Specific Processes

3 Calculation of Estuarine Planning Levels

To manage estuarine flood risk around the Pittwater Estuary, Estuarine Planning Levels (EPLs) have been calculated to be used in Pittwater Council's planning and development assessment processes. This has been achieved by accounting for and calculating the following:

- Identifying the 100 Year ARI ocean tidal level and incorporating sea level rise;
- Calculating the wind setup and wave heights within Pittwater.
- Calculating wave run-up and overtopping, which requires:
 - Identification of the typical foreshore types around Pittwater; and
 - Calculation of the reduction in overtopping wave heights as a result of distance from the foreshore.
- Applying a freeboard to allow for any uncertainties primarily associated with local wave and wind action.

The components of the EPLs are shown diagrammatically in **Plate 3.1**. **Appendix C** provides summary tables for the components used in the calculation of Estuarine Planning Levels.

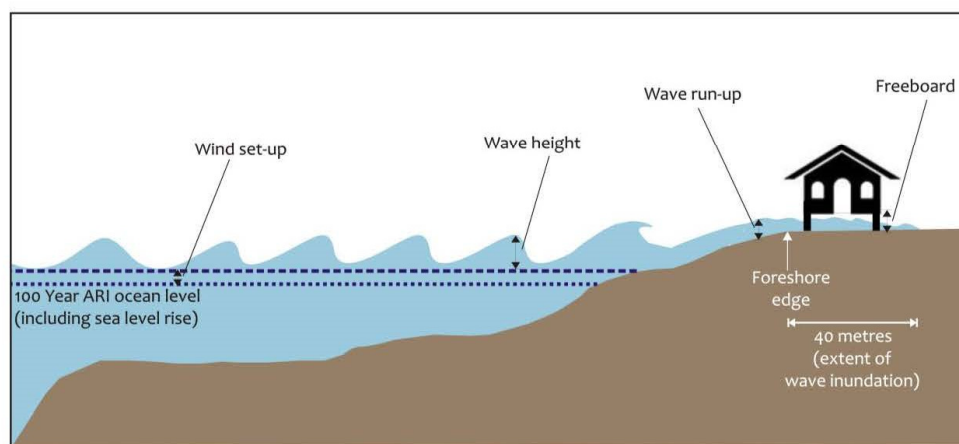


Plate 3.1 Estuarine Planning Level Components

3.1 Tidal Event Mapping and Sea Level Rise

It was considered appropriate to adopt the 100 Year ARI ocean water level event as the design event for planning purposes within the Pittwater coastal zone. In order to calculate the 100 Year ARI ocean water level, the Fort Denison tide gauge (Sydney Harbour) has been identified as an appropriate ocean water level gauge. This gauge data is applicable at Broken Bay (Pittwater) as the coastal processes, which contribute to the recorded levels, do not vary significantly between the two locations. Extremal analysis of the Fort Denison tide gauge data has been applied. The extreme water levels provided from this gauge provide a historical record of the combined effects of the processes described above. The 100 Year ARI level at Fort Denison was determined to be 1.4 mAHd (to one decimal place).

The extent of the 100 Year ARI ocean water level has been mapped using Airborne Laser Scanning (ALS) elevation data for the study area, and local survey data, where available (i.e. at the Careel Creek Barrenjoey Road culvert and upstream in the main channel of Careel Creek). In addition to the 100 Year ARI ocean water level, Pittwater Council identified the need to consider several other tidal levels for planning purposes. These other levels have not been incorporated into the calculation of EPLs. However, the extents have been mapped along with the 100 Year ARI ocean water level extent for future use by Council.

To provide an estimation of the projected impact of sea level rise on these tidal events, predicted sea level rise was applied based on the sea level rise benchmarks for 2050 and 2100 and the guidelines provided in the *Coastal Risk Management Guideline: Incorporating sea level rise in coastal risk assessments* (DECCW, 2010b). Table 3.1 provides the levels that were used with the present day levels, based on 2009 recorded tidal levels.

Table 3.1: Present Day, 2050 and 2100 Ocean Levels

	Present Day Level (nearest 0.1m)	2050	2100
Predicted Sea Level Rise	0 m	0.4 m	0.9 m
Fortnightly High Tide (Still Water)	0.6 mAHD	1.0 mAHD	1.5 mAHD
Monthly High Tide (Still Water)	1.0 mAHD	1.3 mAHD	1.8 mAHD
Bi-annual (Six-monthly) King Tide (Still Water)	1.2 mAHD	1.6 mAHD	2.1 mAHD
100 Year ARI Ocean Water Level*	1.4 mAHD	1.8 mAHD	2.3 mAHD

*Does not include wind set up or wave run up.

Tidal mapping for the present day and the 2050 and 2100 sea level rise scenarios is provided in Figures 3.1 to 3.4.

Sea level rise has been incorporated into the determination of Estuarine Planning Levels (EPLs) by calculating EPLs for 2050 and 2100 (in addition to 2010). This has been undertaken by incorporating the 2050 and 2100 sea level rise predictions of 0.4m and 0.9m respectively (DECCW, 2010a) in the 100 Year ARI ocean water level.

3.2 Wave Height and Wind Set-up

When selecting a design event upon which to calculate local wave heights, the likelihood of those waves occurring at the same time as the 100 Year ARI ocean water level was considered. Therefore, the following design events have been adopted for local wind generated waves for the various locations around the Pittwater foreshore:

- Where swell processes dominate (Northern end of Pittwater), the 100 Year ARI wave conditions are likely to be associated with the 100 Year ARI ocean water level;
- For locations east of Church Point, the 100 Year ARI ocean water level is not likely to be associated with 100 Year ARI local sea waves and as such the 50-year ARI local sea waves have been used in the computation of the design water level; and
- For locations west of Church Point, the 100 Year ARI ocean water level is likely to be associated with the 100 Year ARI local sea waves.

Wind setup values and wave parameters were adopted from the results of the Pittwater Estuary Processes Study (Lawson & Treloar, 2003).

To account for the local variations in wind setup and wave height around Pittwater, the wind setup and wave heights were calculated at 37 locations around the foreshore. These locations represent areas of similar wave and wind conditions. The locations are shown on Figures 3.1 to 3.5.

3.3 Wave Run-up and Overtopping

The height of wave run-up and the depth of overtopping are dependent on the foreshore type and the height of the foreshore edge (crest level). The inland extent of the wave inundation is assumed to be 40m from the foreshore crest. Therefore, the EPL applied to a development depends on the distance of the development from the foreshore edge.

3.3.1 Foreshore Types

The nature of the foreshore (foreshore type) is critical in the calculation of wave run-up and overtopping. The Estuary Planning Levels determined in 2004 (Lawson and Treloar) incorporated five foreshore types that were assumed to be representative of the foreshore types present. These included:

- 1 in 10 sandy beach (no crest height);
- Vertical wall, crest at 1.5m AHD;
- Vertical wall, crest at 2.0m AHD;
- 1 in 2 sloping rock revetment wall (no crest height); and
- Natural rocky shoreline (no crest height).

As part of the current project, Council identified the need to verify the appropriateness of the foreshore types used in the calculations and to incorporate appropriate crest heights for all foreshore types.

Field inspections were undertaken by boat of the entire Pittwater foreshore on 8 June 2010. Photographs were taken using a GPS camera to capture the foreshore character and typical foreshore types were subsequently identified. Photograph locations were then compiled in GIS and observed foreshore types were spatially delineated.

The field inspection demonstrated that the predominant foreshore type for the developed parts of Pittwater foreshore is sea walls of varying heights (typically 1-1.5 m high). Natural rocky shoreline and natural slope (grassed and/or sandy) were the other typical foreshore types observed. Mangroves were also observed in Careel Bay. **Appendix D** provides some photographs of typical foreshore types around Pittwater.

The typical foreshore types around Pittwater are shown on **Figure 3.5**. It should be noted that these are typical only and do not accurately represent the actual foreshore type for every property. Property owners or developers have the opportunity to select the appropriate foreshore type for their property when calculating an Estuarine Planning Level (EPL).

For the purposes of calculating EPLs for the current project, the following idealised foreshore type categories have been incorporated into the updated calculations:

- 1 in 10 natural slope (representing grassed and sandy gently sloping foreshores);
- 1 in 5 rocky shoreline (representing natural rocky foreshore or sloped rip rap);
- Vertical sea wall (e.g. block work or other retaining walls); and
- Mangroves.

For these foreshore type categories, with the exception of mangroves, calculations were undertaken for three foreshore crest levels, being:

- 1.0mAHD;
- 1.5mAHD; and
- 2.0mAHD.

It should be noted that EPLs for crest levels less than 1.0mAHD will be equivalent due to inundation by the local water level.

3.3.2 Inland Extent of Wave Overtopping

Where a block slopes steeply back from the shoreline edge structure, the EPL may affect only a small part of the block. However, where a block is relatively flat, wave run-up may penetrate some distance inland, but is attenuated by percolation and friction. This landward reduction of wave inundation cannot be estimated with great confidence, and has been based on observational experience.

It is assumed that wave run-up diminishes to zero at a point 40m inland from the edge structure. This means that at the foreshore, the EPL is set to the “maximum EPL” and at 40m from the foreshore the EPL is set at the local (still) water level. A linear interpolation has been used to calculate the EPL for areas between 0m and 40m from the foreshore, as shown in Plate 3.2.

This assumption has been based on reported observations, newspaper reports and personal communications at coastal locations in NSW, including Avoca Beach on the central coast (Surf Life Saving Club car park & Fig Street, Avoca), and Surf Beach and Kiama Park on the south coast.

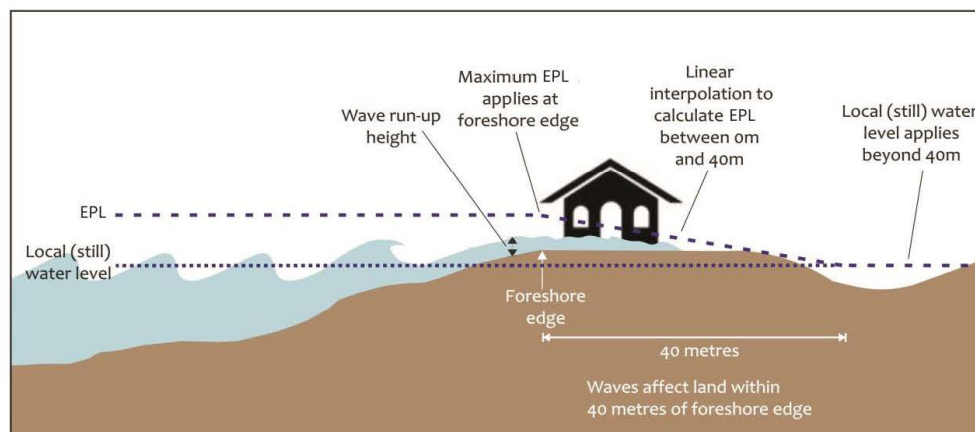


Plate 3.2 Calculation of Landward Reduction in Wave Inundation

3.4 Freeboard

The estimation of all of the components that make up the EPL at each selected location includes some uncertainty, and the degree of uncertainty varies with each water level component. It is greatest for wave run-up; and wave run-up is normally the largest water level component, other than astronomical tide.

It is common practice to take some precaution over this uncertainty. This is generally achieved through the application of a freeboard. A freeboard of 0.3m is considered appropriate for the definition of the EPL.

Prior to explicit incorporation of provision for sea level rise in planning levels, a freeboard of 0.5 m has commonly been adopted in NSW, incorporating a 0.3 m freeboard with an additional 0.2 m to account for potential sea level rise (much less than the current predicted sea level rise).

As a component of the EPL, a freeboard of 0.3m is added to the local (still) water level. For the purposes of the 'Estuarine Planning Level Request Service' the freeboard allowance will be included in the base EPL and would not be added separately.

It should be noted that the freeboard has not been included in the provisions of flood extents to identify flood affected properties. However, those properties identified as being affected by coastal inundation would have a freeboard included in their EPL. This is discussed further in **Section 4.1**.

3.5 Planning Horizons

Flood risk management and coastal management often take into consideration a 100 year planning framework to account for changes over that time period. In the case of sea level rise, planning horizons have already been specified, as per the IPCC Climate Change Assessment (IPCC, 2013).

As such, planning for a 100 year time scale from current conditions is more challenging with the prospect of sea level rise. Potential back-calculation of the rate of rise is relatively complex, since the IPCC report (2013) shows the projected rate of sea level rise is likely to occur exponentially over the long term. This is due to the nature of the physical processes driving climate change, and means that calculations performed are unlikely to be particularly accurate when based on a linear approach.

As an alternative, taking the worst case rate of climate change and adding to existing levels each year is one approach that could be used. Council would then need to review their Climate Change Policy every 5-10 years, and all EPLs would be increased accordingly with each revision.

4 Properties Affected by Estuarine Planning Levels

4.1 Identifying Affected Properties

Those properties affected by Estuarine Planning Levels (EPLs) have been identified using EPL extents generated from the EPL calculations described in this report and the Airborne Laser Scanning (ALS) survey for the area.

Properties within the following extents are affected by EPLs:

- The Local Water Level Extent: this is the 100 Year ARI ocean water level plus local wind setup; AND
- The 'Worst Case' 'Maximum' EPL Extent within 40m of the foreshore: this is the highest wave run-up and overtopping level possible at that location. It should be noted that no reduction factor has been applied to the overtopping height. For the purposes of identifying the 40m setback, it has been assumed that the foreshore crest/edge is located at the 0.5mAH contour.

The combination of these extents is shown as the EPL extent on **Figures 4.2A to 4.2H** (with the mapping areas used for these figures shown on **Figure 4.1**). The EPL extents are shown for the 2010, 2050 and 2100 sea level scenarios. It should be noted that no freeboard has been applied for the purposes of mapping the extents. However, a freeboard of 0.3m will be applied for all planning levels issued to properties (as discussed in **Section 3.4**)

The properties within the EPL extents (for 2010, 2050 and 2100) are shown on **Figures 4.3A to 4.3H**.

4.2 Properties Affected by Estuarine Planning Levels

The incorporation of updated equations and foreshore types into the calculation of the EPL and the use of the 2007 ALS survey data has resulted in a marginal decrease in the number of properties affected by EPLs for 2010, but an increase for 2100. A summary of the number of properties affected by an EPL under the various scenarios has been provided in **Table 4.1**.

Table 4.1 Properties Affected by Estuarine Planning Levels

Scenario	Number of Properties
Properties identified with Estuarine Risk (2004)	1,556
Properties Identified with 2010 (existing) Estuarine Flood Risk (current study)	1,466
Properties Identified with 2050 (future) Estuarine Flood Risk (current study)	1,663
Properties Identified with 2100 (future) Estuarine Flood Risk (current study)	1,898

In calculating the number of properties affected in the 2010 scenario, it is noted that the floodgates along Pittwater Road have been assumed to be in operation during a flood event. This hydraulic control would provide effective flood mitigation in the 2010 scenario, however, with projected sea level rise, the road itself is likely to be breached during a flood event and the flood gates would be rendered inoperable. This is certainly the case for the 2100 SLR scenario. The 2050 SLR scenario appeared to have very minor road overtopping, however a conservative approach has been adopted and so these properties have been included in Table 4.1 and the database of affected properties.

4.3 Public Access to Estuarine Planning Levels

The EPL for any proposed development on properties within 40m of the foreshore edge is calculated for the proposed foreshore type (or existing if to remain the same after the development) and the distance of the development from the foreshore edge. The resulting EPL will account for the 'local water level', wave run-up and overtopping and the reduction in the wave height as a result of distance from the foreshore, plus a freeboard of 0.3m, as described in Sections 3.3 and 3.4.

The EPL for any proposed development on properties beyond 40m of the foreshore edge will be equal to the 'local water level' at the property location, plus a freeboard of 0.3m.

For the purposes of notifying affected property owners, a draft database has been prepared as part of the current study for Council. The draft database divides properties into one of seven types, as outlined in Table 4.2.

Table 4.2 Property Types for Public Notification

Property Type	Number of properties
Type 1: Property identified as Estuarine Risk (2004) – to be removed under current study	101
Type 2: Property identified as Estuarine Risk (2004) — to be revised to 2010 (current) Estuarine Flood Risk	1,392
Type 3: Property identified as Estuarine Risk (2004) — to be revised to 2050 (future) Estuarine Flood Risk	39
Type 4: Property identified as Estuarine Risk (2004) — to be revised to 2100 (future) Estuarine Flood Risk	70
Type 5: Property not identified as Estuarine Risk (2004) — to be revised to 2010 (current) Estuarine Flood Risk	74
Type 6: Property not identified as Estuarine Risk (2004) — to be revised to 2050 (future) Estuarine Flood Risk	129
Type 7: Property not identified as Estuarine Risk (2004) — to be revised to 2100 (future) Estuarine Flood Risk	194

Note: Changes in the cadastre have occurred in the time since 2004 (e.g. lot amalgamation, especially in the vicinity of the National Park). Some changes in property numbers are due to this.

Property Types 2, 3, 4, 5, 6 and 7 will have a Flood Category of "Foreshore Inundation Risk" for the purposes of mapping and flood-related development controls to inform the application of the Pittwater 21 Development Control Plan and notations for Section 149(2) Certificates.

5 Community Engagement

Community engagement represents a key component of the project. The foreshore properties affected are predominately residential properties and community understanding and acceptance is critical to the implementation of EPLs. In addition, the presentation of likely sea level rise impacts to the community is a key component of this study. The following outlines the key components of the community engagement process to facilitate feedback from the community:

- Presentation to the Pittwater Estuary Community Working Group;
- Councillor Briefing and Public Exhibition;
- Letters to Affected Properties; and
- Community Call-back Service and Information Sessions.

Due to changes in State Government and Council policy regarding climate change, it is intended that this document will be made available for public exhibition for a second time prior to finalisation of the study.

These components of the community engagement strategy are discussed below.

5.1 Pittwater Estuary Community Working Group

The Pittwater Estuary Community Working Group was initially established to assist Council in the Estuary Management process. However the role of the group has been expanded so that they now also provide assistance in the Flood Risk Management process, including providing input on sea level rise.

Cardno presented the draft findings of this project to the Community Working Group on 16 June 2010. Prior to the meeting Cardno had completed the ocean water level mapping (including two sea level rise scenarios) and mapping of the 2004 EPLs (including two sea level rise scenarios) and had also undertaken the ground-truthing. The results of these tasks were presented to the Community Working Group along with some background to the project. Following the presentation, discussions were held with the Group regarding the way properties would be included in the EPL extent and the implications of climate change on Pittwater and the estuary foreshore.

5.2 Previous Public Exhibition and Community Engagement

With the completion of the draft version of this report and mapping, a program of community engagement was undertaken to communicate the results of the assessment to provide opportunities for community feedback. The following community engagement strategy was undertaken to progress the project through the public exhibition phase:

- **Councillor Briefing** — Pittwater Council's elected councillors were briefed by council staff in April 2011;
- **Question and Answer Sheet** — A question and answer sheet was prepared to facilitate discussions with the community. A copy was sent to all affected properties and was made available to download from Council's website (a copy of the question and answer sheet is provided in **Appendix E**);

- **Public Exhibition** — The draft report and associated mapping was reported to Council's elected representatives at a Council meeting in early May 2011, where it was recommended that the report and mapping be placed on public exhibition during May and June 2011;
- **Online Information and Feedback** — Immediately following endorsement from Council to place the draft final report and mapping on public exhibition, the following information was uploaded to Council's website:
 - An explanation of the project and the progress to date;
 - A copy of the draft report;
 - Copies of the inundation map series (Figures 4.2A to 4.2H) and affected property map series (Figures 4.3A to 4.3H);
 - On-line comment form;
 - Question and answer sheet; and
 - On-line booking form to make an appointment to discuss the project with the project team via the call-back service or for one of two community information sessions;
- **Letters to Affected Properties** — Immediately following endorsement from Council to place the Draft Report and Mapping on public exhibition, individual letters were sent to all affected property owners outlining the following information (a copy of the information sheet and generic letter are provided in **Appendix E**):
 - The background to the project;
 - Information about sea level rise;
 - How to view maps and make comments on-line;
 - Details and how to book in to the community information sessions; and
 - A copy of the question and answer sheet;
- **Community Call-back Service** — Council collated all incoming phone calls and on-line comments and Cardno representatives provided a call-back service to interested residents. Four days of community call-backs were undertaken on the following dates:
 - 17 May 2011;
 - 26 May 2011;
 - 2 June 2011; and
 - 7 June 2011.
- In addition, residents were advised that if they were unavailable on all of the above dates, a special appointment could be made at a time that suited them;
- **Community Information Sessions** — to provide additional and one-on-one face-to-face information to the community, two community information sessions were held on the following dates:
 - 24 May 2011 (in Mona Vale); and
 - 31 May 2011 (in Avalon).

5.3 Results of Community Engagement to Date

The community call-back service and community information sessions allowed members of the community to individually discuss the project with Council staff and consultants. Via an on-line booking system, telephone or in person, the community were able to book a 15 minute one-on-one meeting to discuss the findings of the study.

For the community call-back service, a total of 30 bookings were made for the four days (with an approximate average of 8 bookings per call-back day). For the information sessions, a total of 20 bookings were made for the two days (with an approximate average of 10 bookings per day). Overall, a sum total of 50 bookings were made, which represents a reasonable response rate when compared to other community engagement programs undertaken by Council.

Although the formats differed, residents tended to ask similar questions and raise similar issues at both consultation session types (call-backs and information sessions). In general, residents interested in gaining an understanding of:

- A general overview of the study and what it entailed;
- The proposed EPL at their property;
- How their property would be affected by sea level rise; and
- How the proposed EPLs would affect their property (especially in relation to dwelling extensions, redevelopment, foreshore structures and property sale).

Other comments from residents included improvements to the readability of some of the maps and also to Council's online planning levels tool. Comments on the study methodology and report text were minimal.

A number of additional issues were raised by the community that did not fall into the scope of this study. These have been summarised and forwarded separately to Council, where the relevant Council staff will be informed of each issue so that it can be addressed.

Appendix E provides a summary of each community engagement appointment in terms of the key issues raised. Note that names and addresses have been removed to uphold privacy.

5.4 Revised Draft Report

The feedback received during the public exhibition period has been incorporated into a revised draft version of the document and mapping. Due to the time elapsed since the public exhibition period and changes in state and Council policy regarding sea level rise, the revised draft will be put out on public exhibition for a second time to allow the community to review any changes that may have occurred.

The public exhibition period will involve the provision of the study both in hard copy and online, opportunity for public feedback and a letter will be sent to all affected properties notifying them of the revised study and the opportunity to comment.

5.5 Finalisation of Report and Mapping

Following the second public exhibition phase, the outcomes of the exhibition will be incorporated into this document and mapping. The final report and associated mapping will be reported to a Council meeting with the recommendation that it be adopted by Council.

The adoption of the final report and mapping by Council will result in the new estuarine planning levels (EPLs) and relevant Section 149 notations on planning certificates being applied to all properties identified as subject to an estuarine inundation risk.

A revision of Council's Estuarine Risk Management Policy for Development in Pittwater as well as Pittwater 21 Development Control Plan (DCP) may also be required and would be exhibited in accordance with the applicable statutory requirements and Council's community engagement policy.

6 Assumptions and Qualifications

This document has been prepared using spatial information, reports, policy documents and legislation as referenced in the text and assumes this available information is accurate at the time of report preparation.

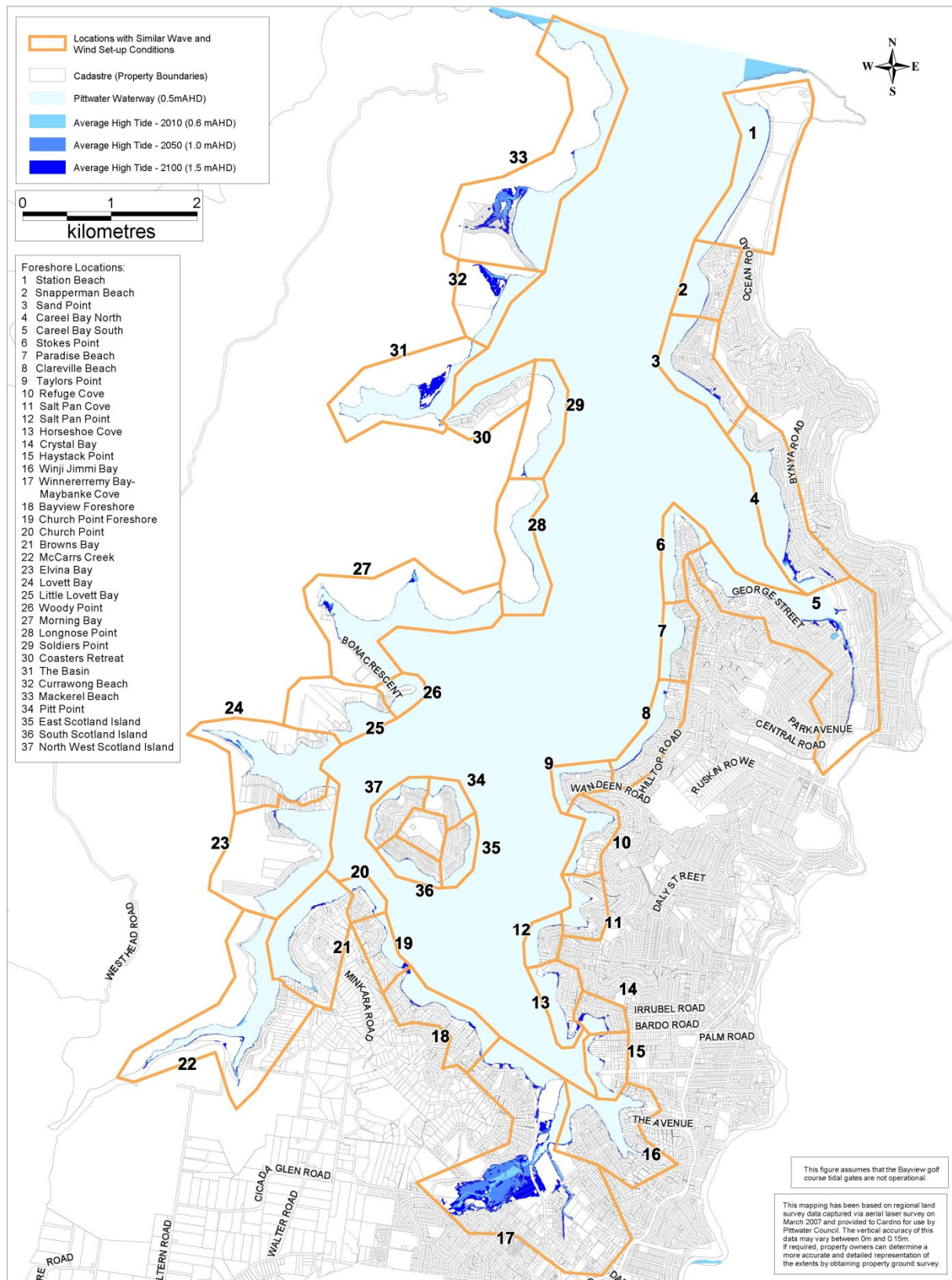
The mapping undertaken in this project has been based on regional land survey data captured via aerial laser survey on March 2007 and provided to Cardno for use by Pittwater Council. The vertical accuracy of this data may vary between 0m and 0.15m. If required, property owners can determine a more accurate and detailed representation of the extents by obtaining property ground survey.

7 References

- CEM (2002). Coastal Engineering Manual, U.S. Army Corps of Engineers, Engineer Manual 1110-2-1100, Washington D.C.
- Coastal Engineering Research Centre (1984). *Shoreline Protection Manual*, 4th edition. U.S. Department of the Army, Washington, D.C.
- Department of Environment, Climate Change and Water (2010b). *Coastal Risk Management Guideline: Incorporating sea level rise in coastal risk assessments*. NSW Government
- Department of Environment, Climate Change and Water (2009). *Sea Level Rise Policy Statement*. NSW Government.
- Department of Environment, Climate Change and Water (2010a). *Flood Risk Management Guide: Incorporating sea level rise benchmarks*. NSW Government.
- Department of Planning (2007). *Planning Circular 07-003. New Guideline and Changes to Section 117 Direction and EP&A Regulation on Flood Prone Land*. NSW Government.
- Goda, Y. (2000). *Random Seas and Design of Maritime Structures*. World Scientific, Volume 15.
- IPCC AR5 (2013). Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Intergovernmental Panel on Climate Change.
- Lawson and Treloar (2003). *Pittwater Estuary Processes Study*. Prepared for Pittwater Council.
- Lawson and Treloar (2004). *Estuary Planning Level Mapping Study*. Prepared for Pittwater Council.
- NSW Government (1990). *Coastline Management Manual*.
- NSW Government (2005). *Floodplain Development Manual*.
- Pittwater Council (2007 and as amended). *Pittwater 21 Development Control Plan*.
- Public Works Department (2001). *Wallis Lake. Floodplain Management Study, Foreshore Flooding Assessment*. Manly Hydraulics Laboratory. MHL Report 1023.
- Whitehead & Associates Environmental Consultants (2014) *South Coast Regional Sea Level Rise Policy and planning Framework*. Prepared for Shoalhaven City Council and Eurobodalla Shire Council, July.

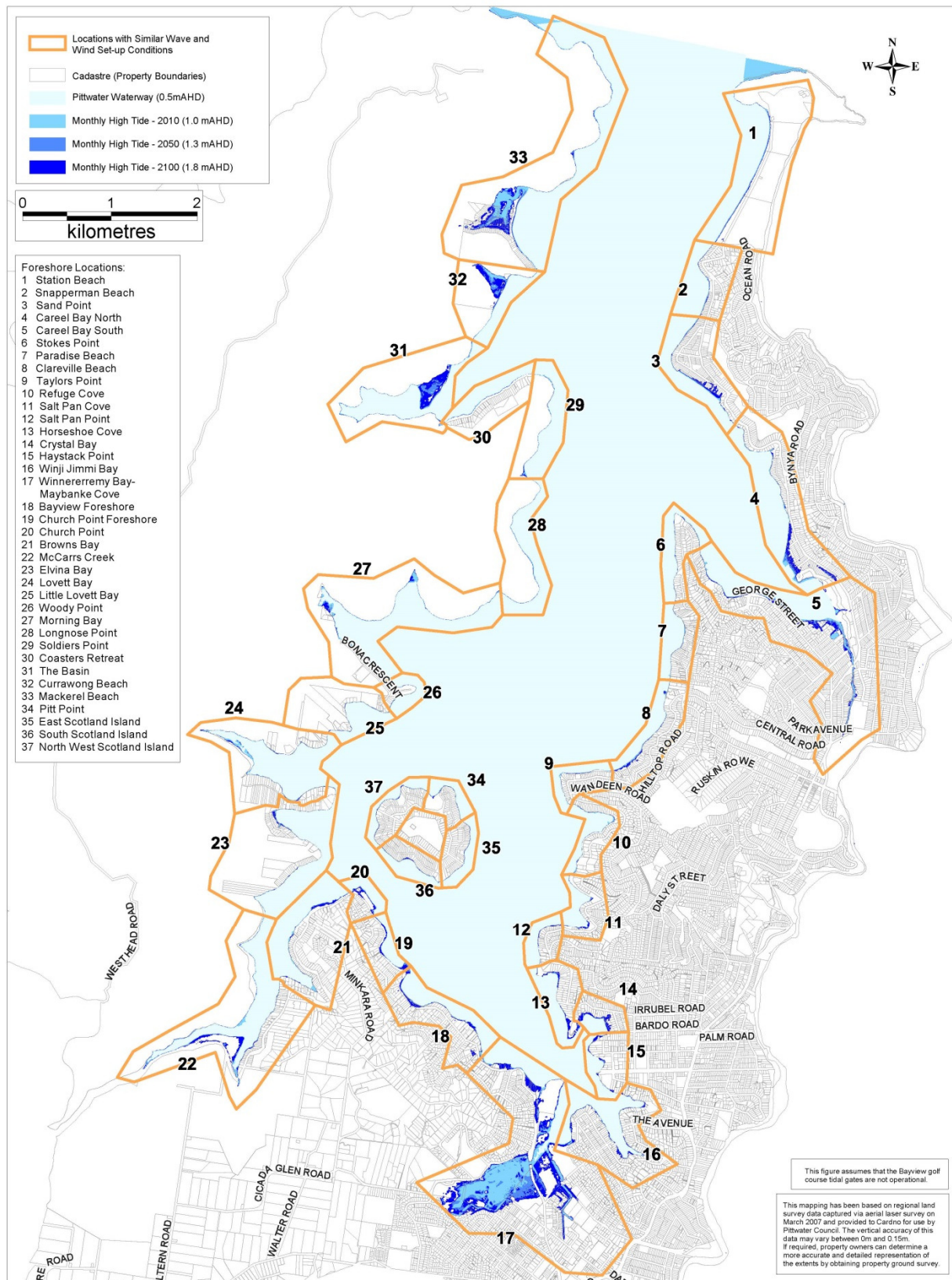


Figures



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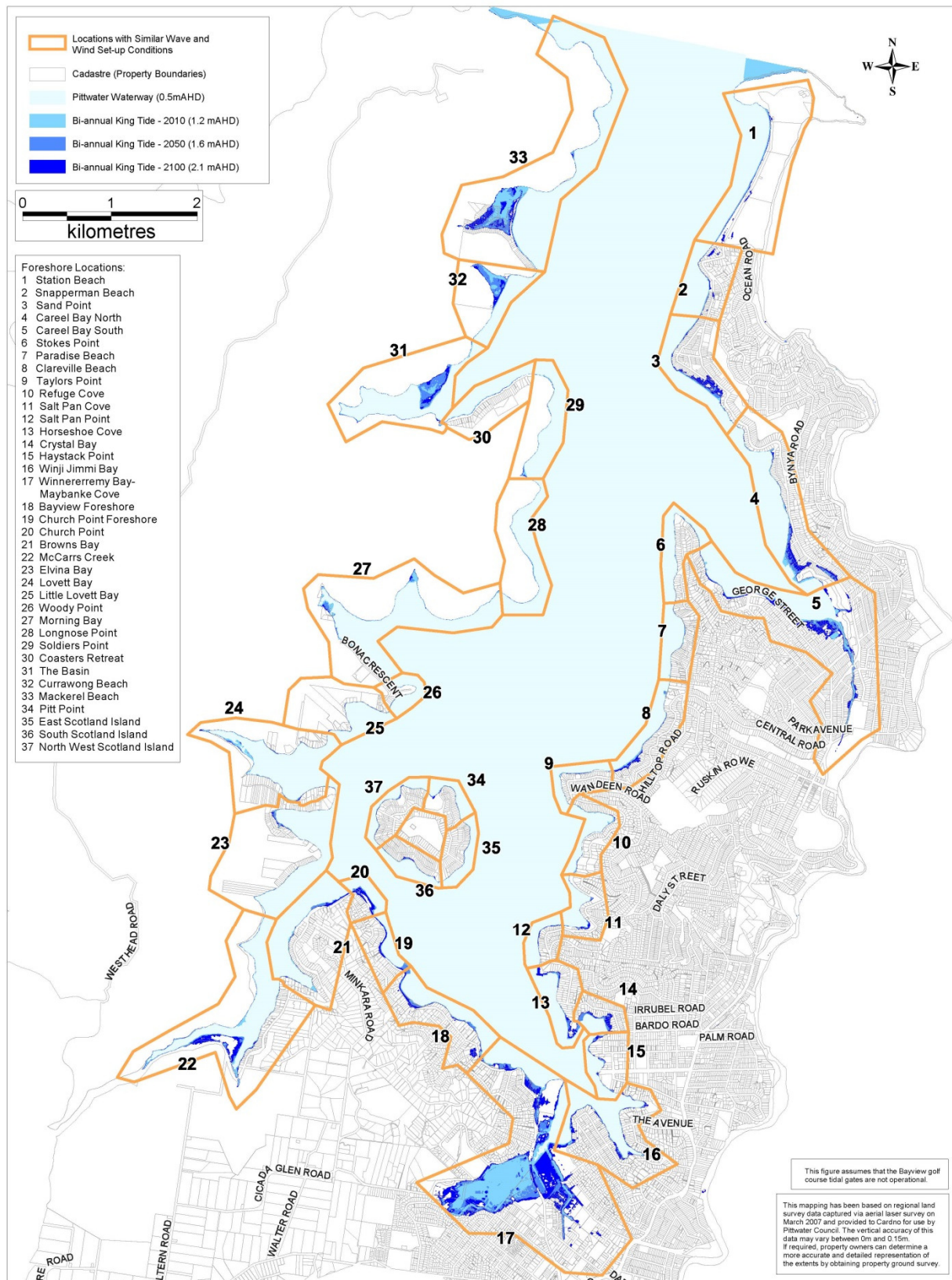


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PITTWATER ESTUARY
MAPPING OF SEA LEVEL RISE IMPACTS

FIGURE 3.2
MONTHLY HIGH TIDE (TYPICAL HIGH TIDE)
(STILL WATER)

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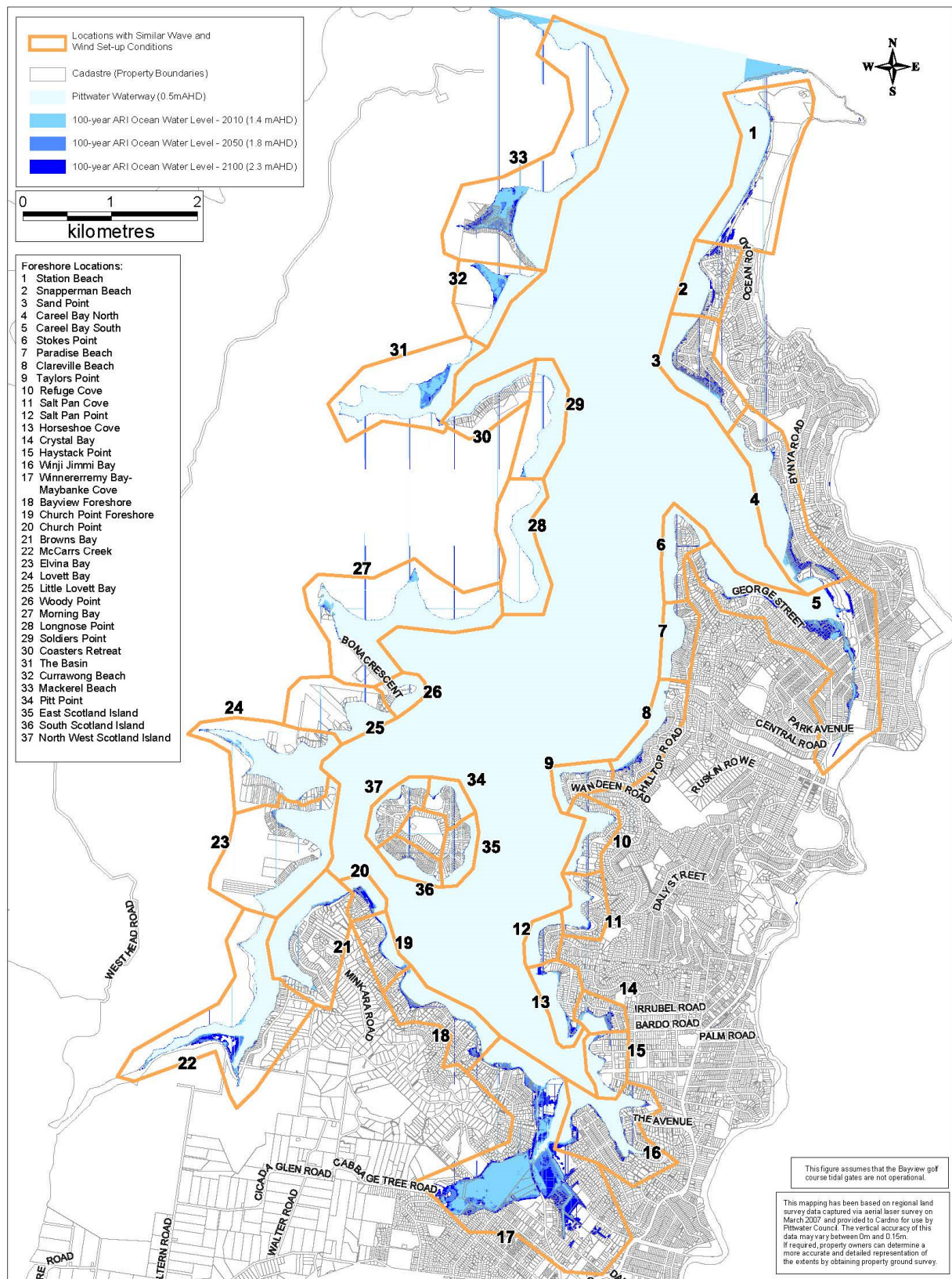


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PITTWATER ESTUARY
MAPPING OF SEA LEVEL RISE IMPACTS

FIGURE 3.3
BI-ANNUAL (SIX-MONTHLY) KING TIDE
(STILL WATER)

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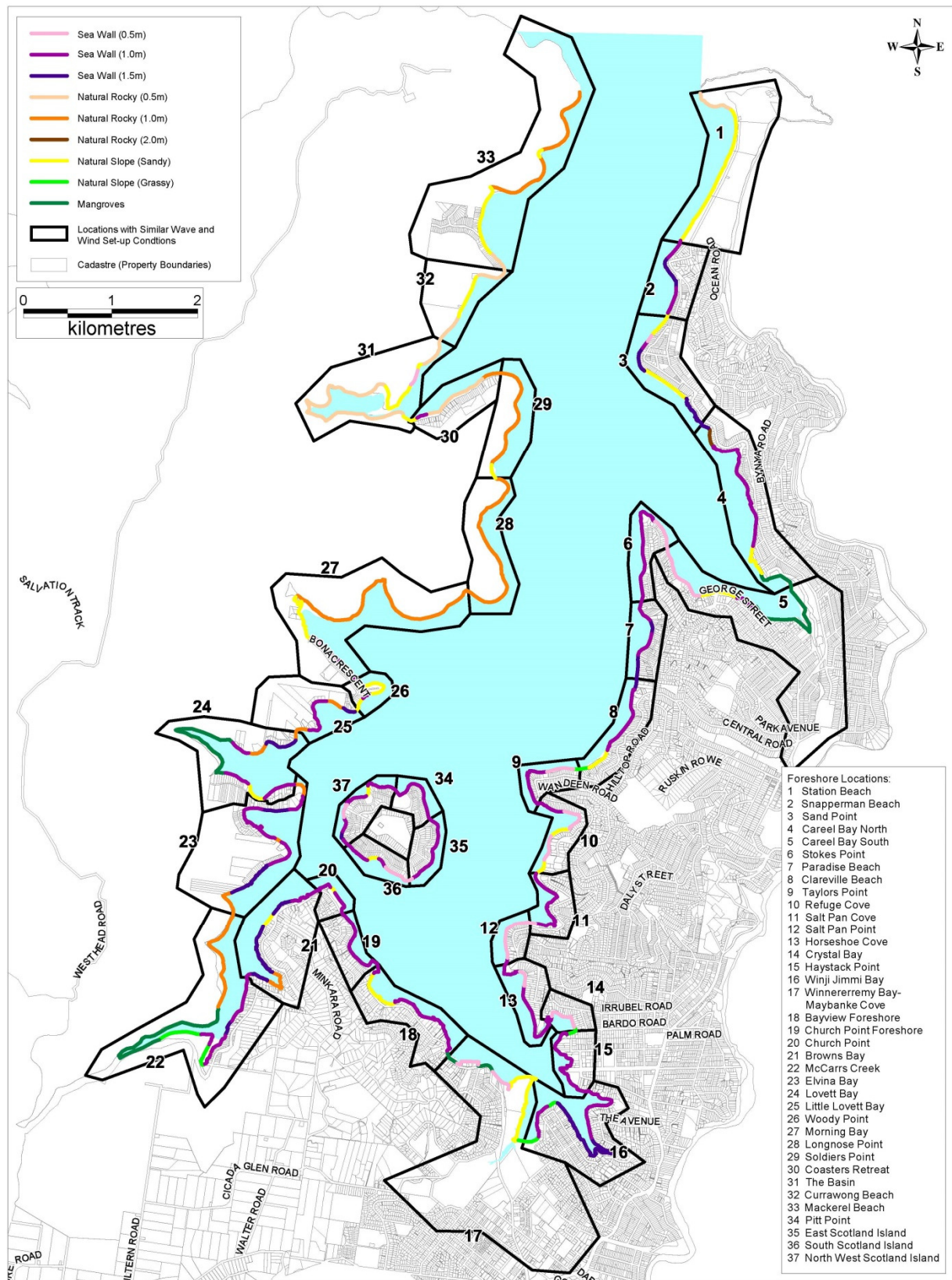


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PITTPATER ESTUARY
MAPPING OF SEA LEVEL RISE IMPACTS

FIGURE 3.4
100 YEAR ARI OCEAN WATER LEVEL
(VERY HIGH TIDE - 1% CHANCE IN
ANY ONE YEAR) (STILL WATER)

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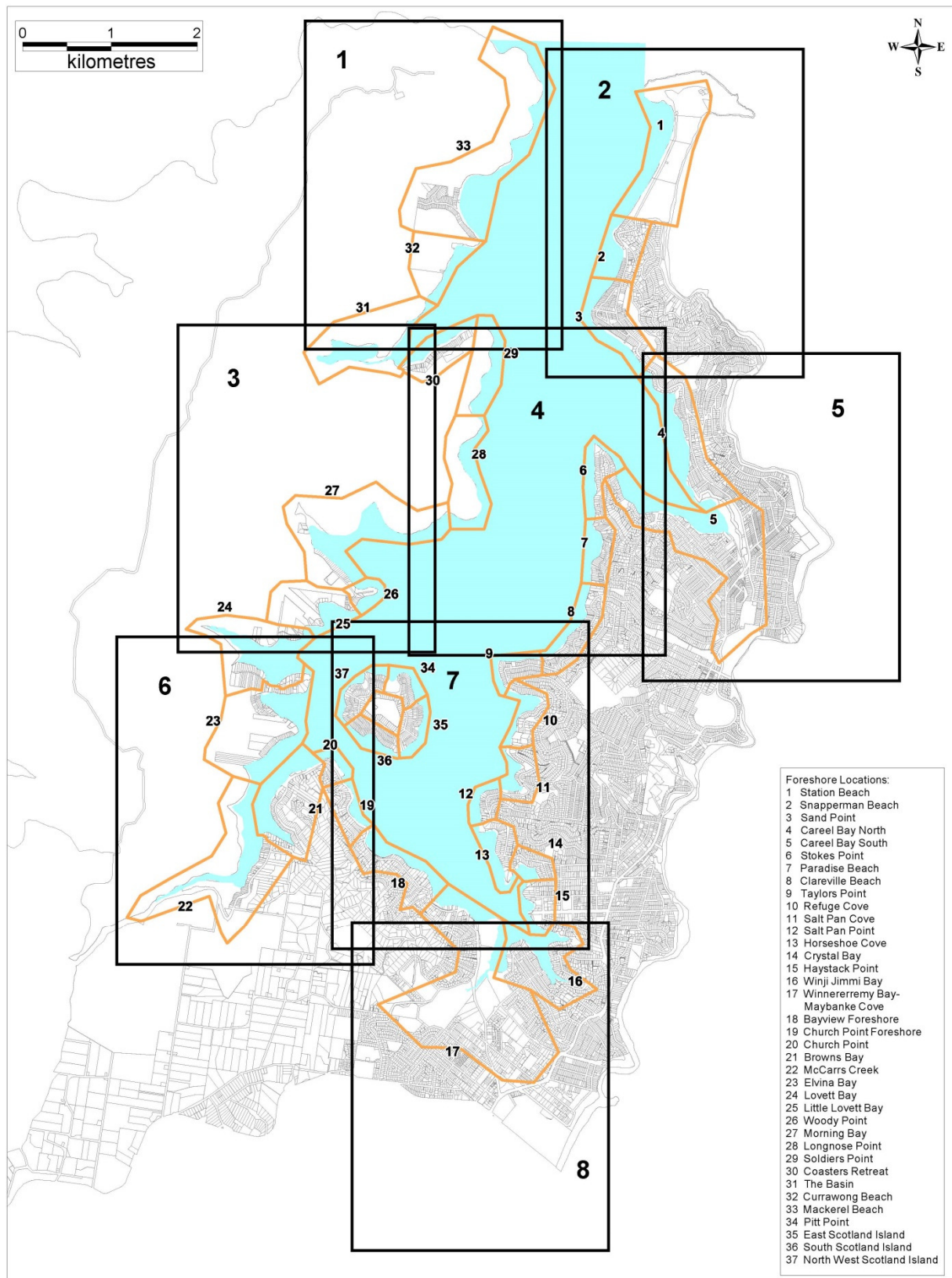


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PITTWATER ESTUARY
MAPPING OF SEA LEVEL RISE IMPACTS

FIGURE 3.5
TYPICAL FORESHORE TYPES AND
LOCATIONS OF SIMILAR WAVE AND
WIND SET-UP CONDITIONS

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PITTWATER ESTUARY
MAPPING OF SEA LEVEL RISE IMPACTS

FIGURE 4.1
MAPPING AREAS AND
LOCATIONS KEY

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