Our future on the coast

NSW Coastal Management Manual Part B: Stage 2 – Determine risks, vulnerabilities and opportunities

NSW GOVERNMENT

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Caves Beach (Photo: Bob Clout)

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Determine risks, vulnerabilities and opportunities

Stage 2 involves undertaking detailed studies that help councils to identify, analyse and evaluate risks, vulnerabilities and opportunities.

This includes:

- engaging with the community and stakeholders
- refining understanding of key management issues
- identifying areas exposed to coastal hazards and threats to coastal values
- analysing and evaluating current and future risks (detailed risk assessment)
- identifying scenarios for social and economic change and related opportunities for coastal communities
- preparing a planning proposal to amend maps of coastal management areas, to commence the Gateway process
- identifying timing and priorities for responses, thresholds and lead times.

2.1 Overview of Stage 2

The following sections of the *Coastal Management Act 2016* and associated mandatory requirements in Part A are most relevant to this stage.

Section 12 Purpose of coastal management programs.

Section 14 Preparation of coastal management programs.

Section 15 Matters to be dealt with in a coastal management program.

Section 16 Consultation.

Studies prepared in Stage 2 provide information to support decision-making in later stages of the planning process. The additional information assists communities to better understand coastal management issues and to analyse and evaluate coastal risks and opportunities.

Stage 2 studies may be prepared for any or all coastal management areas. These studies build on existing information about the environmental, social and economic characteristics of an area and how this may have changed over time, or is projected to change.

Studies may relate to:

- identifying and mapping the boundaries of coastal management areas
- understanding coastal processes, sediment budgets and all coastal hazards and risks as appropriate to the local government area
- understanding threats to coastal wetlands, littoral rainforests and environment areas and values
- understanding opportunities and constraints for coastal use areas and refining key coastal land use planning issues
- establishing a baseline that allows councils to monitor, evaluate and report on their achievements and performance against their management objectives
- assessing the vulnerability of communities, including factors such as socioeconomic characteristics, the sensitivity of natural assets, and the location, age and design of built assets and infrastructure
- identifying opportunities for reducing vulnerability, building resilience, strengthening adaptive capacity and enhancing the economic potential of coast-related businesses.

The studies undertaken in Stage 2 will be most beneficial when designed to reflect the scale and complexity of the issues in each coastal management area and the interrelationships between adjacent and/or overlapping coastal management areas.

Table B2.2 (in **Section 2.11**) provides examples of situations where more detailed studies are likely to be required for the four coastal management areas.

Table B2.3 (in **Section 2.11**) outlines matters to consider when identifying and designing new studies in the relevant coastal management areas.

Important considerations when planning additional studies are the current level of understanding of the issues identified in Stage 1, the time and resources available, and community and stakeholder perceptions of risks and vulnerabilities.

2.2 Intended outcomes from Stage 2

Information that is targeted and well-structured will best assist councils, stakeholders and communities to make management decisions about the coastal zone.

The outcomes of these studies may assist councils to:

- refine the mapping of coastal management areas
- provide detailed information necessary for a planning proposal to amend the mapping of coastal management areas for planning purposes in council's Local Environmental Plan (LEP)
- provide context and data to support the identification and evaluation of management options in Stage 3
- improve understanding of the complexity of issues and community perspectives
- quantify the nature and extent of exposure to coastal hazards and threats to public and private assets (both natural and built)
- understand the factors that contribute to vulnerability and to current and future risks
- define the socioeconomic characteristics such as demographics, coast-dependent economic activity, land use patterns and future development scenarios which influence vulnerability and capacity to respond now and in the future
- understand the range of potential future scenarios (see **Section 2.8.5**)
- understand the local community's attitude to risk in terms of what may be acceptable, tolerable or unacceptable (see **Table B1.4** in Stage 1)
- identify opportunities to reduce risks and enhance the environmental, social and economic values.

Communication with Councillors and other public authorities on the results of the studies undertaken and how the results will be used in the preparation of the coastal management program (CMP) is recommended.

2.3 Community and stakeholder engagement

Community and stakeholder engagement during Stage 2 adds value to the coastal planning process by:

- explaining the findings of studies completed in Stage 2. In some cases, the community and stakeholders may be involved in the design of studies
- raising awareness of the significance and complexity of the issues
- ensuring that relevant perspectives are incorporated when analysing the likelihood and consequences of events and on the acceptable and tolerable level of coastal risk for planning purposes
- preparing the community and stakeholders to participate in identification and evaluation of management options in Stage 3.

It is important that the outcomes of Stage 2 are accessible, easily understood and meaningful to the community and stakeholders. This helps build trust and commitment to the outcomes.

2.3.1 Engagement about coastal risks

It is recommended that councils communicate with the community and stakeholders about the study methods being used and any inherent uncertainties.

Detailed understanding of values and assets (both natural and built) within a coastal management area is necessary when considering likelihood, consequences and hence risk. This understanding is best developed through a structured process that includes input from the community and stakeholders, as well as technical and scientific experts.

Risk analysis and evaluation can be conducted in workshops that involve a range of affected community members, stakeholders, public authorities and experts.

Community and stakeholder engagement can also assist in:

- identifying studies and solutions that are tailored to local circumstances
- identifying opportunities for the community, public authorities and stakeholders to provide additional data and resources
- determining potential exposure, sensitivity, vulnerabilities and consequences
- identifying potential risks based on historical information and personal experience
- identifying opportunities for risk management and adaptation measures
- evaluating the acceptability or otherwise of a risk linked to any coastal hazard or threat
- developing 'community and stakeholder ownership' and acceptance of the outcomes of the risk management process.

In general, the community engagement activities in Stage 2 will be at the 'inform', 'consult', or 'involve' levels in the International Association for Public Participation IAP2 spectrum.

2.3.2 Socioeconomic studies

A socioeconomic assessment may help councils and public authorities to better understand the values, vulnerability and opportunities affecting a local community. It can help clarify social and economic risk factors and the community's acceptance of risks. It can also help identify beneficiaries and determine their willingness and capacity to pay for coastal management actions.

Table B2.4 (in **Section 2.11**) provides additional information about the issues that may be included in a socioeconomic assessment. The table also outlines the types of socioeconomic data that may be required for the evaluation of management options identified in Stage 3. Aspects to consider include projected demographics, trends in local population and changes in coastal use into the future.

The more complex the decisions required, the more comprehensive the social and economic analysis may need to be.

Consultation with residents, landowners, businesses and the wider community may give insight to:

- how people use different parts of the coastal zone
- access, use and amenity of beaches and foreshores
- the relative value of different natural and built assets and willingness to contribute to the protection of those values
- trends and scenarios for the value, access, use and enjoyment of the coast
- how information is obtained about coastal issues that may affect their livelihoods and lifestyles

- the extent to which local businesses and employment are coast-dependent.

When undertaking socioeconomic studies, councils may find useful information in the Threat and Risk Assessment (TARA) for the Marine Estate.

Figure B2.1 Community engagement activities are an important part of Stage 2, Tanja, March 2016 (Photo: D Wiecek/OEH)

2.4 Studies in coastal wetland and littoral rainforest areas

Detailed studies of coastal wetlands and littoral rainforests areas, including their proximity areas, may be required when there is evidence that current management arrangements are not achieving the relevant coastal management objectives, see *Coastal Management Act 2016* (CM Act) Section 6.

Potential studies for coastal wetlands and littoral rainforests are outlined in **Table B2.5** (in **Section 2.11**). The studies can provide information for councils to make strategic coastal management and land use planning decisions at the local and regional scale.

Depending on the management decisions that are required, studies may provide information such as the:

- spatial extent and revised boundaries of coastal wetlands and littoral rainforests
- condition, connectivity and ecosystem services associated with coastal wetlands and littoral rainforests
- historical evolution of the wetland or littoral rainforest and the projected future condition

- critical factors influencing the vulnerability of coastal wetlands and littoral rainforests
- potential impacts (linked to exposure, sensitivity and vulnerability) that may result from changes in land use of adjoining areas or climate change
- potential to offset other factors that may adversely impact on the coastal wetlands or littoral rainforests
- opportunities to protect, rehabilitate, improve the resilience of, and support the social and cultural values of coastal wetlands and littoral rainforests.

Studies to support the management of coastal wetlands and littoral rainforests areas are also likely to be relevant to coastal environment areas, particularly in relation to water quality, sediment and nutrient loads and changes in hydrology (see also **Section 2.6)**.

Figure B2.2 Stage 2 studies can support improved mapping and provide information about how key threats impact on wetland health, function and services (Photo: OEH)

2.5 Studies in coastal vulnerability areas

Detailed studies may be required to determine current and future risk from coastal hazards.

Coastal hazards include:

- beach erosion
- shoreline recession
- coastal lake or watercourse entrance instability
- coastal inundation
- coastal cliff or slope instability

- tidal inundation
- erosion and inundation of foreshores caused by tidal waters and the action of waves, including the interaction of those waters with catchment floodwaters.

Studies in Stage 2 may help councils to identify the exposure and sensitivity to coastal hazards and develop an understanding of the consequences and likelihood.

The scope of the studies undertaken, the scenarios and the range of probabilities considered are best designed to reflect the types of assets and indicative risk levels obtained through the first-pass risk assessment in Stage 1.

In situations where essential infrastructure, or very strategic or high-value assets may be exposed to coastal hazards, it is important to consider the probability of extremely rare scenarios, as well as uncertainty in coastal forcing, processes and response. For further information refer to **Section 2.8.4**.

This information will assist councils to analyse the risks and evaluate management actions for areas exposed to coastal hazards (in Stage 3). It will also help councils to identify and map coastal vulnerability areas for land use planning and emergency management (see objects (a), (g) and (i) of the CM Act and the management objectives in Section 7 of the CM Act).

Stage 2 studies in areas exposed to coastal hazards may consider, as relevant:

- The broad geological and geomorphic structure and evolution of the coast.
- The context for regional and local coastal processes, and how those processes have evolved and may evolve in the future.
- The spatial and temporal scale of coastal processes (including open coast, estuary and rocky headland processes).
- The development of conceptual models of sediment transport and sediment budgets. **Figure B2.3** shows the components of the coastal sediment budget.
- Sediment dynamics within and between primary, secondary and tertiary sediment compartments on the open coast and in estuaries.
- A detailed sediment budget at the local (tertiary sediment compartment) scale.
- Oceanic processes and natural variability in wave climate affecting the region and local area. These may vary at a range of timescales such as El Niño and La Niña, or the Interdecadal Pacific Oscillation (IPO).
- Factors influencing coastal water levels and coastal processes such as storm surge, coastal trapped waves and catchment flooding.
- Human modification of the coast that affects coastal processes and landforms including structures such as revetments, seawalls and training walls, reclamation works, dredging and entrance management policies.
- The potential effects of climate change including shoreline rotation, sea level rise, changes in storm type, frequency, magnitude, duration and direction, as well as other potential impacts on hydrodynamic forcing along the coast.
- The degree of uncertainty in the above factors, including climate change scenarios and inherent variability of coastal processes.

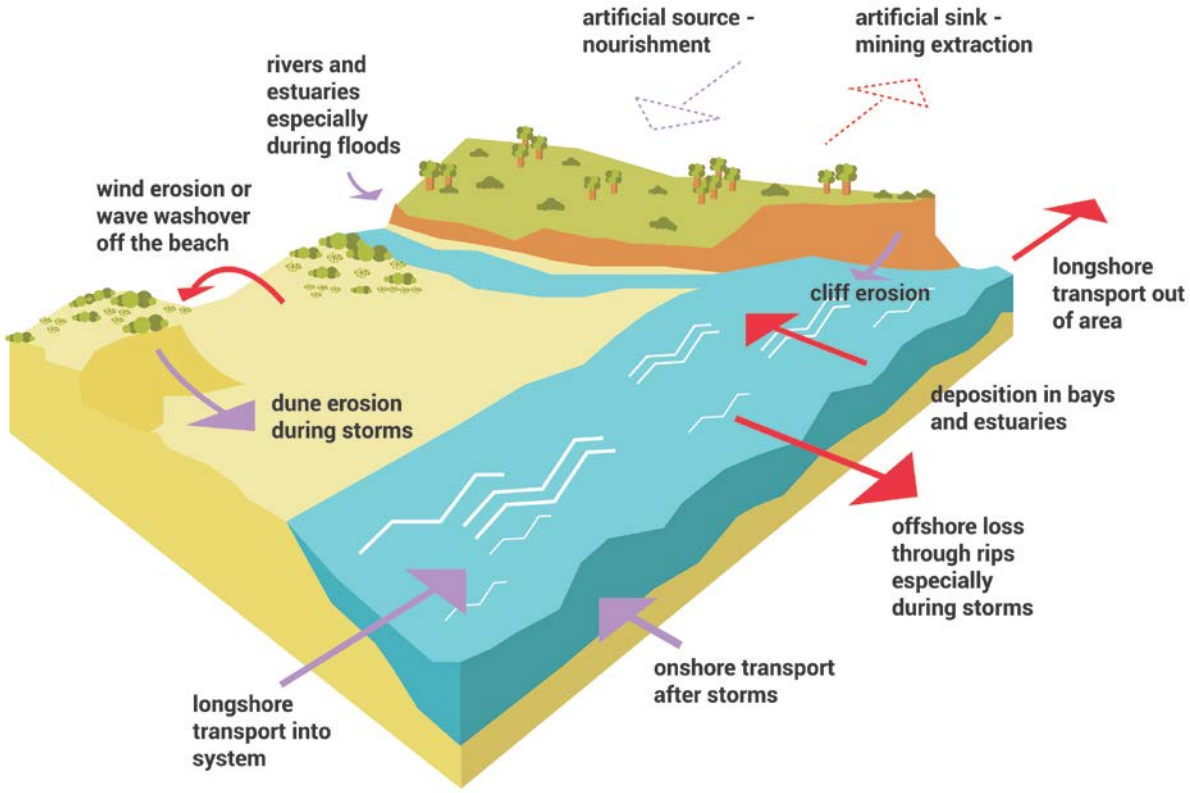

Figure B2.3 Components of the coastal sediment budget (Source: Coastal Dune Management, NSW Department of Land and Water Conservation, 2001)

Figure B2.4 shows the boundaries of primary and secondary sediment compartments in part of the NSW coast. Sediment compartment boundaries are mapped at national to regional scales and are based on criteria such as the geological structure of the coast, major topographic features such as headlands and peninsulas, dominant landforms in a section of coast and the orientation of the shoreline.

Consultation with adjoining councils where coastal processes in a secondary sediment compartment or estuary extend across the council boundary is important. There are specific consultation requirements in these circumstances under the CM Act.

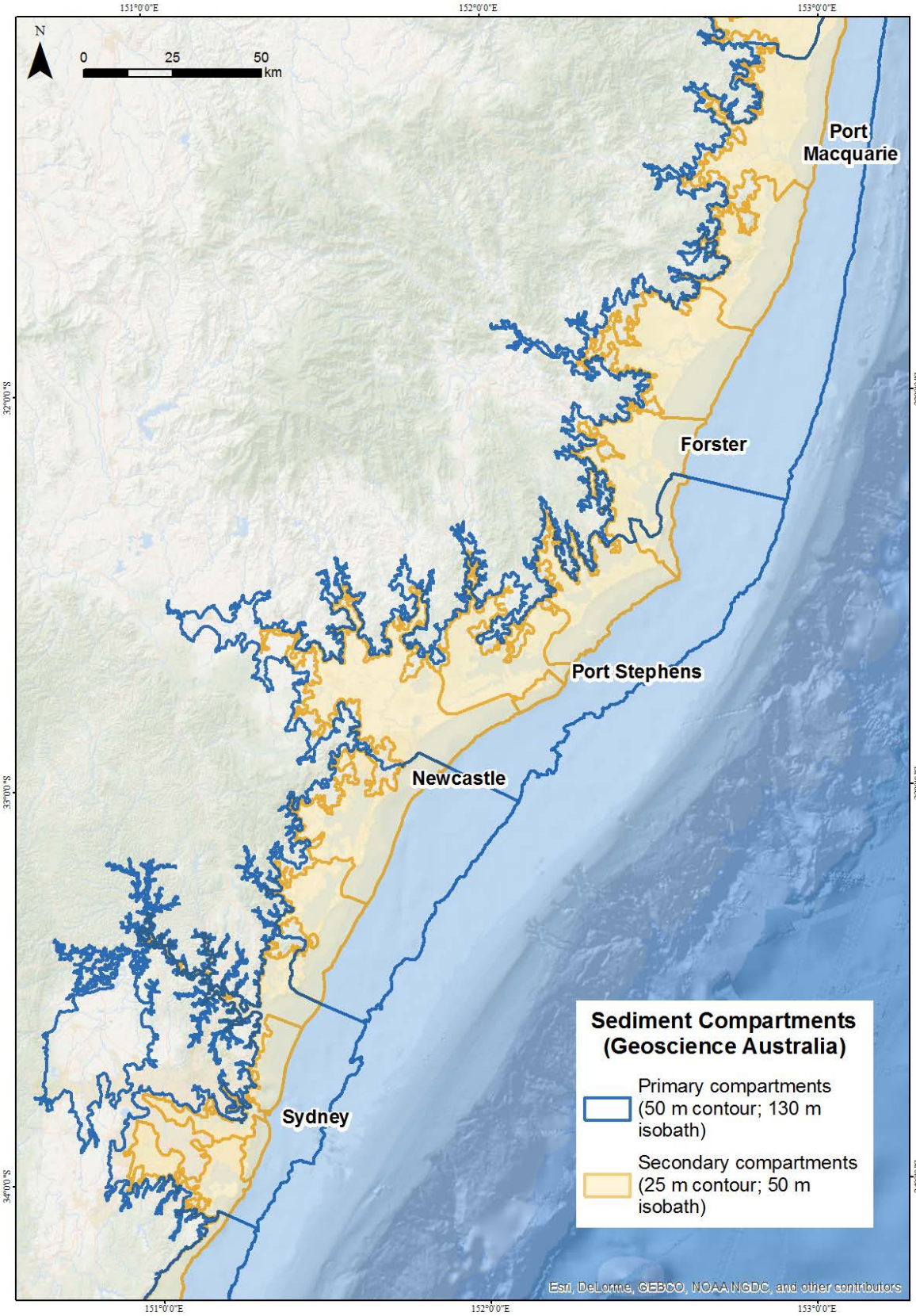

Figure B2.4 An example of primary and secondary coastal sediment compartments

2.5.1 Beach erosion and recovery

Beach erosion refers to the removal of beach materials by wave action, tidal currents, littoral currents, or wind. It is usually associated with storms or with elevated water levels and can occur on the open coast and in estuaries.

Beach erosion events are often interspersed with a beach recovery phase when sediment moves back onshore to rebuild the beach and dunes. The sediment budget is maintained in a closed sediment compartment.

The area in which beach erosion and recovery takes place is referred to as the beach fluctuation zone. **Figure B2.6** illustrates the erosion and recovery phases on a beach.

The impact of an erosion event varies with:

- recovery time since the last erosion event
- the extent to which the sediment budget at the site is affected by cyclical fluctuations, such as those due to local longshore drift, beach rotation or accretion on a tidal delta.

A consideration in studies of beach erosion is the changes in the distribution of sediment between the nearshore, alongshore, beach face, fore-dune and estuaries. This may include the effect of over-wash, coastal inundation, tidal currents, stormwater, flooding and the landward movement of sediment by wind.

Studies of beach erosion can assist to improve knowledge about the likelihood of the hazard over timeframes relevant to management of existing infrastructure and development, as well as for future planning of the coast. Timeframes to consider include immediate, 20 years, 50 years, 100 years and beyond.

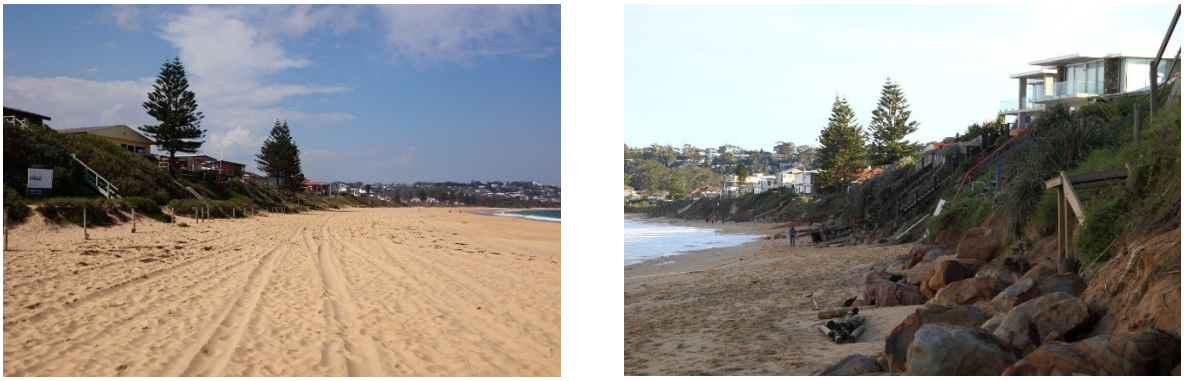

Figure B2.5 Wamberal Beach in an accretion phase (April 2016) and following storm erosion (June 2016) (Photos: M Kinsela/OEH)

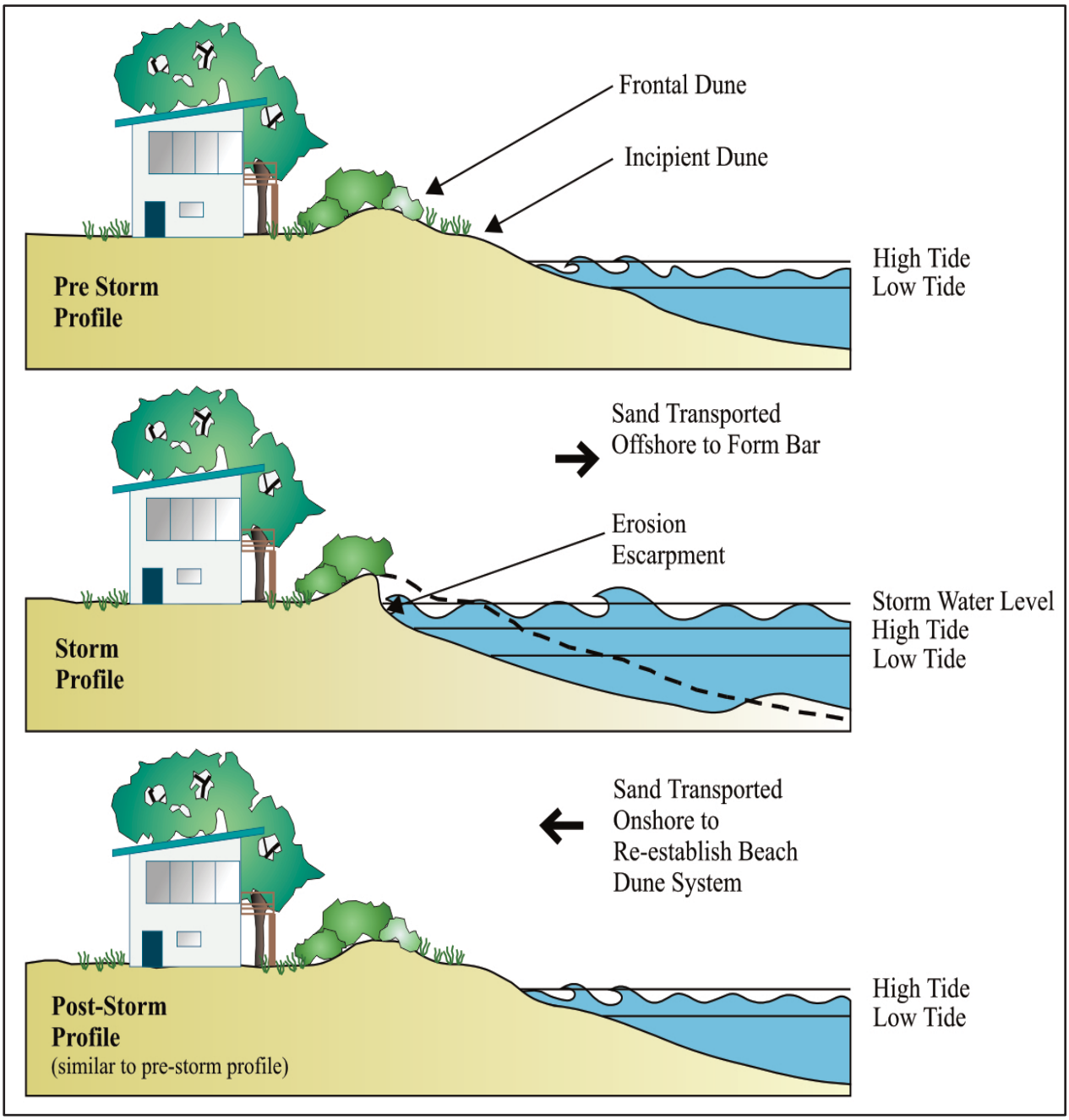

Figure B2.6 Beach erosion and recovery phases

Figure B2.7 Storm damage to Warilla seawall, including loss of access control fencing and safety signage (Photo: D Wiecek/OEH)

2.5.2 Shoreline recession

Shoreline recession refers to continuing landward movement of the shoreline or a net landward movement of the shoreline over a specified time. As shoreline recession occurs, the beach fluctuation zone is translated landward.

Recession can occur on open coast beaches and in estuaries, particularly where there may be limited opportunity for deposition and shoreline recovery. Integrated studies of beach erosion and shoreline recession will often be necessary to distinguish processes and trends operating at different time scales.

Where shoreline recession is occurring, studies may be required that consider the contributing factors and the rate of recession, such as:

- longshore sediment transport into and out of the embayment or sediment compartment, particularly where loss exceeds gains from sand moving into the embayment from up-drift sources
- offshore sand losses where rips have scoured sediment seaward during major storms
- permanent sand losses into stabilised and vegetated dunes landward of the active beach, or on headlands
- permanent interruption or exclusion of sand from the beach fluctuation zone by artificial structures
- persistent sand losses into estuary entrances
- persistent loss of finer grained sediment from estuary shorelines
- impacts of climate change and sea level rise.

Figure B2.8 summarises the steps in an integrated beach erosion and shoreline recession assessment. **Figure B2.9** shows conceptually the shoreline recession process. **Table B2.6** (in **Section 2.11**) outlines potential studies to improve understanding of beach erosion and shoreline recession.

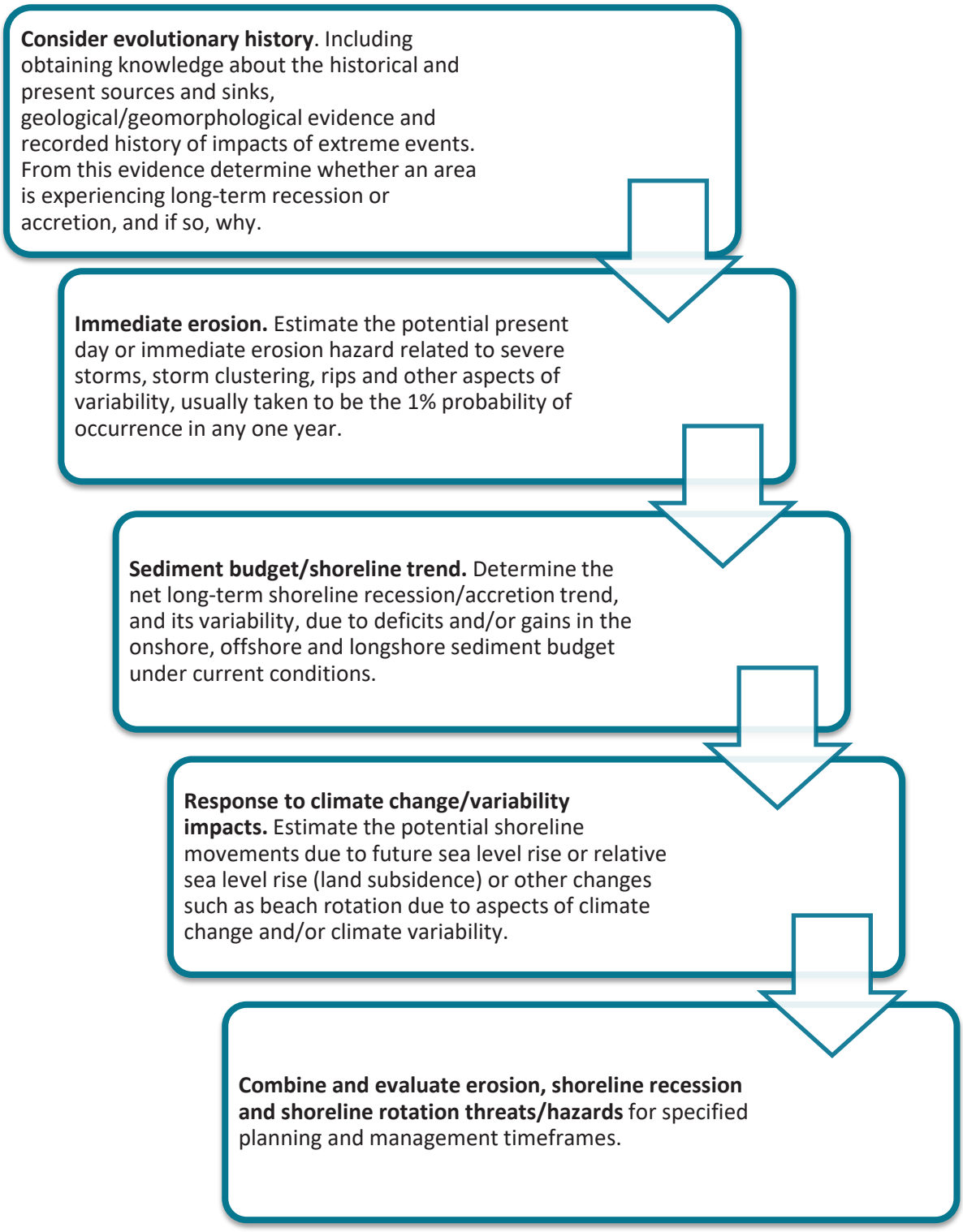

Figure B2.8 Steps in an integrated beach erosion and shoreline recession assessment

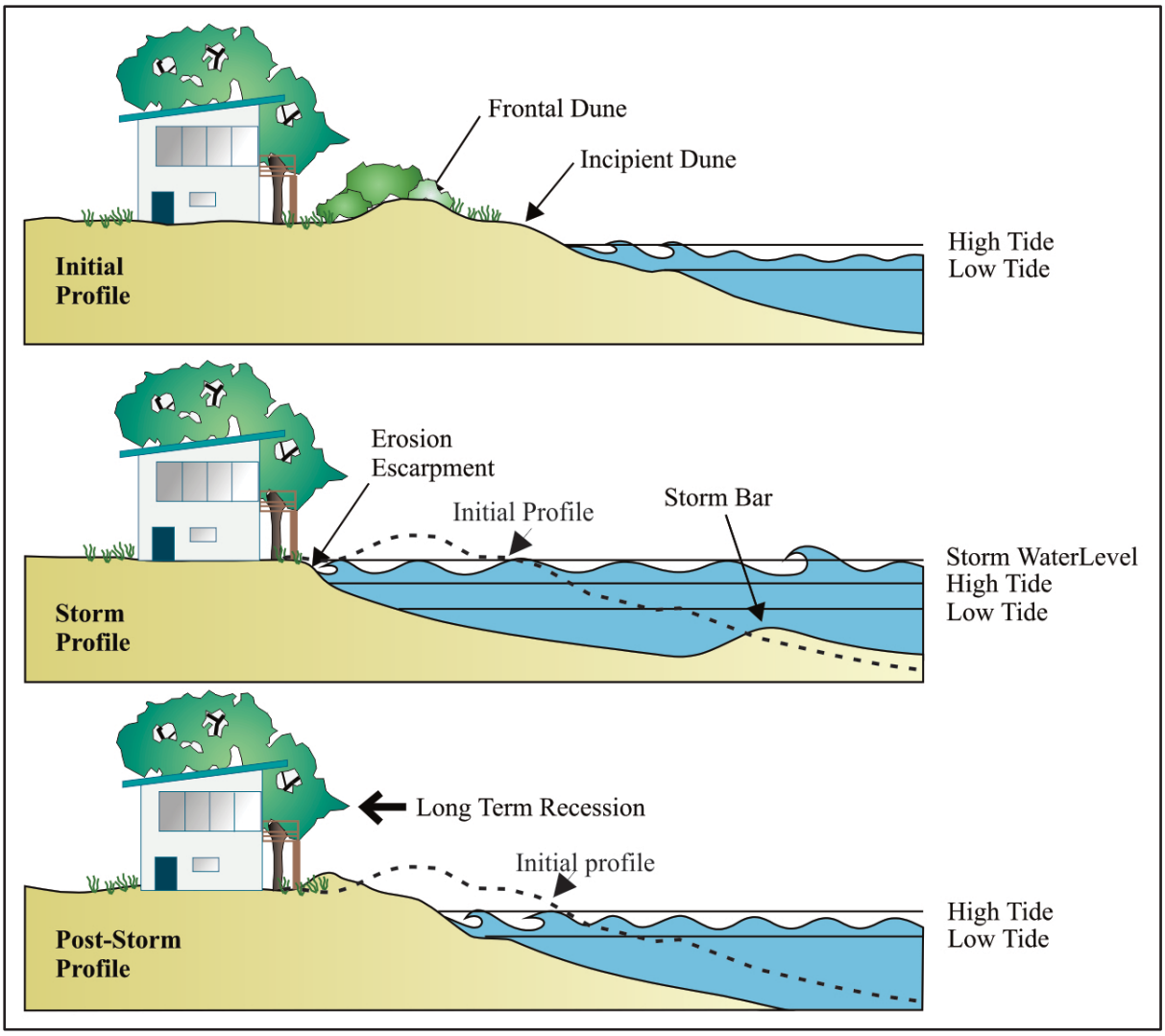

Figure B2.9 Long-term shoreline recession

2.5.3 Coastal lake or watercourse entrance instability

Both natural and trained entrances of estuaries and coastal lakes present a variety of potential hazards and risks. The entrance dynamics and the condition of the entrance also affect flood hazards, water quality and ecological health in the estuary or coastal lake. Refer to **Section 2.6** for further information about the relationship between entrance condition and pressures on the health of coastal waterways.

Many estuary entrances are partially infilled with sand forming highly mobile flood tide deltas, e.g. Lake Macquarie. Entrances are highly dynamic environments with their shape constantly changing in response to processes such as alongshore sediment transport, tidal flows, storms, and catchment flooding.

Figure B2.11 illustrates sediment pathways in an estuary entrance. For trained entrances, the sediment transport patterns are modified, with potential impacts on beach erosion, current velocity and channel stability.

Where an entrance is also in a coastal use area (e.g. used by commercial or recreational vessels, or for swimming or fishing), risk considerations may include public safety and risk to human life. **Table B2.7** (in **Section 2.11**) identifies potential studies of coastal lake and

watercourse entrance instability. The studies may refine the understanding of these processes and quantify the risks related to entrance instability.

Intermittently closed and open lakes and lagoons (ICOLLs) are highly sensitive to catchment runoff and the frequency of entrance opening and closure.

Entrance conditions affect a range of factors such as berm height, water levels, flushing, water quality, salinity and sediment dynamics in coastal lakes and lagoons. High water levels behind a closed entrance may exacerbate the impacts of catchment flooding on:

- residential properties and development on the lake foreshore
- roads, stormwater and sewerage systems
- public access and recreational use for foreshores
- coastal wetlands and floodplains.

Entrance condition also affects ecological processes such as prawn and fish spawning and growth, with important economic implications for local fisheries.

Artificial opening of the entrance of an ICOLL can have significant environmental impacts and may result in dangerous and high velocity flows, and safety risks. The sensitivity of the waterway and potential adverse impacts are important considerations to inform entrance management decisions for ICOLLs.

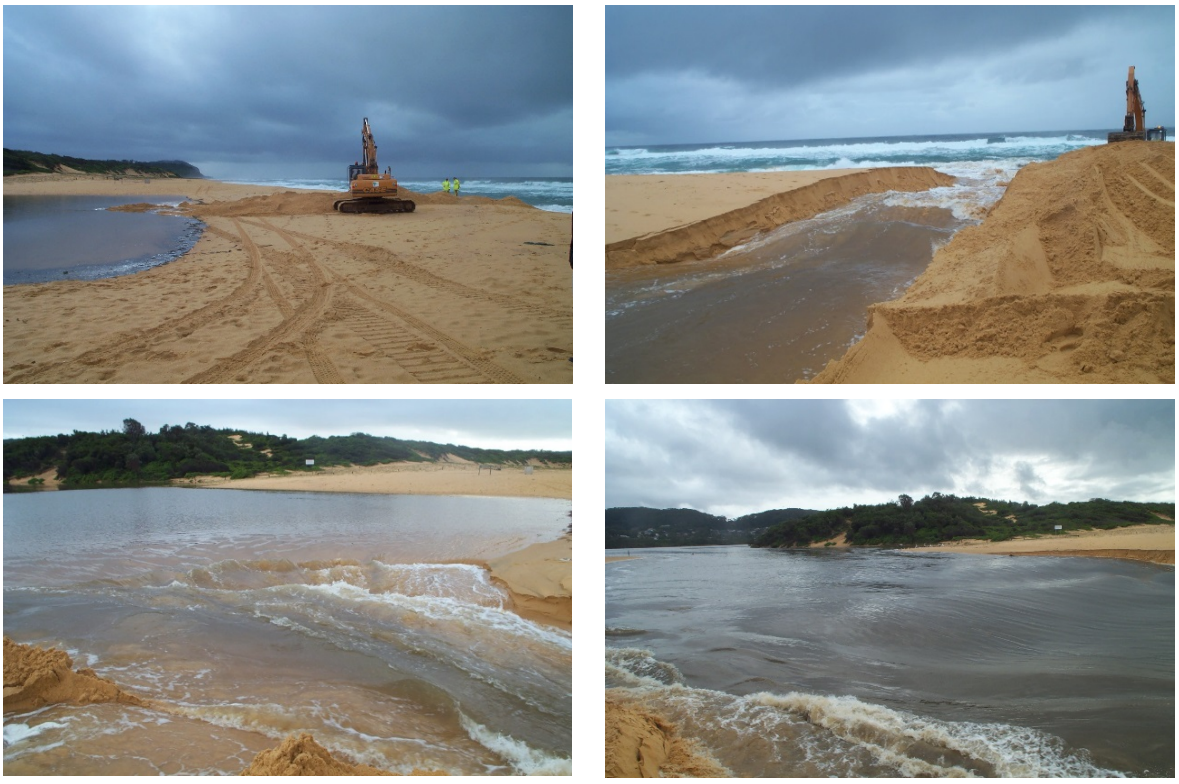

Figure B2.10 Artificial lagoon opening, Wamberal Lagoon, May 2003 (Photo: D Hanslow/OEH)

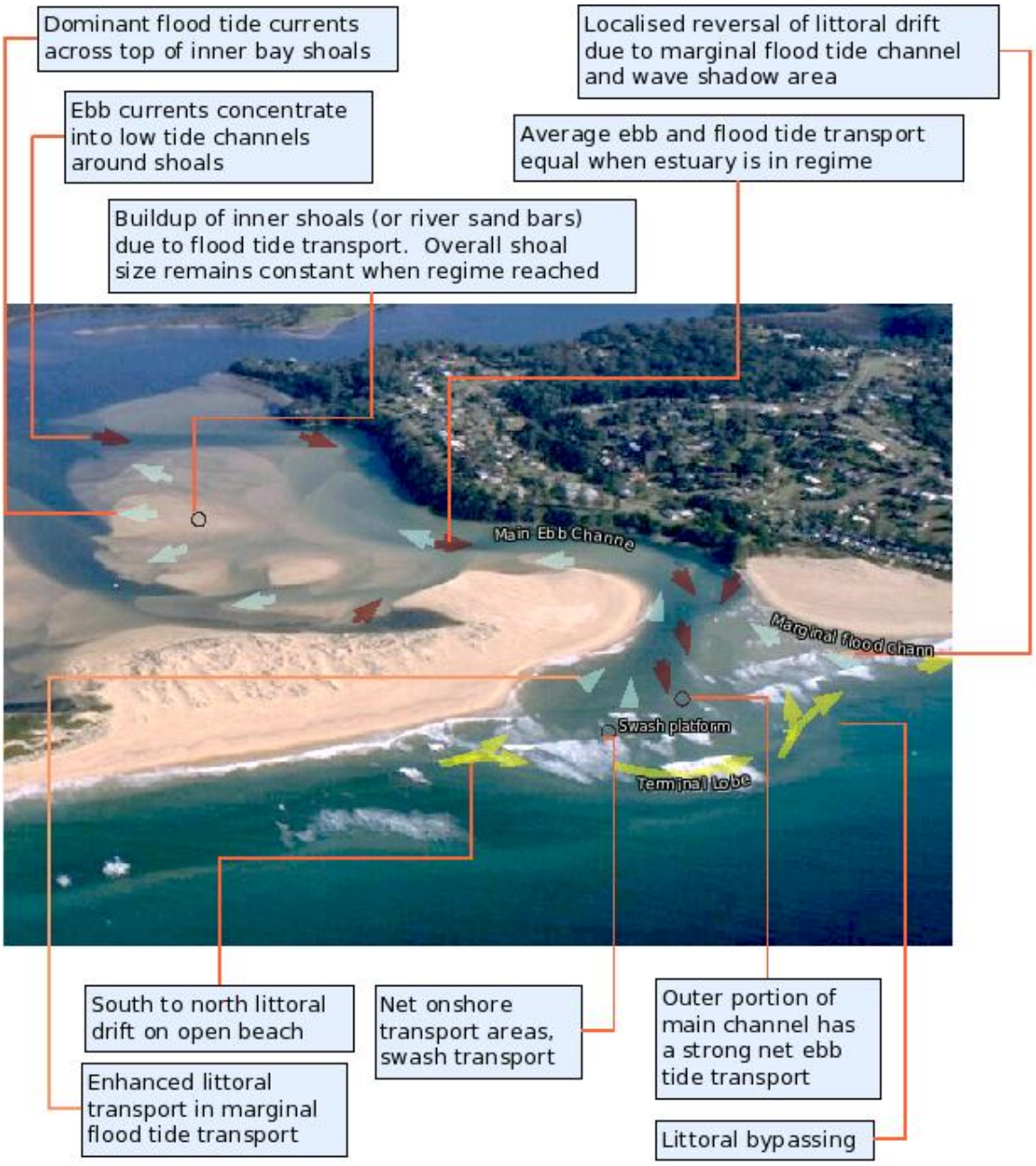

Figure B2.11 Sediment transport pathways at an estuary entrance, Tuross Heads

2.5.4 Coastal inundation

Coastal inundation is the temporary flooding of a portion of land within the coastal zone. It is desirable to distinguish between:

- coastal inundation, which is generally related to storm events (in this section)
- tidal inundation, which is generally related to elevated tidal water levels under average meteorological conditions (see **Section 2.5.5**).

Coastal inundation occurs when a combination of marine and atmospheric processes raises ocean water levels above normal elevations and inundate low-lying areas or overtop dunes, structures and barriers. It is often associated with storms resulting in elevated still water

levels (storm surge), wave setup, wave run-up and over-wash flows. Overtopping and inundation can occur on:

- beaches and coastal dunes
- cliffs and bluffs (in extreme storm conditions)
- seawalls, revetments and entrance training structures.

Storm surge and powerful waves can also penetrate estuaries giving rise to strong currents or seiching. In the longer-term, the extent of coastal inundation will be influenced by water levels that are elevated by other processes such as climate change and sea level rise.

Figure B2.12 Wave run-up at Casey's Beach (Photo: G Armstrong/Eurobodalla Shire Council)

Figure B2.13 shows the different components of water level that contribute to temporary coastal inundation.

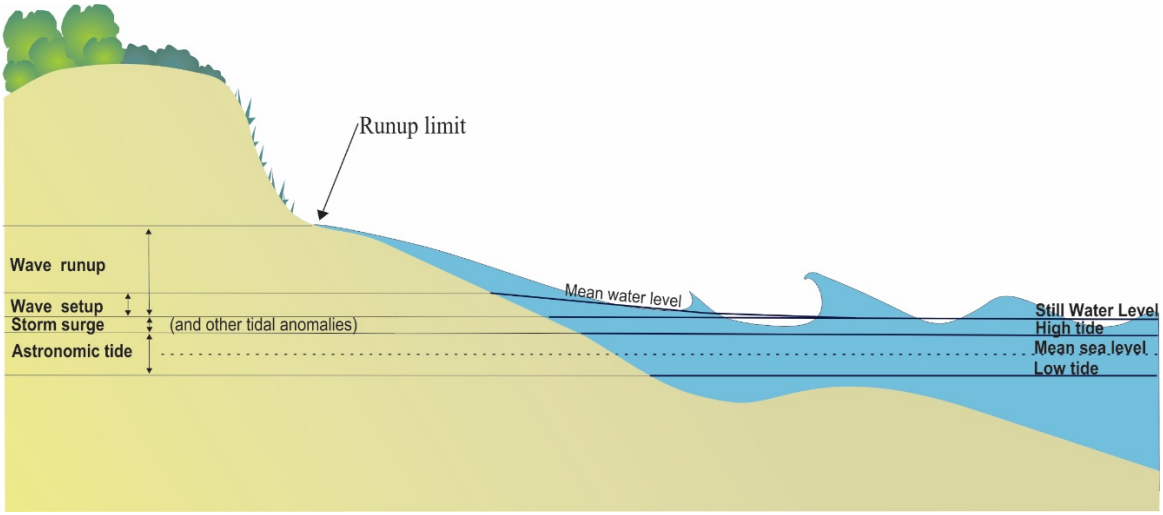

Figure B2.13 Elevated water levels on the open coast

The purpose of a coastal inundation study is to quantify the likelihood of occurrence and the resultant spatial extent, depth and velocity of seawater inundation and the associated risks. High-resolution elevation data is very useful when refining the extent of coastal inundation risks.

Coastal inundation risks may relate to:

- public safety and loss of life due to drowning or impact of debris
- inland propagation of ocean waves, tsunamis, seawater and currents causing damage to property, vehicles, moored vessels, infrastructure and ecosystems
- impacts on both business activity and the financial security of a region
- loss of access to isolated coastal communities
- contamination of soils and groundwater with salt water
- exacerbated coastal erosion.

Table B2.8 (in **Section 2.11**) identifies studies that may be needed to inform decisions about the management of coastal inundation issues.

Coastal inundation and flooding may also occur as the result of a tsunami. Tsunamis result from earthquakes and can pose a risk to coastal assets, public safety and human life. When considering the likelihood and risk associated with tsunamis, the NSW State Tsunami Plan can provide important information for councils and assist in their broader emergency management preparedness.

Figure B2.14 Storm inundation at North Entrance, June 2007 (Photo: Wyong Shire Council)

Figure B2.15 Waves overtopping seawall at Kiama Harbour depositing debris on foreshore, June 2016 (Photo: D Wiecek/OEH)

2.5.5 Tidal inundation

Tidal inundation or nuisance flooding is the inundation of land by tidal action under average meteorological conditions. Tidal inundation may include shorter-term incursion of seawater onto low-lying land during an elevated water level event such as a king tide or more permanent inundation due to land subsidence, changes in tidal range or sea level rise. In some scenarios, the risk associated with tidal inundation may be exacerbated when a king tide coincides with coastal inundation or catchment flooding.

Figure B2.16 Tidal inundation, Marks Point, May 2015 (Photo: D Hanslow/OEH)

Any changes in mean sea level will directly affect the extent and severity of tidal inundation hazards.

Tidal inundation risks may relate to:

- habitability of low-lying coastal land, including public health and maintaining public infrastructure such as stormwater and sewerage systems
- tenure of permanently inundated land
- contamination of soils and groundwater by salt water
- change of ecological character and spatial extent of coastal wetlands
- loss of access and isolation of coastal settlements
- loss of foreshore recreational access and opportunities
- increase in flooding upstream due to increased ocean and estuary tail-water levels.

Studies can assist to determine the likelihood of these hazards over timeframes relevant to management of existing infrastructure and development, as well as for future planning and development of the coast. Timeframes to consider include immediate, 20 years, 50 years,

100 years and beyond, taking into account the potential effects of climate change and sea level rise.

High-resolution elevation data (such as from LiDAR) is important when refining the extent of tidal inundation risks.

Table B2.8 (in **Section 2.11**) identifies studies that may be needed to inform decisions about the management of coastal and tidal inundation issues.

Additional information on these interactions is provided in the *Floodplain Risk Management Guide: Modelling the Interaction of Catchment Flooding and Oceanic Inundation in Coastal Waterways*.

2.5.6 Coastal cliff or slope instability

Geotechnical or slope instability hazard occurs on the headlands and bluffs within and separating coastal sediment compartments. The differing degree of instability often relates to the interaction of weathering and erosion processes on different geological formations and rock types.

For example, interbedded sandstone and mudstone or unconsolidated sandy materials overlying more impervious rock units tend to be susceptible to erosion and instability. Slope instability may also be an issue where there are high erosion escarpments in coastal dunes and beaches.

Geotechnical hazards present risks both to property and to life, such as rock falling from headlands and cliff faces, collapse of unconsolidated materials (such as high dune escarpments), reduced foundation capacity, and the collapse of cliffs under houses and development.

Figure B2.17 Rockfall from coastal cliff, Newcastle, October 2002 (Photo: OEH)

Detailed geotechnical studies may be required when the Stage 1 scoping study indicates complex interactions between geotechnical hazards and coastal assets or public access. **Figure B2.19** provides an overview of processes operating on cliffs and bluffs.

Additional information is provided by the Australian Geomechanics Society 2007. Examples of relevant studies for slope instability issues are included in **Table B2.9** (in **Section 2.11**).

Figure B2.18 Cliff protection works, Bilgola beach (Photo: D Hanslow/OEH)

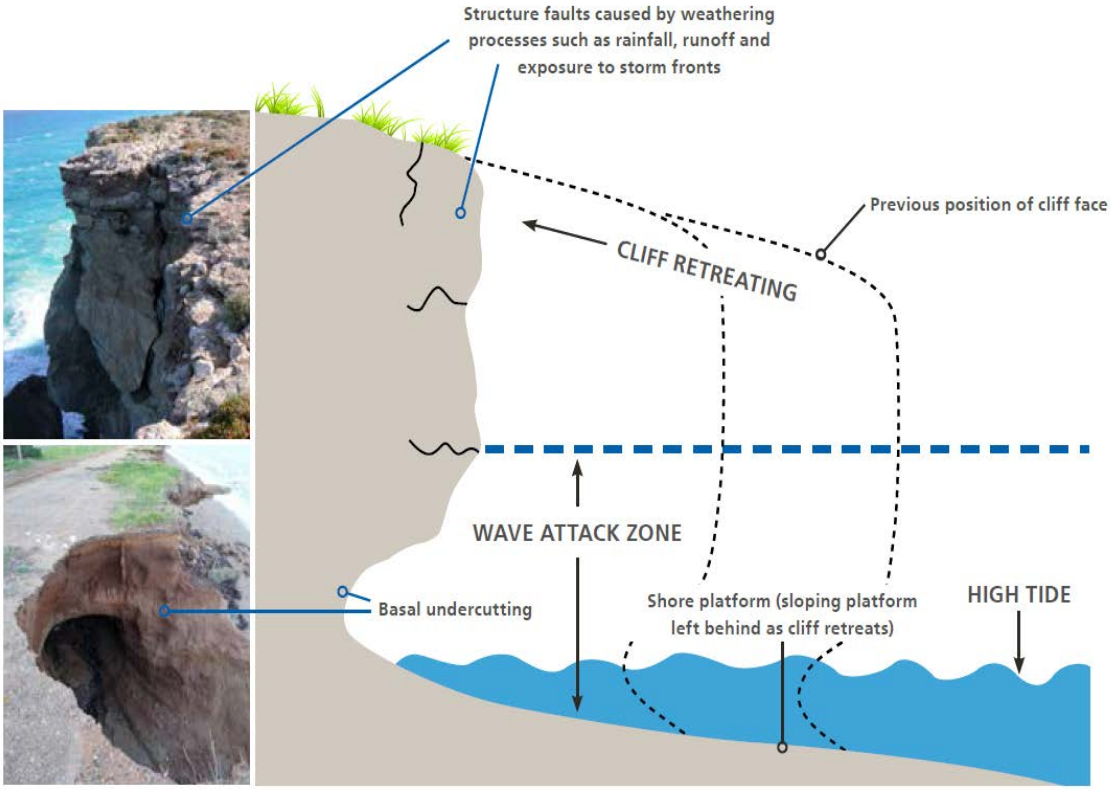

Figure B2.19 Weathering and erosion processes operating on cliffs and bluffs (Source: Coast Protection Board of South Australia)

2.5.7 Erosion and inundation of estuary foreshores caused by the action of waves and catchment floodwaters

Councils may consider the preparation of detailed hydrodynamic and sediment transport studies when Stage 1 identifies that estuary and coastal lake shorelines are actively eroding or accreting.

The impacts of these hazards may include:

- loss of foreshore vegetation and degradation of coastal habitats
- land tenure issues where foreshore property boundaries are ambulatory
- damage to residential or commercial buildings
- damage to public and private infrastructure
- disruption of services and facilities
- loss of public access and public safety issues.

Detailed studies can provide information about the geomorphology and evolution of the foreshore and specific drivers of erosion or accretion, including fluctuating water levels, wind waves, boat wash, tidal and/or wind-induced currents or catchment flooding.

Many foreshores and floodplains are comprised of unconsolidated material that was deposited during the evolution of the estuary. They may not recover from erosion events and ongoing recession or bank erosion is likely to occur.

The erosion of estuary foreshores may also be associated with the long-term evolution of the estuary due to geomorphic processes.

Figure B2.20 Mapping changes to the historic shoreline of Winda Woppa and Jimmy's Beach illustrates the dynamic nature of estuaries (Source: Ana Vila-Concejo/University of Sydney)

Erosion and inundation of estuary foreshores can also be influenced by entrance training works, dredging and entrance management practices that may change tidal ranges, allow the incursion of oceanic waves and change current velocities and sediment dynamics.

The impacts of sedimentary processes on the health and condition of fringing vegetation, such as coastal wetlands, seagrass beds, saltmarsh, mangroves, and riparian communities are important considerations for studies relating to estuary foreshores.

Inundation around estuaries may occur due to coastal or catchment flooding, operating independently or due to a combination of both, derived from the same meteorological event (a coincident event). The interaction of catchment flooding and coastal processes is an important consideration in determining overall flood and inundation risk in coastal waterways.

Examples of the studies that may be relevant to improving understanding of estuary foreshore erosion and inundation are included in **Table B2.10** (in **Section 2.11**). Additional information on catchment flooding is provided in the *Floodplain Development Manual: the management of flood liable land* (2005).

Figure B2.21 Estuary bank erosion, Shoalhaven River (Photo: OEH)

2.5.8 Coastal hazard mapping

The outcomes of coastal hazard studies may include mapping to indicate the spatial extent and impact of the coastal hazard. When preparing hazard mapping it is recommended that accompanying text describes:

- the information and models that have been used to undertake the hazard mapping
- the level of confidence in the hazard mapping.

Hazard mapping is a useful tool for analysing and communicating coastal hazard risk. The hazard mapping may be used to inform the likelihood component of the risk analysis. The risk analysis may require overlaying hazard mapping with spatial information on built and natural assets. Community and stakeholder consultation may also assist in identifying items located in hazard zones that are not mapped in public authority GIS layers such as historical informal landfill sites.

Mapping may also be used to indicate regional scale sediment budgets that drive beach response and shoreline change including sediment sources, sinks and pathways, and connectivity within the sediment compartments.

Hazard mapping may be used to underpin a planning proposal and in defining the coastal vulnerability area.

First-pass (qualitative) assessments of the coastal hazard risk in a scoping study are less complex and may involve the use of available regional scale mapping, application of conceptual and simple numerical models, and expert scientific and engineering judgement. The risk levels determined in a first-pass risk assessment are qualitative.

More sophisticated hazard mapping may be desirable in Stage 2 to refine risk levels, vulnerabilities and opportunities. This may include mapping the potential range of erosion hazard extents using exceedance probabilities.

The exposure of areas to tidal inundation hazard depends on the pathway available to tidal waters. Availability of high-resolution topographic elevation data allows for more accurate mapping of tidal inundation pathways, indicating areas that provide a direct hydraulic connection between coastal waters and low-lying areas.

2.5.9 Risks to life

Many coastal processes and hazards pose a threat to public safety and risk to life for people living on or using the coast.

Quantitative measures of the likelihood of death, injury or illness may be estimated for coastal processes, hazards and threats to the coastal environment. Public safety issues and risks to life may arise from:

- cliff and bluff instability, beach erosion, dune collapse and slumping of foreshores
- waves, run-up and overtopping of rock platforms, structures and natural shorelines
- inundation, waves and currents caused by extreme storm events or tsunamis
- coastal flooding and floating debris
- surge effects associated with coastal inundation
- dangerous surf conditions, rips and collapsing sandbars
- shallow or variable water depths and submerged objects
- dangerous coastal entrance conditions
- poor water quality, pathogens and contaminants
- inappropriately located access tracks, walkways and lookouts
- use of vehicles on beaches, foreshores and waterways
- poorly designed and maintained foreshore structures that result in rocks and debris on beaches and in the surf zone, or material being dislodged and transported landwards towards built assets
- undermined structures or exposure of hazardous objects and contaminated landfill.

Factors which may need to be considered in an analysis of public safety issues and risks to life in the coastal zone include:

- local seasonal variations in population
- community understanding of the risks
- age, health and ethnicity of the population using the coast
- likely exposure to contaminants and pathogens
- likely exposure to very large coastal storm events
- potential for catastrophic failure of cliffs and bluffs or sand dunes
- the use of appropriate design standards and warning signage in hazardous areas
- existing emergency management and disaster relief arrangements.

Table B2.11 (in **Section 2.11**) provides examples of studies which may be useful to enhance understanding of risks to life.

Figure B2.22 Damage to the foreshore at Casey's beach creates risks to public safety (Photo: G Armstrong/Eurobodalla Shire Council)

Figure B2.23 Risks to public safety from coastal erosion, Park Beach, Coffs Harbour (Photo: OEH)

2.6 Studies in coastal environment areas

Detailed studies for coastal environment areas may be considered when there is evidence that the ecosystems are degraded or threatened, current management arrangements are not achieving the management objectives, or where planning or protective measures are required for areas of environmental significance.

Studies undertaken in Stage 2 can help councils to identify where actions may be required to maintain or improve waterway health and support community values and uses of waterways as well as broader objectives such as healthier, more resilient communities and cities.

As catchments are developed and population increases, the volume of stormwater entering waterways increases and carries with it increased loads of nutrients, pollutants and pathogens from both point and diffuse sources.

The health of coastal waterways is influenced by a range of land use planning decisions and management practices, water management, sewage and industrial wastewater treatment and disposal and management of stormwater.

During Stage 2, councils may identify current and potential impacts of land use change on a waterway. This will help identify and evaluate appropriate management responses. Additional information on a risk-based approach for considering waterway health is provided in the Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land Use Planning Decisions.

Several of the issues affecting coastal environment areas may also impact on coastal wetlands and littoral rainforests areas. Thus, there may be overlap in the scope of detailed studies for these two management areas in the coastal zone.

Some coastal environment area issues may also overlap with coastal vulnerability areas and coastal use areas (e.g. recreational infrastructure and recreational use of the surf zone, foreshores and waterways).

Studies in Stage 2 may provide information that helps to:

- redefine the extent and boundaries of the coastal environment area
- identify and map current threats to the ecological functions and ecosystem services in the coastal environment areas
- identify which physical and/or ecosystem components may be vulnerable to degradation now and in the future
- understand how coastal hazards, now and in the future, interact with other threats to coastal environment areas, including climate change and sea level rise
- identify the impacts of land-based activities, entrance management, sediments and acid sulfate soils on the health of waterways and aquatic ecosystems
- identify point sources and areas of diffuse source nutrients and pollutants
- identify opportunities to reduce the threats to coastal environments and ecosystems
- identify opportunities to improve resilience through the rehabilitation or improved management of ecosystem components
- prioritise management actions and understand any associated trade-offs in terms of the health of coastal environment areas
- identify appropriate land use controls such as zoning and management plans for reserves in the coastal environment area.

Table B2.12 (in **Section 2.11**) provides an overview of issues in coastal environment areas, and the types of detailed studies which may be relevant in Stage 2, depending on the location, land use history and land management practices.

Figure B2.24 Volunteers surveying seabirds, Five Islands Nature Reserve, NSW south coast (Photo: R Morris/OEH)

Figure B2.25 Cliffs and coastline, Malabar Headland National Park (Photo: C Weston/OEH)

Figure B2.26 Bateau Bay picnic area, Wyrrabalong National Park (Photo: J Spencer/OEH)

2.7 Studies in coastal use areas

Studies may be undertaken in coastal use areas when information is required to assist council in making decisions about land use planning and coastal access and use.

These studies may assist council to:

- protect and enhance the scenic, social and cultural values
- maintain public access, amenity and use of coastal lands and waters, including public recreation spaces and surf zones
- facilitate development that is appropriate to the location and natural scenic setting of the coast, incorporating principles of urban design as consistent as possible with provisions in the State Environmental Planning Policy (Coastal Management) 2017 (CM SEPP) and Coastal Design Guidelines
- facilitate coastal planning that protects cultural and built heritage values and assets
- acknowledge Aboriginal peoples' social, cultural, spiritual, customary and economic use
- recognise the coast as a vital economic zone
- identify and plan for changes in demographic and socioeconomic character
- enhance the social, cultural and economic wellbeing of the community
- ensure the built environment is in keeping with the vision for the area
- provide adequate public open space.

Many councils will, for the urbanised parts of their coast, have a high level of overlap between the coastal use area (used for recreation, residential or commercial development or activities) and the coastal vulnerability and coastal environment areas.

Information about the community living in, accessing and using the coastal use areas is a key input to understanding the risks associated with coastal hazards and threats to coastal values.

Different types of urban development are outlined in the *Coastal Design Guidelines for NSW*.

Table B2.13 (in **Section 2.11**) provides examples of the studies that may be relevant to coastal use areas.

Figure B2.27 Coastal use area, Evans River (Photo: J Lugg/OEH)

2.8 Coastal risk assessment

A detailed risk assessment may be required in Stage 2 if the first-pass risk assessment (Stage 1) identified complex issues, potentially high and unacceptable risks, significant uncertainty or complex management choices.

Unacceptable risks are likely to occur when high-value assets (natural, cultural or built) and critical infrastructure are situated within areas affected by coastal hazards, particularly in the short to medium-term.

The risk assessment undertaken in Stage 2 may use the information provided by additional studies to confirm and clarify the nature and significance of coastal risks.

The risk management framework is set out in ISO 31000 (2009). **Figure B1.4** and **Figure B1.6** illustrate the risk management process, and the relationship between the first-pass and detailed risk assessments, respectively.

It is important to identify objectives for the detailed risk assessment considering the outcomes of the first-pass risk assessment and the additional information from Stage 2 studies.

The risk analysis and evaluation may benefit from consultation with relevant stakeholders so that different perspectives are incorporated in the analysis of consequences and likelihood.

Councils may revisit the context for their risk assessment including:

- the areas or issues of interest
- the history of past events and the likelihood of change to type, frequency or intensity of events
- the vulnerability and exposure of the community to coastal issues including changing coastal hazards (refer to **Figure B2.28** and **Section 2.8.1** and **2.8.2**)

- the sensitivity and adaptive capacity of the community (refer to **Sections 2.8.3** and **2.8.4**)
- the timeframes being considered
- the future scenarios that will be considered (refer to **Section 2.8.5**)
- the level of risk that is acceptable to the community
- the criteria to be used to assess the consequence and likelihood inputs to the risk analysis
- the level of certainty needed for decisions about the management of the coast
- how the outcomes of the risk assessment will be used to identify appropriate management responses.

The information from the detailed risk assessment will help identify priority issues for response and appropriate risk treatment management options in Stage 3.

2.8.1 Vulnerability

In the detailed risk assessment, it is important to consider the vulnerability of coastal assets, systems and communities. Vulnerability in a coastal context can be determined by:

- developing an understanding of the exposure and potential impacts of hazards and threats
- assessing the sensitivity of communities, assets and values to potential impacts
- assessing the capacity to respond and adapt – this is also influenced by the environmental, socioeconomic and planning context.

Assets and coastal values that have a high exposure and sensitivity to the impacts of coastal hazards, combined with a low capacity to mitigate the impacts or be modified to adapt, are highly vulnerable. **Figure B2.28** shows schematically how these components of vulnerability interact.

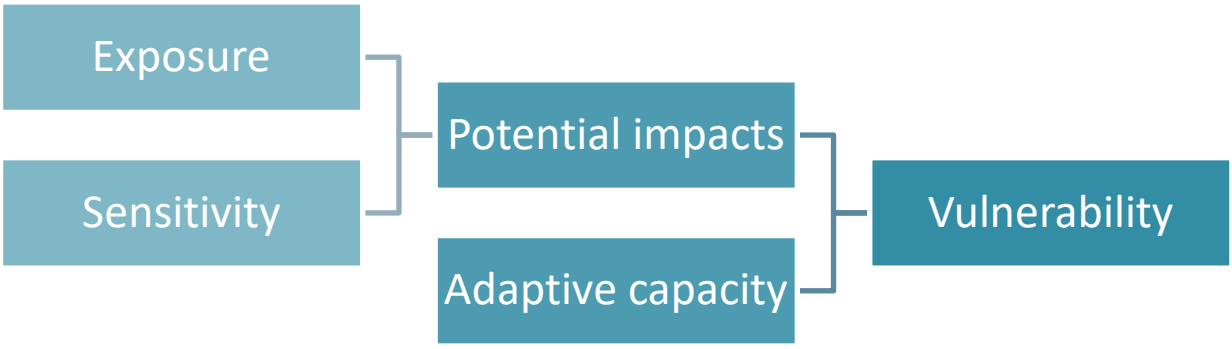

Figure B2.28 Components of vulnerability

2.8.2 Exposure

In a coastal context, exposure relates to the potential for individuals, assets and values to be impacted by a hazard and threats. Assets and values at risk can include residential properties and communities, buildings and structures, public infrastructure assets, as well as environmental assets. It can also refer to social values, economic activity and critical infrastructure networks.

Exposure information combines the location and characteristics of the assets and values at risk. This information is useful for risk analysis and determining the vulnerability that describe how the individuals, assets and values are likely to behave when subjected to natural or human-induced forces.

2.8.3 Sensitivity

In the coastal context, sensitivity relates to the type and extent of change in a coastal system (such as a landform, ecological community or settlement) when it is subject to pressures from coastal hazards or threats.

The studies undertaken in Stage 2 will help councils understand the dynamics of coastal systems (sediment transport, erosion, accretion, recession, inundation and ecological processes) and help determine the sensitivity of the coastal zone to future changes.

If a system or asset is sensitive to hazards and threats, it is likely to be more vulnerable under future climate change scenarios, including sea level rise, temperature and storminess. It is important to consider the sensitivity of the local area to diverse future scenarios.

It is also important to understand how any interdependencies between systems influence sensitivity; for example, when assessing the risks to port infrastructure, the sensitivity of electricity supply, water supply, roads and transport routes may also need to be considered.

2.8.4 Adaptive capacity

In the coastal context, adaptive capacity refers to the capacity of a system (such as a beach and foreshore, or an array of ecological communities), or a community, to respond to risks. Adaptive capacity relates to individuals, communities, organisations and assets.

When assessing vulnerability and risk, adaptive capacity is an important consideration. Adaptive capacity is influenced by factors such as:

- Whether there is space and time to change or move.
- The availability of feasible mitigation measures and technologies that can reduce the risk.
- The ability to adjust behaviour. In the case of human settlements and communities, this is affected by socioeconomic factors that will be identified in Stage 2 studies.
- The availability of resources and willingness/capacity to pay for management actions, also affected by socioeconomic context.

2.8.5 Future scenarios

For the detailed risk assessment, it is appropriate to consider a range of possible future scenarios. These might include future scenarios for climate change (incorporated into the hazard assessment, for example) and future scenarios for population growth, development and use of the coast. Certainty about future scenarios will vary with the timeframe being considered.

To explore a range of possible risk outcomes and appropriate risk treatments it is recommended that a range of scenarios be considered when identifying consequences over immediate to long-term (100 years and beyond) timeframes.

The difference between these scenarios and the choice of the most appropriate scenario for the risk assessment will depend on:

- the design life of the exposed assets
- the socioeconomic importance of the asset or the service it provides to the community; for instance, is critical infrastructure involved?
- the inherent uncertainty over longer timeframes
- the strategic context of decisions being made about land use, for instance, decisions about existing or infill development or extending development into new areas and greenfield sites.

For example, if an asset has a high-value and short design life it may be appropriate to focus on worst-case or high-end projections over the short timeframe. Alternatively, when considering a low value or readily adaptable asset, it may be appropriate to consider lower range projections when assessing vulnerability and risk.

When considering future scenarios for critical infrastructure or long-term land use planning decisions, it is appropriate to gain an understanding of the full range of risks over longer timeframes and high range projections.

2.9 Moving on to Stage 3

Stage 2 will assist councils understanding of the complexity of the issues and risks affecting the environmental, social and economic assets and values in each coastal management area.

Councils will have identified opportunities to enhance the environmental, social and economic values of their coastal area and manage current and future risks.

During Stage 3 councils will identify and evaluate management options and actions that can be implemented to reduce vulnerability and risks. These actions will help build the community's resilience and ability to adapt to change. Councils will also determine how progress in risk mitigation will be measured.

The detailed information from Stage 2 will help set the priorities for identifying management actions in Stage 3. Stage 2 will also provide the information needed to determine the level of option evaluation required in Stage 3.

In some circumstances, councils may progress to Stage 3 or to Stage 4. The situations in which councils move from Stage 2 to Stage 3 or Stage 4 are summarised in **Figure B2.29**.

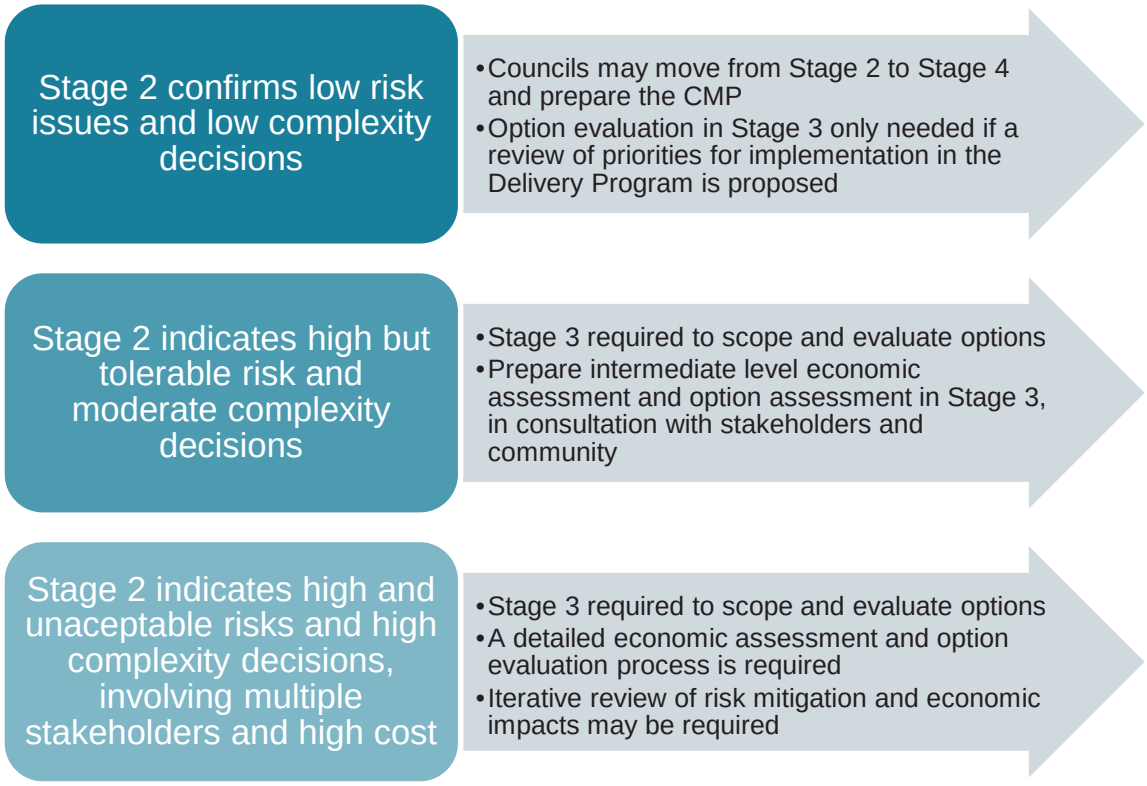

Figure B2.29 Moving on from Stage 2

2.10 Using Stage 2 information to support a planning proposal

In Stage 1 councils may identify that a planning proposal is required to amend the mapping of coastal management areas originally mapped in the CM SEPP. The studies in Stage 2 provide important information to help the planning proposal meet the Gateway requirements.

The planning proposal sets out the justification ('strategic merit') for making or amending a LEP (in this case amending coastal management area originally mapped in the CM SEPP).

If another authority is the planning proposal authority, this information will still be important for council to recommend any changes to relevant planning controls, including maps.

2.11 Compendium of issues relating to potential studies

Table B2.1 Examples of when detailed studies may be desirable

Coastal wetlands and littoral rainforests areas
• There are significant gaps in knowledge about the past, present and future evolution of coastal wetlands and littoral rainforests areas, including factors influencing the condition and resilience of these ecological communities such as the impacts of climate change. • There is evidence that SEPP maps are out-of-date or incorrect. • There have been significant increases in current and future threats to the condition of coastal wetlands or littoral rainforests such as changed drainage, clearing, or sediment or nutrient inputs. • There has been an increase in the vulnerability of coastal wetlands and littoral rainforests to the cumulative impacts of threats to their resilience, functioning, diversity or connectivity. • There are new opportunities to rehabilitate or enhance the wetland or rainforest and/or opportunities to increase community enjoyment of coastal wetland and littoral rainforest. • There is an increased appreciation of ecosystem services that are derived from coastal wetlands and littoral rainforests. Note: Also refer to the coastal environment areas section below.
Coastal vulnerability areas
• The Stage 1 scoping study has indicated that the current risk level is high or extreme and intolerable. • There is a high level of uncertainty about the geomorphic response to coastal processes and hazards. • An extreme event or sequence of events results in new estimates of the hazard extent or severity and it becomes apparent the hazard has been underestimated. • New measurements or modelling tools become available that would significantly reduce the uncertainty around, and/or change, previous risk assessments. • Design features of built assets do not accommodate coastal processes and may increase the consequence of the hazard. • New structures or other developments are likely to be adversely affected by, or adversely affect, coastal processes. • Coastal hazards have the potential to cause loss of life or threaten public safety (e.g. severe wave events, or slope failure, particularly in bluff and cliff areas). • A detailed cost-benefit analysis is likely to be required to evaluate management options. • Significant changes in coastal land use are proposed.

- Significant changes to the social or economic profile of the coastal area have altered the consequence and vulnerability profile, and this would alter the outcomes of the previous risk assessment and potentially result in changes in land use.
- Where a probabilistic coastal hazard assessment is desirable to inform decision-making that will distinguish shorelines that may behave as fast responders to extreme events and climate change drivers and those that may be more resilient to change.
- New scientific information becomes available about coastal processes and drivers, including climate change and sea level rise. This may include new information about the ways in which sandy coastlines will respond to climate change and sea level rise, including the distribution of sand between the nearshore, the beach face and the frontal dune system. Improved understanding of these sediment budget issues will influence the selection of appropriate management responses.

Coastal environment areas

- There are significant gaps in knowledge about the condition or resilience of coastal waterways, headlands, beaches, rock platforms or coastal dunes, so that there is insufficient suitable information available for a quantitative risk analysis.
- There have been significant increases in threats to the resilience of coastal environment areas including the catchments of estuaries, lakes and lagoons.
- There are high levels of uncertainty about the interaction of biophysical processes or the potential impacts of climate change in coastal environment areas.
- The spatial and temporal scale of the existing or predicted impact requires definition; for instance, are the identified impacts acute, short-term, chronic or long-term?
- The cumulative impact of threats to the resilience, functions, ecosystem services, connectivity and diversity provided by a coastal environment area are important.
- There are opportunities to enhance the natural attributes of the coastal environment area such as planting and weeding programs, restoration of tidal circulation or control of fire regimes.

Coastal use areas

- There are significant gaps in knowledge about the Aboriginal, historical and natural heritage of the coast that would impact on management decisions.
- There are gaps in knowledge about the social and economic value of coastal use areas; or there have been significant changes in the way the community uses and values the coast, that impact on future plans for development in the use area.
- There have been significant changes in coastal access, use or public safety.
- There are opportunities to increase public access, usage and/or enjoyment of the coastal environment, including the surf zone.
- There are high levels of dependence of social and economic activity on specific coastal assets; for instance, a consequence may be influenced by the social value of a surf club building which is a hub for community recreation and social activity, or by the economic importance of a trained estuary entrance and safe, reliable navigability to the commercial fishing industry. The relative significance of loss of coast-related social and economic activity when compared with other changes to local and regional development is an important consideration.
- There are proposals to develop buildings that are not in character with existing development or the natural setting, which may adversely impact visual amenity.
- There have been changes in types of buildings, their height and their impact on beach usage due to overshadowing and/or wind funnelling effects.
- There are opportunities to change the developed form and land usage to benefit the wider community's enjoyment of the coast.
- There are plans to increase the population density or develop new urban areas in the coastal zone that require consideration of urban design principles.

Table B2.2 Matters that might be considered when planning Stage 2 studies

- Do ecological or shoreline monitoring studies (e.g. in relation to migratory shorebirds) need to be conducted at specific times of the year or after specific events?
- Do opportunities exist to partner with other councils, public authorities, academic institutions or community organisations to undertake studies and disseminate information?
- Does the project schedule and budget allow sufficient time and resources to complete detailed technical studies, surveys and risk analysis, including time for council to seek advice from public authorities or the NSW Coastal Council?
- How will council define and quantify non-market ecosystem services, community and social values in a detailed cost-benefit analysis or socioeconomic assessment?
- How will council explain the impact of scientific uncertainty to local residents and stakeholders?
- How will council manage diverse technical opinions and controversial general community comment on coastal science and engineering studies?
- How will the outcomes of the proposed studies add value to analysis and decision-making?
- Is relevant data available from councils, public authorities or other sources for assessments at the level of detail required and agreed upon?
- What information does the business community require to encourage ecologically sustainable development that enhances the 'saltwater' economy?
- What planning horizons are most suited to the threat and risk assessment and subsequent decisions, considering the types of development in the local council area (e.g. brownfield, greenfield or infill), the scale of coastal hazards, social/population and environmental change, and the possible need to change local environment plans (LEPs) and/or development control plans (DCPs)?
- Who should be involved in any proposed workshops or working groups? How will these be conducted in a timely, cost-effective, meaningful and manageable manner?
- Will the proposed studies clearly articulate the scope of the threat and risk assessments and the relevance of outcomes to all stakeholders?

Table B2.3 Matters that may be included in a socioeconomic analysis

- Comprehensive socioeconomic information is desirable when a detailed economic assessment (including cost-benefit analysis and distribution analysis) will be prepared in Stage 3, as part of the evaluation of coastal management options.
- General issues which may be considered include:
  - How does the current management of the coast contribute to the social and economic wellbeing of the communities in the local government area?
  - How could future management of the coast contribute to the social and economic wellbeing of communities in the local government area in line with the principles of ecologically sustainable development?
  - Are these social and economic benefits only local in scale, or do they extend to the state scale/significance?
  - Which stakeholders are likely to be directly affected by coastal issues (including residential, recreational and business uses; and government authorities) and potential management responses?
  - What are the social and economic characteristics of relevant community stakeholders?
- **Issues to consider when establishing the social and economic resilience or vulnerability of a coastal community, and in evaluating potential coastal management responses may include:**
  - How many stakeholders/residents/businesses are involved and/or affected?
  - Who uses the coast and how do they use it?
  - What component of local recreational activity is directly attributable to coastal access?
  - For residential property, what is the real estate value of any affected properties?
  - How has the real estate value varied over the last decade and what are the drivers of property price variability?
  - What is the age of the affected landholders?

- How long have they lived at this location?
- What is their income level and what is the category of their employment?
- How far do they travel from home to work?
- Are they permanent residents or absentee/occasional residents and how does the holiday population increase impact on the use of public facilities and infrastructure including access, sewerage, water supply and parking?
- Is income derived from rental of coastal properties during holiday periods or at other times?
- What specific benefits do residents enjoy from their location?
- How would these benefits change with the various management responses?
- To what extent are these benefits sensitive to coastal management decisions?
- For businesses – in what ways is their business dependent on proximity to the coast?
- What is the economic benefit of these coast-dependent businesses (the 'saltwater' economy)?
- What state or local infrastructure has been provided on the coast to support these businesses and associated employment?
- What is the value of this infrastructure and what is its asset life?
- What maintenance or replacement measures for these assets are identified in council's asset management plan?
- To what extent are coast-dependent businesses also dependent on visitors/tourism?
- How many visitors are in the area annually and how seasonal are visitor numbers?
- What is the proportion of day visitors?
- Where do visitors stay and what are the expenditure patterns?
- Is there evidence that local coastal use and/or use of the coast by visitors is dependent on a specific beach locality, or specific access and amenity features?
- How does proximity to the coast affect the recreational preferences of local people?
- What community assets attract people; for instance, natural beaches, beaches with easy parking, beaches with alongshore pathways and lookouts, beaches with modern toilet and shower facilities, beaches with a lifeguard and/or volunteer surf patrol?
- How much of their recreation time do people spend on beaches or foreshore areas?
- What is the membership of local environment or service groups relevant to the coast (e.g. Coastcare, Reserve Management Trusts, and surf clubs)?
- What economic value do these groups add to the local community?

Table B2.4 Potential Stage 2 studies to understand issues and enhance management of coastal wetlands and littoral rainforests areas

Potential issues	Types of studies which may be conducted in Stage 2
General	
Lack of understanding of baseline condition and evolutionary history of coastal wetlands and littoral rainforests.	Consideration may need to be given to whether detailed studies are required to better understand the extent, values and condition of areas mapped in the CM SEPP. Studies may be conducted to determine the evolutionary history of coastal wetlands and littoral rainforests and potential trajectories of extent and condition. This may include the foreseeable impacts of climate change and projected changes in land use.
Social and cultural values	
Inadequate information about the cultural heritage values (including sites, places, resources and landscapes).	Baseline studies or surveys, literature reviews. Collaborative projects with local Aboriginal communities, local historical societies and resident groups.
Impacts on cultural sites or resources in coastal wetlands or littoral rainforests area.	Studies with local Aboriginal communities of opportunities to restore cultural values.
Impacts on historic heritage values of coastal wetlands or littoral rainforests.	Studies of historic land use and features in and around coastal wetlands and littoral rainforests and opportunities to enhance heritage value and education.
Vegetation, biodiversity and ecological integrity	
Invasive plant and animal species and pathogens.	Studies of the distribution and rates of expansion of invasive species in littoral rainforests, and actions required.
Inappropriate fire regimes.	Studies of the recovery of coastal wetlands and littoral rainforests after wildfire events. Studies of different fire treatments around urban areas.
Clearing and fragmentation of habitats, including urban expansion and edge effects; impacts of urban areas and agricultural uses on coastal wetland margins.	Studies of potential connectivity links across cleared areas of wetland or littoral rainforest and links between these habitats and other coastal environment areas. Studies and trials of managing urban and agricultural impacts on coastal wetlands.
Inappropriate plant, animal or firewood collection in coastal wetlands or littoral rainforests.	Studies of habitat loss associated with removal of logs, hollow trees, etc. and studies of options to address these issues.
Tracks and trails used by pedestrians, bicycles and off-road vehicles.	Studies of the impact of access arrangements on biodiversity and habitat extent and condition. Feasibility studies for alternative routes and opportunities for community enjoyment of coastal wetlands and littoral rainforests without adversely impacting on them.
Foreshore erosion, reclamation or dredging.	Studies to understand changing habitats for protected species such as migratory waders and opportunities to restore areas that have been subjected to dredging or siltation due to past catchment activities.
Inappropriate land use.	Studies on the social value of retaining or returning natural coastal habitats from existing use, particularly unproductive agricultural use, such as many areas behind tidal flood infrastructure. Studies of the impacts of grazing and other agricultural activities.
Hydrology	
Changing hydrology – through groundwater or drainage modification or other variations in water levels.	Investigation of impact of drying on wetland habitats, including loss of peat soils and degradation of groundwater-dependent ecosystems.

Potential issues	Types of studies which may be conducted in Stage 2
	Impact of changed tidal regime, drainage works or changes in stormwater quality and quantity.
Structures such as levees, seawalls and floodgates that constrain the area, function and migration of wetland communities.	Studies to better understand the significance of the changing balance between saltmarsh and mangrove communities, due to various structures and processes. Studies to understand the interactions between freshwater and saline coastal wetlands. Studies to investigate the impact of structures on fish passage and habitat migration. Studies to investigate the opportunities for offsets to address past anthropogenic disturbances of the natural system. Studies to understand the impact of not maintaining floodgates that were designed to prevent the incursion of tidal or saline waters.
Persistent inundation of intermittently or tidally inundated coastal wetlands, such as may occur with sea level rise or changes to tidal levels associated with entrance management.	Studies to identify potential changes in community structure, habitat extent or ecosystem services when inundation patterns are modified due to subsidence, entrance dredging or the impacts of climate change, including increased frequency of high tide inundation.
Contraction of saltmarsh areas and the ability for migration of wetland communities.	Studies to better plan for the migration of coastal wetland systems (e.g. saltmarsh) on low-lying shorelines subject to increasing inundation due to the impacts of climate change.
Water quality	
Catchment runoff or poor stormwater quality, including: • sediment load in water discharged into the areas of interest • nutrient levels or organic load from existing and new development areas (including residential, agricultural, industrial and wastewater treatment) • litter carried in stormwater • other contaminants.	Detailed catchment studies to identify vulnerable areas and predict sediment and nutrient loads with changing land use especially for catchments listed in Schedule 1 of the CM SEPP. Studies to identify sources and options for sediment and nutrient control. Studies of actual or modelled catchment loads of nutrients to identify vulnerable catchments. Studies of the impact of changes in land use zoning or land management measures on export of sediments and nutrients from vulnerable catchments. Studies of the sources and impacts of litter and other contaminants.
Acidic or low dissolved oxygen (DO) events, such as those linked to discharges from exposed or oxidised acid sulfate soils or flooding.	Monitoring of water quality in vulnerable waterways in the marine estate. Studies of discharges from high-risk acid sulfate soils (see Acid Sulfate Soils Assessment Guidelines for further issues). Studies of low DO events and fish kills in wetlands. Opportunities to contain and/or remediate areas adversely impacted. Options for source management.
Waste dumping, including toxic waste.	Monitoring of high-risk sites; studies of the distribution of contaminants in groundwater or surface waters. Studies to identify options to raise awareness of and enforce compliance and to identify opportunities to remediate affected areas.
Changes to salinity and/or the salinity regime associated with entrance management works, dredging, floodgate management, increased freshwater extraction, controls on catchment inflows or climate change.	Studies to identify potential changes to community structure and diversity as conditions favour species with greater or lesser salinity tolerances.

Table B2.5 Potential Stage 2 studies of beach erosion and shoreline recession

Potential issues	Types of studies which may be conducted in Stage 2
Beach erosion	
Evolutionary history and geomorphic context of the coast is poorly understood, especially the nature of offshore sediment distribution.	Studies to refine understanding of how coastal landforms evolve, and how sediment compartment boundaries and the interaction of sediment sources and sinks changes over time.
Existing or proposed coastal development and infrastructure are located within the areas exposed to beach erosion.	Studies of the variability of oceanic processes, including both spatial and temporal dimensions. Councils may access long-term datasets of wind, rainfall, waves, tides and currents wherever possible and determine whether semi-quantitative or full statistical hazard and risk analysis is appropriate. Studies to better define the short-term beach variability associated with storm clusters, rips and beach rotation within the beach fluctuation zone as defined in the CM Act. Studies of the effect of short to medium-term cyclic processes which may drive episodic beach erosion, including: • analysis of reliable long-term records of storm magnitude and frequency as it relates to the coastal region, which may include several local councils and national parks • reviewing the interactions of storm frequency and intensity with the medium and longer-term drivers of water level, beach erosion and beach orientation, for example, the Interdecadal Pacific Oscillation (IPO). Identify opportunities to mitigate risk through modification of the likelihood and consequences associated with coastal hazards.
Existing or past development (e.g. past mineral sand mining and underground mining) and coastal structures, including entrance training walls and seawalls, are affecting coastal processes and coastal erosion events.	Studies to investigate the impact of these structures and uses on sediment budgets, including how the effects of the structures interact with waves, currents, storms, and cyclic drivers of water levels and coastal processes. It is important to consider the effects of relative sea level changes that may be occurring, such as those associated with subsidence. Historical mining records, including subsidence data and geological evaluations of river delta areas, may be helpful. Identify opportunities to offset the impacts that are a legacy of past practices.
Inadequate information about sediment budgets in the short-term.	The development of a conceptual model of the sediment budget including sources and sinks for sediment gain or loss. Where possible, the variability in beach fluctuation zone, volume and profile change can be quantified, taking into consideration factors like storms, storm clusters, rips, beach rotation, headland bypassing and entrance dynamics, as well as losses and gains associated with: • onshore sand supply • sand lost offshore • longshore transport • sand losses or gains to tidal inlets • biogenic sediment production • sand lost to backbarrier (over-wash) • sand lost to dunes (aeolian).
Uncertainty about the likelihood (probability) and consequences of a coastal hazard occurring at timeframes relevant to the management of both existing and future planning and development of the NSW coast.	Appropriate methods to determine the uncertainty depend on the level of risks, the level of uncertainty and the availability of suitable data. Methods for describing and quantifying the likelihood component of risks associated with coastal hazards include: • semi-quantitative – assess components of the sediment budget using existing data, studies based on photogrammetry and modelling and expert judgement to inform decisions

Potential issues	Types of studies which may be conducted in Stage 2
	• statistical probability analysis.
Shoreline recession	
The effect of coastal structures and evolutionary history on longer-term coastal sediment budget processes and on coastal responses to changes associated with climate change, including sea level rise, is not sufficiently well understood to enable decision-making.	As for coastal erosion, important considerations will include coastal geomorphic structure and evolution, including responses of the coast to previous climate change, and the effect of coastal structures on processes such as sediment bypassing around headlands, for different sea level scenarios and wave regimes.
Existing development and infrastructure are located within the area exposed to coastal hazards when long-term factors related to sediment budget, climate change and sea level rise are considered. There is potential for future development to be in areas exposed to coastal hazards.	Important considerations include other factors which influence coastal processes and the morphology of the sandy coast, operating at various interacting time scales. Shoreline recession studies seek to develop a conceptual model of the sediment budget including sources and sinks for sediment gain or loss in the long-term and how processes are expected to change with sea level rise and other aspects of climate change (see below). Identify opportunities to reduce the vulnerability of existing or proposed development, including relocation of infrastructure at the end of its economic/design life.
Uncertainty about other coastal responses to the effects of longer-term changes in coastal process drivers, including climate change and relative sea level rise.	Short to long-term water level anomalies and trends considered when defining the degree to which shorelines are ambulatory or essentially oscillate around a mean position. Examples include: • Sea level variation components including extreme sea level events and sea level anomalies (such as coastal trapped waves), medium-term (approximately decadal) cyclic variations in coastal drivers and responses such as El Niño/La Niña and beach rotation processes. • The response of the coastal system to long-term changes to sea level and other climate drivers, using best available information about rates of change. This may include studies of the behaviour of coastal foredunes in areas with different sediment budgets and different exposure to over-wash and/or alongshore sediment transport processes. • Relative sea level changes that can result from land subsidence, particularly in coastal areas where underground mining has occurred, or where development has taken place/will take place on areas that were river deltas. • The morphodynamic interaction of coastal processes and landform change which can affect heights of storm surges and tidal levels at the longer timeframes. • Tsunami exposure.
Integration of multi-scale shoreline evolution factors to predict shoreline recession.	Studies to collect detailed geomorphic information, including the sediment and geometry of the beach and shoreline. The studies assist to integrate the effects of coastal structure, nearshore and inner-shelf bathymetry, sediment availability, sand barrier type, inlet sedimentation and contemporary coastal processes. Mechanisms which may be considered in the analysis include: • the interaction of storm events and rising sea level • how a landward and upward shift of the coastal profile could occur (e.g. beach erosion and offshore deposition)

Potential issues	Types of studies which may be conducted in Stage 2
	• the extent to which dune or flood tidal delta volumes can accommodate sediment loss from the beach due to rising sea level • the consideration of the slope of the nearshore profile and the evolution of sediment compartments • the potential for landward and upward back-stepping of an entire barrier, due to barrier over-wash and tidal inlet deposition • the impact of headland emergence on coastal processes as sea levels rise. The application of statistical simulation frameworks such as Monte Carlo analysis may be necessary when projecting future sediment budget processes in geomorphically complex settings. Simple models of coastal change, such as the Bruun Rule may not be appropriate in these contexts.

Table B2.6 Potential Stage 2 studies of coastal lake and watercourse entrance instability

Potential issues	Types of studies which may be conducted in Stage 2
Poor understanding of the evolution of barriers, entrances and flood tide deltas. Historical studies have demonstrated the dynamic nature of shoreline deposits adjacent to flood tide deltas making these localities some of the most vulnerable to change on the coast of New South Wales.	Review previous historical changes to the position of shorelines and inundation events on shoreline deposits that are marginal to flood tide deltas.
Poor understanding of the role of tidal deltas in the coastal sediment budget and potential consideration of use of flood tide delta sediments for beach nourishment. Removal of sediment from an entrance deposit is likely to stimulate localised beach erosion as waves and currents entrain and transport sand from the beach back into the entrance, to restore the previous 'equilibrium' between the entrance and the beach/surf zone.	Studies to quantify the interrelationship of sediment deposits in estuary entrances and sediments on the adjacent beaches and nearshore areas.
Poor understanding of the impacts of climate change and sea level rise on entrance dynamics. It is likely that as sea level rises, the flood tide deltas of estuaries will store sand from adjacent beaches and the nearshore. In the medium to long-term, estuary flood tide delta deposition may be an important sediment sink for coastal compartments.	Studies to identify the entrance response to climate change and sea level rise. Studies to identify changes to entrance hydrodynamics and sediment transport as a result of the impacts of climate change and sea level rise.
Inadequate information about coastal lake or watercourse entrance instability and the effects of entrance training on sediment budgets. The estuary flood tide delta may become a more permanent sink in	Studies to determine the interaction between fluvial, tidal and wave processes, which determines the morphology and entrance condition and the balance between open, closed or transitional entrance conditions.

Potential issues	Types of studies which may be conducted in Stage 2
circumstances such as the creation or reinforcing of an artificial opening to the estuary and/or dredging of the estuary mouth. This creates additional accommodation space and sediment transport drivers, encouraging persistent sand accumulation inside the estuary (see Nielsen and Gordon 2015).	
Limited understanding of the behaviour of ICOLL entrances and how different management intervention affects entrance processes and other coastal hazards within the estuary or lake.	Studies to determine the factors influencing the intermittent opening behaviour of ICOLLs and the considerable variation in frequency and duration of opening between systems. Studies to determine the impact of a closed entrance on water levels in the lake or lagoon and related inundation of low-lying foreshore areas. Studies to determine the impact of forced opening of entrances on the efficiency of entrance scour and the duration of opening. Studies of the impact of entrance opening and closing on the safety and accessibility of the entrance area for swimmers, impacts on boating access, water quality and fishery productivity. Identify opportunities to modify entrance management practices.
Impacts on water quality, hydrodynamics and ecology of coastal lakes.	Studies to determine the relationship between entrance processes and the water quality and ecology of coastal lakes. Studies to quantify the impact of trained entrances on the circulation, flushing and tidal range of coastal lake systems. Identify opportunities to improve water quality and ecosystem health. These matters are also relevant to studies for coastal environment areas.

Table B2.7 Potential Stage 2 studies of coastal and tidal inundation

Potential issues	Types of studies which may be conducted in Stage 2
Inadequate information about the risk of coastal inundation associated with storm surge, extreme waves and consequent over-wash impacts.	Detailed studies of storm surge and extreme wave processes. Studies to determine the potential impacts of climate change on coastal inundation.
Inadequate information about the risk of wave run-up and overtopping of dunes and barriers.	Detailed studies of wave run-up and overtopping processes. Detailed studies of beach slope and dune heights (use of coastal LiDAR).
Vulnerable assets and infrastructure.	Detailed studies to better understand impact thresholds and how existing vulnerability of coastal development can be managed to avoid an increase in vulnerability and risk. These studies may relate to residential and commercial development, roads, power, telecommunications, water supply, stormwater systems or sewage infrastructure. Identify potential opportunities to reduce the vulnerability of assets and infrastructure and/or opportunities to relocate over time as infrastructure requires replacement or upgrade.
Inadequate information about the potential risks associated with tidal inundation.	Studies to determine the interactions between different coastal processes and forces that can combine to influence the level of inundation. Determine the uncertainties associated with the modelling methodologies, data and information used for inundation assessments. Studies to determine vulnerable assets and infrastructure, including private assets and public assets and infrastructure such as sewage lines and pump stations, parks and pathways, low wharves and jetties. Studies to quantify the interaction of catchment flooding and coastal processes.
Poor understanding of the impacts of climate change on coastal and tidal inundation.	Studies to investigate the potential effects of climate change on tidal inundation processes and how they influence inundation frequency and spatial extents.
Poor understanding of flow pathways, needed to inform management priorities.	Studies to determine the processes involved in inundation of low-lying areas, in particular flow pathways, the storage capacity of an area in relation to the volume and frequency of flows, and the drainage patterns of an area. Conceptual models may be used to provide a representation of the features, processes and management issues for particular areas. They can help to understand the source of the inundation, the pathways to low-lying areas, and the spatial extent of the areas being inundated and in turn the potential consequences.
Poor understanding of the interaction of catchment flooding and coastal processes, needed to inform risk analysis and management priorities.	Hydrodynamic studies to investigate the interaction between catchment flooding and coastal processes.
Potential impacts on groundwater quality, with risks to ecosystems, agriculture and drinking water supplies.	Studies of groundwater quality with different seawater inundation regimes, including the effects of climate change and relative sea level increases. This information may be needed for cost-benefit analysis if important community services and values are affected. Studies of the impact on groundwater-dependent ecosystems. Identify opportunities to reduce the potential impacts on groundwater systems.

Table B2.8 Potential Stage 2 studies of coastal cliff or slope instability

Potential issues	Types of studies which may be conducted in Stage 2
Inadequate information about the potential risks associated with coastal cliff or slope instability in association with geological structures and different rock types.	Studies to determine the factors influencing cliff or slope instability. Studies to determine the location of vulnerable assets and infrastructure. Identify opportunities to reduce the risks associated with coastal cliff or slope instability.
Insufficient information about the interaction of slope instability issues with unconsolidated materials and rock.	Studies of the evolution of beaches and cliffs, including the lithology, stratigraphy and structural geology of coastal cliffs, the stratigraphy of the back-beach area and the extent of bedrock.
Insufficient information on foundation conditions for buildings behind beaches in areas that may be affected by reduced foundation capacity.	Studies to determine the zone of reduced foundation capacity as outlined.
Poor understanding of the key drivers of slope instability.	Studies of the ways in which development on cliffs has altered natural drainage patterns and concentrated surface and groundwater flows. Studies of the impact of climate change and sea level rise on the weathering and erosion (particularly undercutting) of coastal cliffs and bluffs.
Public safety issues.	Studies to investigate risk to life associated with public use of cliffs, headlands, rock platforms, beaches below cliffs and erosion escarpments on beaches. This may include design and location of pathways, lookout platforms and other structures. Identify opportunities to reduce public safety issues and raise awareness of the risks.

Table B2.9 Potential Stage 2 studies of coastal estuary foreshore erosion and inundation

Potential issues	Types of studies which may be conducted in Stage 2
Inadequate information about the interaction of processes causing erosion and inundation of estuary foreshores.	Studies to determine the nature and composition of estuary foreshores. Studies of the interaction of waves associated with local wind waves related to estuary or lake fetch, incursion of ocean waves, seiching and recreational boating. Studies of the interaction of estuary flooding – from the catchment or from oceanic processes and wave processes.
Poor understanding of the consequences of foreshore erosion and inundation, now and in the future.	Studies of the impact of foreshore erosion and inundation on different types of development and associated infrastructure and on uses in different land tenures. This may include private land and public or recreational land and structures such as boat ramps. Identify opportunities to reduce the impacts of foreshore erosion. Identify actions required to mitigate impacts of foreshore inundation.
Potential conflicts about future land use and land management in foreshore areas.	Studies of long-term changes in rates of estuary foreshore erosion and inundation, as they impact on public and private land and on recreational access, amenity and use.

Table B2.10 Potential Stage 2 studies of risks to life

Potential issues	Types of studies which may be conducted in Stage 2
Inadequate information about the potential risks to life due to coastal processes, or location of infrastructure such as pathways.	Studies to determine if hazards and threats are posing a risk to public safety and whether public pathways are located a safe distance from cliffs and bluffs (both top and bottom). Studies to determine the estimated timeframe before the hazard poses a risk to public safety. Studies to determine community awareness of the risks and the necessity for and appropriateness of signage, at the time of coastal emergency events and generally. Studies of the design of existing structures which may be impacted by coastal processes, including entrance training walls (overtopping by waves), and viewing platforms. Identify opportunities to raise awareness and reduce the risks to life due to coastal processes.
Inadequate information about other risks to life, such as contaminants and pathogens.	Studies of historical land and waterway use, including groundwater (see also coastal use areas). Studies of ecological pathways for contamination (such as in oysters, fish and prawns) – see also coastal environment areas. Identify opportunities to reduce the risk of contaminants and pathogens.

Table B2.11 Potential issues and investigations in coastal environment areas

Potential issues	Types of studies which may be conducted in Stage 2
Impacts of future changes in land uses.	An effects-based assessment can be used to quantify how the land use activity will change the health of the waterway. A typical effects-based assessment: • determines whether the current health of a waterway is supporting the waterway objective(s) • identifies the level of protection required • quantifies the stressor(s) arising from the land use activity • quantifies the sensitivity of the waterway to the stressor(s) • quantifies the extent to which the stressor(s) affects the health of the waterway • quantifies the effectiveness of the management responses in protecting, maintaining and/or improving the health of the waterway. Additional information on a risk-based approach for considering waterway health is provided in the Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions.
Location and management of discharge points for sewer, stormwater and other sources of pollution from drainage systems discharging into the marine estate.	Map locations of stormwater discharge points with patterns of sensitive ecological variables. Water quality studies around discharge points from sewage treatment plants (STPs), to ocean, estuary or groundwater, and stormwater discharge points. Identify opportunities to offset any adverse impacts or provide alternative options for management of stormwater or outfall discharges. Evidence of bioaccumulation of contaminants carried in discharges. Assess possible sources of diffuse pollution that may adversely affect the marine estate.
Invasive plant and animal species.	Study species present in coastal environment areas and their distribution. Opportunities to address the adverse impacts of invasive species.

Potential issues	Types of studies which may be conducted in Stage 2
Conflicts between recreational use and conservation values of beaches and coastal waterways in the marine estate.	Studies of beach and waterway usage such as vehicles on beaches used for passive recreation, motorised vessels in bathing areas and bait/shellfish harvesting. Identify opportunities and/or actions to overcome conflicts.
Dune instability.	The behaviour of coastal dunes when they are destabilised and transgress landward. Reasons for destabilisation may include storms, clearing and dissection of the frontal dunes, fire, sand mining, grazing, extraction or heavy recreational use. Climate change and sea level rise may also impact on the morphology and sediment budget of frontal dune systems. Need for controlled access, education and signage. Willingness of the community to become involved in dune management activities. Community values and objectives for the management of frontal dune systems and dune vegetation may have a strong influence on the management responses that are acceptable.
Urban expansion and edge effects.	Studies of ecological connectivity, water quality in the marine estate, sources of invasive species and recreation demand. Consider both ecological and community use studies; link also to studies for coastal vulnerability areas. Studies may address matters such as: • foreshore and headland management impacts such as filling, mowing, clearing, landscaping or fire regimes • impacts of recreational access – terrestrial and aquatic, e.g. moorings, jetties, ramps, marinas, pathways (especially informal tracks), steps and ramps • impact of invasive species (plant and animal), terrestrial and aquatic • impact of increasing recreational pressure on sensitive coastal habitats, including beaches, dunes, coastal headlands and near urban coastal bushland • opportunities to provide environmentally sensitive, controlled access to environment areas so that the community can enjoy the amenity and develop a greater sense of ‘ownership’ of the natural assets of their area. See also coastal wetlands and littoral rainforests.
Changing groundwater levels.	Studies of causes of lowering or rising groundwater. Impact on coastal groundwater-dependent ecosystems and on ecological communities that are sensitive to waterlogging, or drying. May also affect coastal infrastructure function (e.g. infiltration into sewerage and drainage systems) and coastal hazards (slope stability). Identify opportunities to manage groundwater levels to offset past adverse impacts and to enhance environmental values of the area.
Foreshore erosion, reclamation or dredging.	Hydrodynamic studies and foreshore erosion studies of estuaries and coastal lakes and lagoons. Studies of foreshore and nearshore habitat. The impact on habitat continuity and quality of shoreline protection works (open coast or estuaries), including seawalls, levees, and bank stabilisation with plantings. The impact and effectiveness of various ‘natural’ foreshore management techniques on eroding or persistently inundated estuary shorelines. Opportunities to use dredging to offset shoreline erosion and improve water exchange. Community use studies.

Potential issues	Types of studies which may be conducted in Stage 2
Sediment load and/or deposition.	Sources, amount and character of sediment load and sediment redistribution in aquatic systems. Impacts such as smothering of seagrass and other habitats. Opportunities to redress past inflow deposits and reduce current sediment loads.
Floodplain drainage and levees.	Impacts of barriers to fish passage. Changes to drainage and inundation. Opportunities to offset adverse impacts that are a legacy of past practices.
Acidification (coastal acid sulfate soils).	Studies of the impact of artificial drainage (and water extraction) and floodgate systems, including impacts on groundwater levels, the oxidation of acid sulfate soils and discharges of low pH waters from floodplain drainage systems. Studies of the impact of low pH discharges and other acid sulfate soils impacts on aquatic habitats, fish populations and waterway use. Opportunities to redress past actions that have activated acid release from the soils.
Inappropriate access arrangements, such as moorings over seagrass endangered ecological communities (EECs).	Studies of changes to seagrass health and distribution in areas with boat moorings. Trials of different mooring systems. Waterway usage studies.
Persistent inundation.	Studies of the likelihood of intermittent and permanent inundation at different timeframes. Opportunities for natural systems to migrate to higher ground.
Water quality degradation including excessive nutrient loads and low DO events.	Studies of point and diffuse nutrient sources and discharges that affect the health of ecological communities, including links to catchment land use. Studies of algal blooms and nutrient cycling processes. Studies of organic load entering coastal waterways in the marine estate, directly from catchment runoff and indirectly from excessive growth and dieback of algae and other coastal lake or estuary vegetation. Conditions in which low DO occurs, including entrance conditions and catchment inflows. Studies of fish kills. Opportunities to offset the impact of catchment development through greater flushing as a result of, for example, extended entrance openings and/or reducing the hydraulic friction in channels.
Litter such as plastics, microplastics and fishing line.	Studies of sources of litter (e.g. in stormwater) and impacts on coastal waterways. Community use studies. Identify types of gross pollution interception devices that are suitable for the catchment.
Heavy metal contamination and other contaminants.	Studies of the sources, distribution and impact of toxic contaminants that affect the health of ecological communities or bio-accumulate and impact on the use of estuaries and lakes as fisheries or for recreation. Identify policies and practices required for source control.
Changed water level and salinity regimes due to entrance management to overcome water quality and/or flooding issues.	Studies of estuary and coastal lake hydrodynamic processes. Studies of waterway usage, and usage potential. See also coastal wetlands and littoral rainforests areas.

Potential issues	Types of studies which may be conducted in Stage 2
Loss of value of coastal environment areas, linked to impacts on capacity to provide ecosystem services.	Studies of the condition and value of coastal ecosystems at the local to regional scale, including consideration of environmental ecosystem services (such as clean water, recycling of organic material) and socioeconomic services such as recreational values, fishery values and aesthetics. This information will be a valuable input to the assessment of costs and benefits of major structural protection works or other management strategies.
Opportunities to better define the boundaries of the coastal environment area.	Studies to identify additional areas that may be included as coastal environment areas and thus will require new protective measures such as land use controls.
Potential impacts of climate change.	Studies of the resilience and adaptive capacity of coastal ecosystems to increasing water levels and inundation of low-lying areas and ecosystems subject to climate change stress; for example, rock platforms, dunes, seagrasses, coastal headland heath vegetation and coastal floodplains. Studies to identify areas where habitat migration may occur to accommodate sea level rise and planning to protect those areas. Studies of other potential impacts of climate change on coastal environment areas including increased temperatures, changes in wind and waves, changes in turbidity and foreshore erosion, increased sediment loads, changes in salinity, changes in freshwater quality, quantity and timing of flows.

Table B2.12 Potential issues and investigations in coastal use areas

Potential issues	Types of studies which may be conducted in Stage 2
Lack of information about values and assets of coastal use areas including the social, cultural and economic characteristics of beach, surf zone and foreshore use for residential, commercial (including tourism) and recreational purposes.	Studies to determine the social, cultural and economic value of the coastal use area. This may include consideration of: • The value of assets (natural and built) and the economic value of coast-dependant industries such as tourism, fisheries and ports. • Usage and value of amenity of coastal use areas and critical coastal access infrastructure. This will include surf clubs, seawalls protecting foreshore reserves and/or providing promenades, surfing reserves and access to the surf zone. • Opportunities for increasing employment in economic activities that pertain to the sustainable development of the coastal use area.
Changing spatial patterns in coastal land use and vulnerabilities.	Mapping the locations of urban development (such as private residences and commercial buildings) that are within the coastal use area and updating the information whenever the hazard and risk assessment is updated.
Coastal development – applying the *Coastal Design Guidelines for NSW*	Studies to identify opportunities to: • redesign and redevelop coastal use areas to protect and enhance their scenic, social and cultural values and enhance resilience of coastal communities • enhance urban designs that ensure the bulk, type, scale and size of development is appropriate to the coastal location • incorporate water sensitive design into urban development • provide more public open space for recreational activities • address the impact of back-beach and estuary/lake foreshore buildings on overshadowing of the beach, foreshore and associated parkland, and on wind funnelling.
Uncertainty about willingness to contribute to the cost of coastal management.	Studies to determine the willingness to contribute to the cost of: • upgrades to coastal assets and facilities which enhance access or amenity at beaches, headlands or longer sections of the coast

Potential issues	Types of studies which may be conducted in Stage 2
	• protecting public assets affected by coastal hazards • modification or relocation/redesign of public assets that are impacting on coastal ecosystems (for instance, stormwater and wastewater infrastructure systems) • protecting private property from coastal hazards, up to a specified design life • relocating to another location in the same local government area, but outside coastal risk areas, with or without a financial incentive • innovative residential designs to accommodate coastal hazard impacts.
Lack of information about existing development, and its use.	Studies to document the general age and type of construction of developed areas. Development of a community profile that will provide information about the demography of property owners in a coastal use area. This includes age, period of ownership, resident or absentee owner.
Poorly designed or managed development in coastal use areas impacting on the health, function and resilience of coastal environment areas and coastal wetlands and littoral rainforest areas.	Studies to identify the impacts of development and opportunities for management responses that protect the values of other coastal management areas. Studies of opportunities to zone coastal dunes to allow for transgression or migration in areas where climate change and sea level rise (or other shorter-term processes) may lead to landward migration of the frontal dune, driven by landward movement of sediment (wash-over and wind-blown).
Land tenure.	Studies to identify and map broad categories of Crown land, council land and private land, and how these relate to the key natural, economic and social assets of the area.
Community use	
Community access and recreation.	Studies to determine the significance of coastal recreational activities at the local, regional and state scale. This may include matters such as outstanding surfing breaks, recreational fishing localities, sailing waters or views. Studies to determine the need for access facilities such as car parking, cycleways and pathways to accommodate a growing permanent or visitor population wanting to participate in recreation activities at the coastline. Studies of the need for coastal safety programs in relation to beach, breakwater and rock platform use. Studies of potential threats to recreational activities such as boating, fishing and surfing. Studies of threats to surfing reserves and opportunities for additional reserves. Studies of potential pressure on coastal biodiversity from increased recreational use and identifying opportunities to manage these impacts. Studies to determine opportunities for alternative beach/coast access locations, including access to foreshores and access to waterways and the marine estate.
Potential impact of hazards and mitigation options.	Studies to determine how specific coastal recreational values (including access and visual amenity) and coastal recreation such as surfing and walking would be impacted by coastal hazards or by potential hazard mitigation options, and opportunities to mitigate these impacts. As noted above, community recreational and visual amenity values may have a significant impact on the selection of appropriate dune management options and on objectives for the morphology and vegetation of beaches and dunes.

Potential issues	Types of studies which may be conducted in Stage 2
Impacts of agricultural land uses.	Studies may address matters such as the impacts of stock grazing on dunes, estuary foreshores and in wetlands, or runoff from intensive agriculture areas to coastal waterways and the marine estate.
Historic cultural heritage	
Cultural heritage.	Studies to identify items/areas of cultural heritage and the potential threats to cultural heritage. Urban design studies of the present and future desired characteristics of the 'place' regarding future land use planning and development controls. Opportunities to protect and conserve cultural heritage.
Historic heritage features including lighthouses, shipwrecks, entrance training walls, historic ocean wharves.	Studies to review the local heritage register to identify any features that are located within coastal use areas or whose management requires integration with management of coastal environment areas, coastal wetlands and littoral rainforests areas, or coastal vulnerability areas. Opportunities to protect, conserve and raise awareness of heritage sites.
Aboriginal cultural heritage	
Aboriginal cultural heritage.	Aboriginal cultural heritage studies may include the: • cultural value of coastal ecological communities on public land • condition assessment of gazetted Aboriginal sites and places that are on public land • interactions of issues on land owned and managed by Aboriginal organisations and on land in other tenures. Identify opportunities to acknowledge Aboriginal peoples' spiritual, social and customary use of the coast.
Geological heritage	
Geological heritage.	Studies to investigate the condition of, access to and threats to geological heritage sites. Opportunities to protect, conserve and raise awareness of geological heritage sites.