Local Government Association of South Australia

The voice of local government.

Coastal Adaptation Guidelines

November 2020

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Preface

The Local Government Association of South Australia (LGA) is the voice of local government in South Australia, representing all 68 individual councils across the state. The LGA provides leadership, support, representation and advocacy relevant to the needs of our member councils.

In 2019-20, with funding support from the Local Government Research and Development Scheme, the LGA commissioned Edge Environment to engage with member councils to develop these Local Government Coastal Adaptation Guidelines.

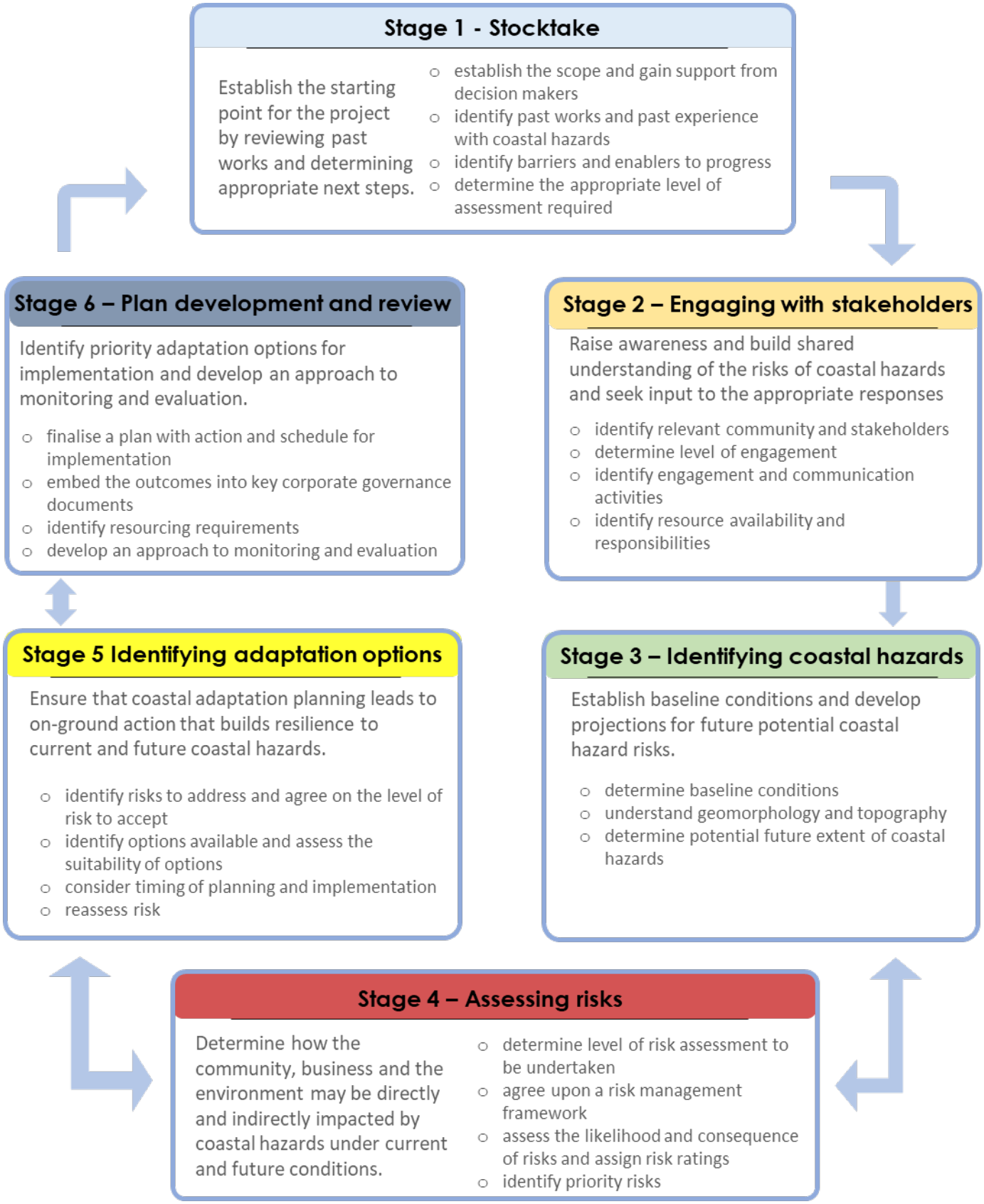
Many Councils find themselves with care control and management of coastal land vested in them as a consequence of section 18 of the Harbors and Navigation Act 1993, and therefore obliged to consider that land as part of their obligations under the Local Government Act, the Development Act and the Planning Development and Infrastructure Act.

The Local Government Coastal Adaptation Guidelines seek to provide comprehensive and contemporary advice specific to local government for coastal climate adaptation planning.

The Guidelines aim to provide support to South Australian councils in assessing and quantifying the likely impacts to councils from coastal inundation and erosion as a result of climate change and identify decision pathways for a range of adaptation options for addressing these impacts. The Guidelines have been prepared to assist councils who are considering or have made decisions to develop coastal adaptation plans. It is not to be considered as a recommendation that they do so.

They are based on international and national best practice, and identify actions and decisions that can be made by councils to address local issues. The framework focuses on key areas of risks for councils including legal liability, financial impacts, planning and asset management.

Six stages of the coastal adaptation planning process.



1. Introduction

1.1. Background

South Australia has over 5,000 km of coastline, stretching from the southeast of the State near the border with Victoria to the west coast. Across this area the coastal environment ranges from beaches and rocky shores along the Greater South Ocean to the waters of Gulfs St Vincent and Spencer, to estuaries and bays lined by mangroves and mudflats.

Under natural conditions, the coastal environment is dynamic, being shaped and reshaped by a combination of wind and waves and local geology and geomorphology. This results in the active erosion of beaches and periodic flooding of low lying land, especially during storm events. Over the longer term, soft and hard rock shorelines also erode.

Sea levels are rising around the globe in response to climate change. In the future, sea levels are expected to continue to rise around the South Australian coastline as a result of climate change. This will further enhance areas of existing erosion and flooding, with impacts becoming greater over the century as sea levels continue to rise.

Half of South Australia's councils are coastal. Eight are located along the 80km metropolitan Adelaide coastline, from Sellicks Beach to St Kilda, with the remaining 26 spread around the regional coastline, from Eyre Peninsula, Spencer Gulf, Yorke Peninsula, Fleurieu and Kangaroo Island and Limestone Coast.

Local government manages assets and delivers services across the South Australian coastline. This includes:

- Constructing and maintaining facilities like boat ramps, jetties
- Building defensive structures like breakwaters, rock walls
- Approving private residential and commercial developments
- Maintaining areas of open space to support sport and recreation
- Conserving natural assets such as dunes and beaches

Given current and projected impacts along the coastline, councils need to actively plan for future asset management and service delivery.

1.2. About the Guidelines

Regardless of their size or location across the state, coastal councils are facing the same issues and resourcing pressures, including: sand and beach management; cliff erosion; access management and signage; environmental management relating to weeds, flora and fauna, revegetation and illegal dumping; dredging; growing need for protection infrastructure like levees, seawalls, groynes; maintenance and replacement cost pressures on recreational infrastructure like jetties, boat ramps; planning and development anomalies.

In 2012, the Local Government Association of South Australia released the LGA Coastal Adaptation Decision Support Pathways (CADP) Guidelines for Councils. The CADP presented a six step 'decision pathways' approach for councils undertaking local coastal climate adaptation planning processes.

Since 2012, the CADP has been successfully utilised by councils in South Australia for a range of local planning exercises. However, since its development, a range of other coastal adaptation tools have been developed based on emerging best practice. In response to these changes and lived experience, the LGA SA has developed these revised Coastal Adaptation Guidelines (henceforth the "Guidelines").

The development of the Guidelines has been informed by a review of international and national best practice coastal adaptation planning and management combined with South Australian policy, planning and implementation experience. Councils provided input to the Guidelines via an online survey, workshops and a user testing session.

All terms and definitions are provided in Glossary at the end of the document. The following are key terms that are put forward to assist in better understanding the coastal adaptation planning processes in the context of these Guidelines.

Coastal hazards

Subset of natural hazards covering tidal or coastal storm flooding, rising sea level, tsunami or meteorological tsunami flooding, coastal erosion (shorelines or cliffs), coastal acid sulfate soils, sand drift, loss of coastal habitats, rise in groundwater levels from storm tides and sea-level rise, and salinisation of surface fresh waters and groundwater aquifers.

Adaptation

Adaptation is practical action taken to help communities and ecosystems moderate, cope with, or take advantage of current and future risks from climate impacts.

Mitigation

Mitigation is action to reduce sources of greenhouse gases, or to enhance the removal of these gases from the atmosphere. This term is also sometimes used in relation to risk mitigation, which describes actions taken to reduce the likelihood or consequence of a risk.

1.3. Audience and structure

The Guidelines have been designed to support coastal councils seeking to develop or implement local coastal climate adaptation plans, referred to here as coastal adaptation plans.

It should be noted that effective coastal adaptation plans and implementation cannot be achieved by council in isolation, there is opportunity to share responsibilities and resources across all levels of government and different sectors within the State.

Coastal adaptation plans have several common features:

- They are local in scale, either dealing with stretches of coastline within a council or individual sites and settlements.
- They address climate change related hazards, especially coastal flooding and erosion exacerbated by the impacts of sea level rise.

- They are “adaptation” focused in that they aim to address or account for future potential conditions as a result of climate change. This is compared with climate change plans that are “mitigation” focused, which address emissions reduction.

The Guidelines provide an overview of coastal processes and climate change impacts relevant to South Australian coastal councils (Section 2) and a summary of the policy and legal context relevant to coastal adaptation planning in South Australia (Section 3).

The Guidelines then present six stages that should be considered when developing a coastal adaptation plan. These have been developed based on national and internal guidelines and frameworks and are as follows:

- Stocktake;
- Engagement;
- Identifying coastal hazards;
- Assessing risks;
- Identifying and assessing options; and
- Plan development and implementation.

Each stage has a consistent structure, which presents the purpose of the stage, process, minimum requirements and recommendations for further reading. The minimum requirements are intended to be recommendations for leading practice and are not mandatory. Case studies from South Australian coastal councils are also identified along with “key questions to ask” when undertaking each stage.

When using these Guidelines please note that:

- The information provided is intended to be concise and not repeat in detail what is adequately covered in other guidelines. Where more detailed information is required, options for further reading are suggested.
- The Guidelines are not intended to be read from front to back in one sitting and as such some information is repeated across sections. They are intended to be consulted periodically as the need arises, such as when designing new projects, preparing consultant briefs or reviewing progress.

1.4. Guiding principles

Coastal adaptation planning presents a complex challenge for councils. While these Guidelines recommend a set of minimum requirements in relation to the six key stages, the following principles are also proposed to guide the overall process. Their development has been informed by experience in South Australian coastal councils and is considered to be best practice for coastal adaptation planning (1).

1. Avoid maladaptation – Avoid implementing adaptation options to address one form of a coastal risk that may exacerbate other forms of coastal risk.
2. Disclosure - Unless there are privacy or legal concerns, seek to disclose information about current and future coastal hazards to external stakeholders, making the information easily accessible.
3. Diversity – Coastal adaptation decision making must include stakeholders from environmental, social and economic realms.
4. Governance - The results of risk assessments should be embedded within key corporate governance documents.
5. Investment – Avoid using public resources to protect private assets.
6. Stakeholder engagement – Engage stakeholders early and regularly during coastal adaptation planning to generate greater support for adaptation options now and in the future.
7. Transparency - Be transparent about the availability of data that relates to coastal hazards.
8. Multiple outcomes - Identifying adaptation options that provide multiple benefits or outcomes across sectors (eg protection, tourism, health, sport and recreation, environment). In doing so, there is growing opportunity to collaborate with other public and private sectors and share costs associated with coastal adaptation planning, implementation, monitoring and evaluation processes.

2. Coastal processes and climate change

The structure and condition of the coast are influenced by a range of natural processes that are broadly grouped into oceanographic and coastal processes. Oceanographic processes describe the action of the sea or ocean and relate mostly to sea levels and waves whereas coastal processes describe the relationship between water levels, waves and underlying geology and geomorphology.

2.1. Coastal processes

2.1.1. Sea levels and tide

Sea level is often described in relation to the tide or storm surge events. The tide causes sea levels to vary each day as a result of the gravitational pull of the moon and sun. In relation to the tide, we might observe daily low and high tide levels, but for planning it is important to understand the (2) (3):

- **highest astronomical tide** (HAT), which is the highest level of water that can be predicted to occur under any combination of astronomical conditions (http://www.ozcoasts.gov.au/climate/sd_fqa.jsp#HAT)

- **lowest astronomical tide** (LAT), which is the lowest level of water which can be predicted to occur under any combination of astronomical conditions. (http://www.ozcoasts.gov.au/climate/sd_fqa.jsp#HAT)

The **mean sea level** is the surface level of the ocean at a particular point averaged over an extended period of time such as a month or year (4). In Australia, mean sea level approximates to 0 m Australian Height Datum (AHD)[1]. At any given gauging station sea level is often relative to a local mark, such as the low water mark.

Extreme sea levels are a combination of tides, storm surges and wind waves.

Storm surges can be caused by local weather systems and associated falling atmospheric pressure and strong surface winds, which increase the water level against the coast. A **storm tide** is the combination of storm surge and tides.

During storm events, the local prevailing wind moving across the sea can create **wind waves** that result in higher sea levels as these arrive at the coast. These are in addition to swell waves generated by distant weather systems.

Wave breaking can further increase coastal sea levels. This is a result of the **wave setup**, which is the temporary increase in sea levels due to effect of wave breaking, and up which is the maximum elevation up the shore that is reached by an individual wave breaking.

The **1-in-100-year storm tide** level is the height that has a 1 per cent chance of occurring in any given year (also known as the 1% Annual Exceedance Probability, AEP). This height varies around the coastline according to the tidal range and the magnitude of storm surges that can occur along a section of coast due to the coastline features and the prevailing meteorology of the region.

[1] Australian Height Datum (AHD) is a coordinate system used for altitude measurement in Australia. This mark was set in the late 1970's since which time several centimetres of sea level rise have occurred.

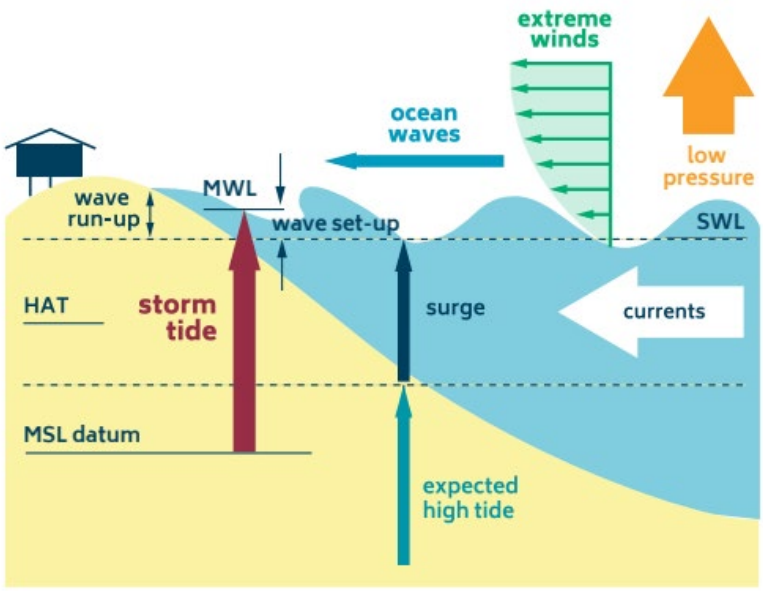


Figure 1 Contributions to coastal sea level from tides, storm surge and wave processes. Source: After Harper 2001 (5)

Where is the tide measured in South Australia?

Tide data in South Australia is collected from operating tide gauges at the standard ports across the State including Port Adelaide (Outer Harbor), Victor Harbor, Cape Jervis, Port Giles, Wallaroo, Port Pirie, Whyalla, Port Lincoln and Thevenard. This data is used for monitoring tides, significant storm events and managing the safe passage of shipping (6).

2.1.2. Geology and geomorphology

The underlying geology of the coast influences the erodibility and hence topography of the shore. This is especially important for understanding the impact of waves and storm surge events on coastal erosion.

Broad scale descriptions of the geology of the South Australian coast are available from a number of sources, including Coastal Landscapes of South Australia (7). This type of information helps to explain the broad structure and formation of geology for a given location or region.

A useful source of generalised coastal geomorphology information is available from the SMARTLINE dataset available on the CoastAdapt platform (http://coastadapt.com.au/coastadapt-interactive-map) (8).

The broad classes shown in the SMARTLINE mapping reflect the fundamental differences in susceptibility to coastal erosion, namely:

- pre-dominantly artificial shores with erodibility unclassified but commonly low;
- pre-dominantly hard rock shores with low erodibility;
- pre-dominantly soft rock shores with moderate erodibility;
- pre-dominantly undifferentiated soft sediment shores with high erodibility; and
- pre-dominantly sandy shores with very high erodibility.

2.2. Impact of climate change

2.2.1. A changing climate

'Climate change' is a change in the climate over periods of decades or longer, affecting both the average climate and its variability. Climate change is caused by substances and processes that alter the Earth's energy budget, including the activity of the sun, natural factors (e.g. volcanic eruptions) and the influence of humans (9).

Human induced climate change is driven by the release of greenhouse gases into the Earth's atmosphere as a consequence of emissions from fossil fuel use and land use change.

The largest measured increase in concentrations of greenhouse gases has been of carbon dioxide in the Earth's atmosphere, which has increased by 40% since 1750 as a consequence of emissions from fossil fuel use and land use change.

Where do I find information on changing greenhouse gas concentrations?

Data on current carbon dioxide levels are readily accessible through the internet, such as for carbon dioxide measured at Mauna Loa Observatory, Hawaii[2]. This data can be accessed for use in presentations or discussions about how the Earth's atmosphere is changing.

A consequence of the release of greenhouse gases into the atmosphere is that increasing amounts of the Sun's energy are being trapped around the Earth, either directly heating the atmosphere or warming the oceans.

Although climate change is a global phenomenon, the warming of the atmosphere and of the oceans can be observed at a national and state scale. For example, there is strong evidence that temperatures in Australia have risen over the past century, although to differing extents across the nation.

2.2.2. What causes sea levels to change?

Sea levels rise due to two main factors:

- Thermal expansion – The heating of the oceans causes water to expand, which causes sea levels to rise. Much of the sea level rise that has occurred in recent decades can be attributed to thermal expansion.

- Melting ice, glaciers – A potentially much greater source of sea level rise is the melting of ice and glaciers, especially in the northern and southern most parts of the planet. This occurs by higher air temperatures and higher ocean temperatures. While the contribution of melting ice to sea level rise in recent decades has not been significant, the majority of the larger extents of sea level rise that may occur in the future can be attributed to melting.

Evidence of sea level rise around Australia is provided by the CSIRO and the Bureau of Meteorology (BOM), which shows that sea levels have risen around Australia over the past few decades, although the extent of change has been greater in northern Australia due to greater thermal expansion.

[2] http://www.esrl.noaa.gov/gmd/ccgg/trends/

Based on the satellite altimetry observations since 1993, the rates of sea level rise to the northwest, north and southeast of Australia have been higher than the global average (10).

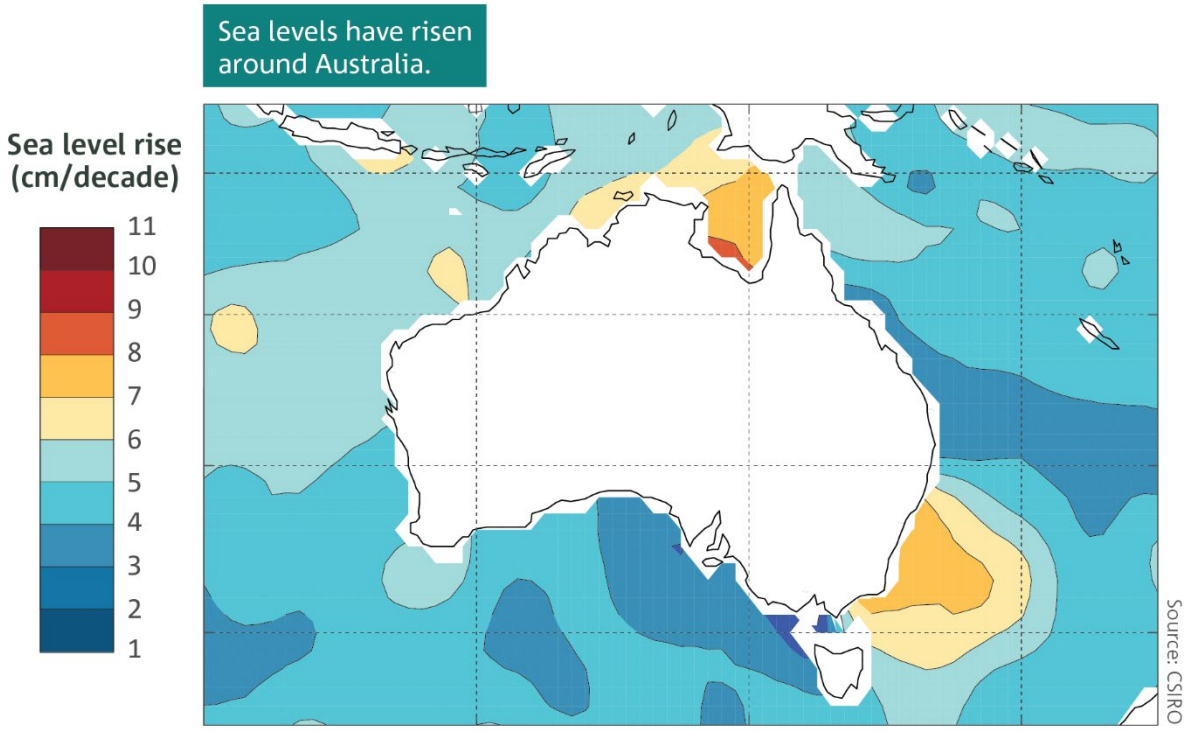


Figure 2 The rate of sea level rise around Australia by satellite observations from 1993 to 2017. Source: CSIRO and BOM (10)

Along South Australia's coast, sea levels rose by 1.5-4 mm/year between 1965-2016. Sea levels are projected to continue to increase in the future as shown in .

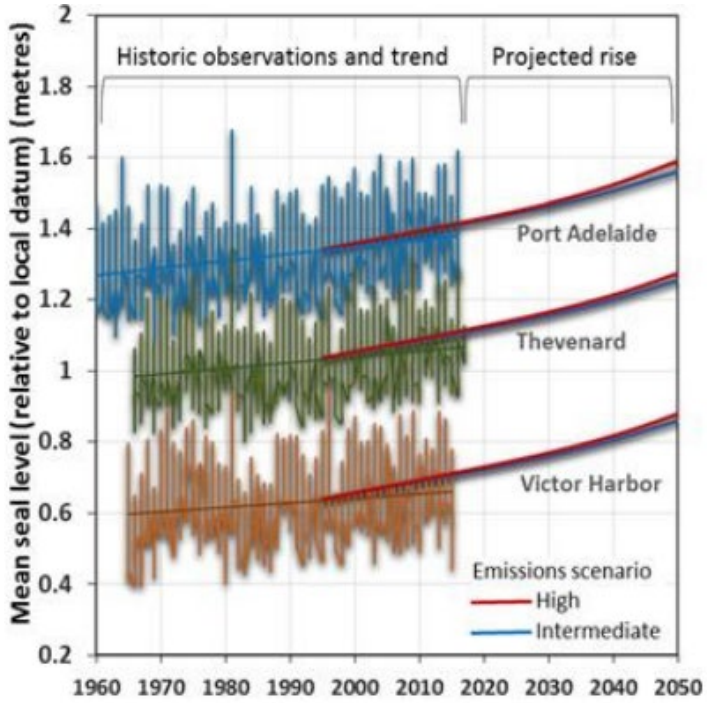


Figure 3 Observed sea level rise and projections of sea level rise data drawn from sea level monitoring stations at Port Adelaide, Thevenard and Victor Harbor (11)

2.2.3. How will the climate change in the future?

Projecting the future climate depends on three main factors:

- Emissions scenario – Emissions scenarios describe the amount of greenhouse gases in the Earth's atmosphere. The Intergovernmental Panel on Climate Change (IPCC), the world's leading scientific body dedicated to providing information on climate change, has developed four main emissions scenarios that are used to guide modelling. There is a low emissions scenario, called Representative Concentration Pathway 2.4 (RCP2.4), two medium emissions scenarios called RCP 4.5 and RCP6.0, and a high emission scenario RCP8.5.

- Climate model – There are a range of global circulation models, called "GCMs", that are used to project the future climate. Projections of the future climate often use the average or median of model outputs.

- Timeframe – The extent of change in the future climate will depend on the timeframe of projections, because the further into the future the projections are set, the greater the amount of greenhouse gases are likely to have accumulated in the atmosphere, leading to increased warming and associated impacts such as greater sea level rise.

Combining these three factors, the IPCC in 2013 presented results for potential future climate (12), in terms of air temperature as well as related factors like ocean temperature and sea levels. This suggests that temperatures at a global level could rise by 1ºC by the end of the century under a low emissions scenario compared with at least 3 to 4ºC under a high emissions scenario.

Drawing on further analysis of the IPCC information by the Goyder Institute for Water Research, and the CSIRO and Bureau of Meteorology, a summary of the projected future climate for each region in South Australia is provided in the regional climate change adaptation plans, which can be accessed through their respective websites, or via the following central portal:

https://www.environment.sa.gov.au/topics/climate-change/programs-and-initiatives/adapting-to-climate-change/regional-adaptation-plans

The CSIRO and Bureau of Meteorology (9) also generated the following information for projected sea level rise for within South Australia:

Table 1 Projected annual change in simulated marine climate variables for 2020–2039 (2030) and 2080–2099 (2090). Source: (13)

Variable	Location	2030, RCP2.6	2030, RCP4.5	2030, RCP8.5	2090, RCP2.6	2090, RCP4.5	2090, RCP8.5
Sea level rise (m)	**Thevenard**	0.11 (0.07-0.16)	0.12 (0.07-0.16)	0.12 (0.08-0.17)	0.38 (0.22-0.54)	0.45 (0.28-0.63)	0.59 (0.39-0.82)
	Port Adelaide	0.12 (0.07-0.16)	0.12 (0.08-0.16)	0.13 (0.08-0.17)	0.38 (0.23-0.55)	0.45 (0.28-0.63)	0.60 (0.39-0.83)

The IPCC Special Report on the Ocean and Cryosphere in a Changing Climate (14) was released in September 2019 and presents the most current assessment of projected changes to the oceans and cryosphere at a global scale as a result of climate change. The key findings from this analysis are that:

- Sea level continues to rise at an increasing rate. Extreme sea level events that are historically rare (once per century in the recent past) are projected to occur frequently (at least once per year) at many locations by 2050 in all RCP scenarios.

- The global mean sea level rise under RCP2.6 is projected to be 0.39 m (0.26–0.53 m, likely range) for the period 2081–2100 compared to 1986–2005. For RCP8.5, the corresponding rise is 0.71 m (0.51–0.92 m, likely range) for 2081–2100.

- Global mean sea level rise will cause the frequency of extreme sea level events at most locations to increase. Local sea levels that historically occurred once per century (historical centennial events) are projected to occur at least annually at most locations by 2100 under all RCP scenarios (high confidence). Many low-lying megacities and small islands (including Small Island Developing States (SIDS)) are projected to experience historical centennial events at least annually by 2050 under RCP2.6, RCP4.5 and RCP8.5.

- Significant wave heights (the average height from trough to crest of the highest one-third of waves) are projected to increase across the Southern Ocean and tropical eastern Pacific (high confidence) and Baltic Sea (medium confidence) and decrease over the North Atlantic and Mediterranean Sea under RCP8.5 (high confidence). Coastal tidal amplitudes and patterns are projected to change due to sea level rise and coastal adaptation measures (very likely). Projected changes in waves arising from changes in weather patterns, and changes in tides due to sea level rise, can locally enhance or ameliorate coastal hazards.

Assessment Report 6, the next full report being produced by the IPCC, is due for release in 2022, after which local sea level rise projections may be revisited. However, noting that sea level rise is occurring at an increasing rate, it is highly likely that sea level rise projections for South Australia will be at least as high if not higher than identified by CSIRO and BOM (10).

3. Policy and legal context

The policy context for coastal climate change adaptation planning is multi-layered. At a national and international scale, there are policies seeking to reduce the emissions of greenhouse gases to limit the extent of climate change, and therefore the potential future impacts of sea level rise. This broader policy setting is summarised at a national level by the Australian Government and internationally by the UNFCCC and is not discussed in these Guidelines.

Within South Australia, the overarching State legislation for coastal management is the *Coast Protection Action 1972*. For councils this presents obligations that are in addition to the meeting the requirements of the *Local Government Act SA 1999* and the *Harbors and Navigation Act 1993*.

3.1. South Australian coastal policy

The *Coast Protection Act 1972* was established to provide a legislative framework for the conservation and protection of the beaches and coast of South Australia. The Coast Protection Board was formed in 1972 to perform the following functions under the Act:

- protect the coast from erosion, damage, deterioration, pollution and misuse;
- restore any part of the coast that has been subjected to erosion, damage, deterioration, pollution or misuse;
- develop any part of the coast aesthetically, or to improve it for those who use and enjoy it;
- manage, maintain and develop those coast facilities that the Board is responsible for;
- report to the Minister where required; and
- carry out, or be involved in, research into the protection, restoration or development of the coast.

Within the Coast Protection Board's Policy Document (15), policies are grouped into six areas. Key features of the Policy Document relevant to these Guidelines are summarised below.

- Development - The Coast Protection Board directs how the development of coastal resources for social and economic activities need to be constrained by the capacity of those resources to meet the needs of future generations and social sustainable goals. The Policy outlines specific provisions on how planning and development in the coastal zone can occur. The Board seeks to: retain coastal open space; minimise impacts of development on the coast; maintain compact coastal settlements and restraining 'sprawl' along the coastline; promote scenic amenity; protect coastal biodiversity; minimise or stop development in areas subject to coastal hazards (including acid sulfate soils); minimise future protection costs by ensuring new development satisfies the Board's flooding and erosion policies; and conserve developed coastal areas for land uses that require a coastal location.

- Hazards - The Policy recognises that sand drift, coastal acid sulfate soils, flooding and erosion are natural processes along the coast. Beaches erode, build up or are in dynamic equilibrium, cliffs erode and low-lying land is periodically flooded during storm surge events. The Policy Document recognises that the level of risk will change over time due to climate change driven sea level rise, local relative sea level change and or long-term erosion trends. A detailed

description of the standards applying to new development with regard to coastal flooding and erosion and associated protection works is provided in the Coast Protection Board Policy Document. The policy shows the intent of the Board; the standards apply to site specific locations and site levels of development proposals. These standards may need to be adjusted from time to time, as knowledge of accelerated global sea level rise improves. The standards were written into the Development Plan, through the Regional Coastal Areas Policies Amendment, by the Minister, 1994. Specific application of the flooding standards on a town-by-town basis is being included at local zoning level in Development Plans the coastal Councils through the normal 3 to 5 year revisions of the each Plan.

- Protection works - One of the Coast Protection Board's duties is to protect the coast from erosion, damage, deterioration, pollution and misuse. This is carried out mostly in conjunction with and through councils, and the Act provides for the Board to make grants to assist councils in this. It also provides for the Board to carry out works and recover a portion of the cost from a council. Most coast protection works are carried out by councils or privately. With the exception of re-nourishing the Adelaide beaches, the Board provides councils with grants of up to 80% of the cost of approved coast protection works and up to the same amount for storm damage repairs.

- Conservation - Primary roles for the Coast Protection Board with respect to consideration are to contribute to conservation of the diversity of plant, animal and marine species within coastal areas, investigate the impacts of development on coastal, marine and estuarine environments, identify, protect and manage coastal environments with high conservation values, acquire land, where it is necessary to ensure protection of areas of high conservation value and provide grants to councils towards approved conservation projects.

- Heritage and landscape - Much of the South Australian coastline is rich in cultural and heritage values. The Coast Protection Board works with councils to preserve and manage areas with significant heritage and landscape value. Specifically, it supports the identification, recognition and protection of coastal areas with a significant landscape value, marine archaeological heritage, cultural significance and scientific significance. The Board has a role in working with stakeholders to ensure that coastal sites with cultural and heritage significance remain to be appreciated and understood by present and future generations.

- Access - The Coast Protection Board manages policies that inform access to the South Australian coast. Access is important because it provides a way for people to interact with the coast, much of which is covered by public reserves. However, access needs to be managed with the potential to impact sensitive coastal environments. The Board works with councils to manage access by ensuring environmentally sustainable access to the coast.

3.2. Local Government Act

Council responsibilities are identified in the *Local Government Act 1999*. As a service provider, landowner and asset manager, councils have responsibilities to consider risks and take appropriate risk mitigation action. The LGA SA prepared a series of Climate Risk Management Guides for Local Government professionals in South Australia. These Guides outlined the responsibilities of councils under the Act in relation to climate risk management. These responsibilities are summarised in Table 2.

Table 2 Responsibilities of councils in relation to climate risk management under the Local Government Act 1999.

Councils must	This means
Make informed decisions (Section 6)	Taking account of readily available information (such as climate risk data and climate projections) when making decisions.
Take measures to protect their area from natural hazards (Section 7)	Recognising climate risks to councils, communities and businesses and providing support to prepare, respond and recover.
Provide infrastructure for its community and for development (Section 7)	Providing infrastructure including local roads, stormwater management and community facilities
Ensure the sustainability of the council's long-term financial performance (Section 8)	Considering the financial implications of climate risks and incorporating additional costs into financial and asset planning.
Apply prudential management policies, practices and procedures to all council projects (Section 48)	Acting with due diligence and foresight, identifying and managing risks and making informed decisions. This means considering and planning for current and future climate conditions.
Prepare prudential reports for certain large projects (Section 48)	Identifying the project's contribution to local economic development, whole-of-life costs, any risks associated with the project, including climate risks, and how to respond to them.
Assess the maintenance, replacement or development needs for infrastructure (Section 122)	Undertaking regular assessments of infrastructure condition and the factors that influence rates of deterioration, and the need for new infrastructure to support the community and economic development.
Prepare an infrastructure and asset management plan (Section 122)	Considering future drivers of demand for infrastructure (including climate change) and how these may impact budgets for maintenance and renewal.
Identify anticipated or predicted changes in any factors that make a significant contribution to the costs of the council's activities or operations (Section 122)	Councils must be vigilant in identifying climate risk factors that may affect the cost of providing functions and services, and these must be identified in strategic plans.
Undertake prudential review of major projects (Section 48)	Reviewing whole of life costs and any risks to major projects. Climate risk should be considered in the prudential review.
Give due weight in all plans, policies and activities to state and national objectives and strategies (Section 8)	Considering how policies and actions align with and contribute to state and national strategies including climate change, transport, water and land use planning strategies.

Councils also have responsibilities under the *Harbors and Navigation Act 1993*, notably Division 4 sections 18 (Care, control and management of property), which (unless the land is proclaimed to be under the management of some other authority, or is land that is privately owned) vests care, control and management of coastal land not within a harbor in the council.

It should be noted that the vesting only applies to adjacent and subjacent land (as defined in the *Harbors and Navigation Act 1993*) . For coastal land, the relevant definition is “adjacent land “, which is land extending from the low water mark on the seashore to the nearest road or section boundary, or to a distance of 50 meters from the high-water mark (whichever is the lesser distance).

Placing such land under the care control and management of Council usually means the land is “local government land” within the meaning of the Local Government Act, and unless excluded from the classification, would be treated as “community land”.

The Act provides for the safe navigation of vessels in State waters and the safe use of these waters for recreational and other aquatic activities. The provision of marinas and other mooring facilities contributes to the achievement of these objectives. In the development of these facilities, the Department of Planning, Transport and Infrastructure, on behalf of the Government of South Australia, has sought to use the lease, licence or transfer of care, control and management of marine facilities to impose development and use conditions as well as limit the ongoing maintenance (such as dredging of access channels) and liability of the Government. In meeting these challenges, developments are the subject of the development process under the Development Act 1993.

3.3. Liability considerations[3]

Councils should always be striving to act in accordance with their statutory responsibilities, and remain exposed to the possibility of legal claims based on allegations that arise from a council’s failure to fulfil their function or responsibilities described in the *Local Government Act 1999*. The obligations under the Local Government Act are expressed in broad terms, which creates the risk of a legal claim, although that risk has to be balanced with the reality that Councils have a wide range of responsibilities, and limited means of raising funds to meet the many competing claims on their budgets.

Councils do receive some statutory protection for “community land” under section 244 of the *Local Government Act 1999*, with exposure to liability limited to cases where the injury, damage or loss is a direct consequence of a wrongful act on behalf of Council in its capacity as “occupier” of that land, but should still be aware of the risk of claims that might not fall within the immunity.

Other factors relevant to Council liability would include responsibilities placed on other authorities, such as the Coast Protection Board, and the role of the State Government in setting State wide policies impacting on coastal management. Further, changes to planning policy, and the planning system, may impact on where the responsibilities for coastal management ultimately fall.

There is always a risk it will be argued that a Council may be liable for loss or damage, especially if it is found to have acted negligently, or in clear breach of statutory responsibilities. Previous examples of claims include allegations of failing to reflect known risks (such as flood risk) in a development plan or failure to exercise powers and functions to appropriately manage flood risk. In certain circumstances, a council might also be at risk if it provides inaccurate information relating to flood risk. Liability may also arise from councils’ responsibilities as a landowner if they fail to manage their land in accordance with common law principles that apply to all landowners, including nuisance and negligence.

[3] Based on the Climate Risk Management Guides for Local Government professionals in South Australia prepared by the LGA SA.

Publication of flood mapping survey information presents a particular risk, in circumstances where Federal and State Governments have committed to a principle of open disclosure of flood mapping information, but where information that is available may not be easily or properly understood.

When should hazard mapping results be publicly released?

Erosion and flood modelling produce visual maps to show the extent of current and future hazards. Historically, there has been a conservative approach to releasing such data where mapping indicated that public and/or private assets were at risk from current or future erosion and flooding. Part of this concern was related to the local government sector's responsibility regarding maintaining privacy over personal information. However, it has also related to concerns that such information may result in declines in property values.

More recently, there has become a greater focus on disclosing risks. This can be important if councils want to raise awareness amongst the community about future risks, which can help build capacity to allow for a greater exploration of future adaptation options. As a result, local government needs to consider the risks of releasing or not releasing hazard information. A discussion of the legal risks of the disclosure of this information is provided in (36).

A landholder may argue that a government negligently caused economic loss through the release of information that has reduced property values even if the information is accurate. Bell-James et al. (37) state that this issue has not yet been considered by Australian courts, but Eburn and Handmer (38) argue that a claim would be unlikely to succeed.

A bigger concern for councils is whether coastal hazard information is inaccurate, which if this was the case could lead to negligence liability. While they advise that the information should be checked for accuracy (eg Christensen et al. 2008 (39)), it is suggested that governments should aim to strike a balance between notifying the public of hazard risk, while communicating any uncertainty and ensure disclaimers are considered in situations of high uncertainty to alert people accessing data to undertake their own inquiries.

Of increasing relevance is not providing hazard information, which may occur for two reasons (36):

- Risk information is not available - While a landholder may commence legal proceedings on the basis that a government failed to obtain and make available information concerning risk, a council may respond to this by stating that it does not have hazard risk information due to a lack of funds to resource data acquisition.
- Risk information has been obtained, but not released - Failure to disclose information that a government does have in its possession may, in some circumstances, be classified as negligent misstatement. If a government has possession of hazard risk information and receives a request to disclose it, a failure to do so may breach its duty to disclose and amount to negligent misstatement.

Given that the key concerns regarding release of hazard information are mostly legal, individual councils ought to consider obtaining their own independent legal advice when deciding whether to release coastal hazard data. Recent experience in South Australia shows that a number of regional councils have released coastal hazard maps to inform coastal climate adaptation planning (e.g. Southend, Wattle Range council; Kangaroo Island council). Aside from legal considerations, key drivers for this have been a desire to engage the community in developing adaptation responses to future coastal hazard risks.

4. Stocktake

4.1. Purpose

Undertaking a stocktake of past hazard and impact assessments and planning processes is essential to establish the starting point for a project. This ensures that previous work is not repeated and that lessons learned are built upon.

During this stage of preparing a Coastal Adaptation Plan, it would be worthwhile for councils to review all past work that has been undertaken with respect to coastal adaptation planning and determine what is an appropriate next step with respect to the scope, objectives, level of detail, engagement and resourcing that is required.

The objectives of this stage could include:

- establishing the scope of the project and gaining support from decision makers;
- identifying past work on coastal adaptation, including risk assessments, hazard mapping and options identification;
- collating stories or photos from past experience with coastal hazards; and
- determining the appropriate level of assessment required, especially with respect to risk assessment, options analysis and planning approvals.

4.2. Process

Scoping report

When a new coastal adaptation planning process commences, or is revisited after a period of time, the scope should be developed and agreed upon with decision makers.

The scope should be summarised in a report or briefing paper and address the following:

- **Extent and scale** - Outline the geographic extent and scale of the project, including the nature of the assets (built and/or natural, public and/or private) and services to be assessed. The extent could range from the coastline for an entire region through to specific settlements in regional areas or local assets like ports or boat ramps.

- **Identify the drivers for action** – The drivers for action could include recent physical damage as a consequence of erosion or flooding, community action requesting greater action on climate change, and economic concerns about current or projected impacts of coastal hazards.

- **Present a snapshot of current conditions** – Current conditions should consider technical, policy and planning context such as from modelling, hazard mapping, shoreline management plans, asset management plans, and evaluation of past coastal management activities.
  In some instances, councils may want to communicate to staff and other stakeholders that they may not have answers to all the questions at the beginning of the project. Coastal adaptation planning is a long process, and thus require time, resources, information and assessments to

make appropriate decisions. Some issues may be beyond councils' roles and responsibilities - it important that councils take into consideration all site-specific factors when scoping the project.

- **Information gap analysis** – Assess the technical, policy and planning information gathered to determine whether any other information is needed to meet the minimum requirements of these Guidelines.

- **Identify barriers and enablers to progress** – Conduct a rapid analysis of barriers and enablers to coastal adaptation to determine whether implementation has occurred efficiently in the past and what might enablers or barriers might exist. Consider using a diagnostic like the "Values-Rules-Knowledge" framework (See **Box 1**).

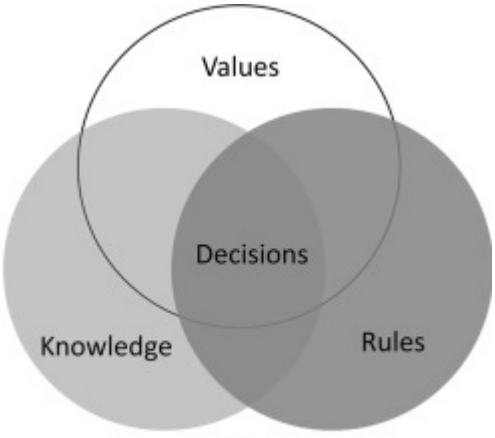
- **Schedule of activities** - Outline the activities that will be undertaken for the project which may include one or more of the steps outlined in Section 5 to 9.

Recommendations on how to structure a scoping report to present to decision makers for support are provided in the LGA SA Adaptation Guidelines.

Box 1 Barriers and enablers to adaptation.

Progress with coastal adaptation planning and implementation can be delayed because of barriers that exist in the decision-making context. While the focus of coastal adaptation planning often commences with technical analyses, the "Values-Rules-Knowledge" (VRK) framing (16) aims to assess whether the adaptation situation is constrained by a knowledge deficit (knowledge), institutional arrangements or systems (rules), or unresolved or unknown societal preferences (values).

This framework can therefore be used as a diagnostic tool to help determine the emphasis of work in a broader coastal adaptation planning project. Used in this way, the VRK concept can help to understand whether progress with implementation is being delayed because of barriers that relate to the decision-making context. Note that the relationship between these factors can change through time as a result of changing social, environmental, and economic conditions.



Other sources of information on identifying barriers can be found in the LGA SA's Science to Solutions project reports and in several National Climate Change Adaptation Research Facility (NCCARF) projects (eg (17) (18)).

Level of detail

Many regions have already undertaken some aspects of coastal adaptation planning, even if only as part of the development of a regional climate change adaptation plan. This is recognised by Climate Compass (19), which is a framework developed by the CSIRO to help government agencies manage the risks from a changing climate to policies, programs and asset management.

Noting the different starting points for work on adaptation planning, Climate Compass identifies three key climate risk management cycles of different detail and purpose: Scan, Strategy and Project. They primarily differ in the detail recommended at each step.

- **Scan** is the typical starting point and gives a high-level sense of the climate risks, the nature of those risks, and where to prioritise further effort.
- **Strategy** is a deeper identification, assessment and treatment of risks relevant to a particular area that has been prioritised for climate risk management.
- **Project** is a detailed assessment and operational plan for a more focused area of work in order to develop a specific action to address climate risk or to ensure climate risk is considered as part of the overall risk assessment for a specific action.

This approach was adapted in the Legatus Group[4]'s Climate Adaptation Guidelines, which identified the three cycles as Scan, Plan and Delve deeper, with this framing considered more applicable to the experience of councils in the region. Using this structure, the Legatus Group's Guidelines present a diagnostic framework to determine what cycle a region may be in, which in turn informs consideration of the resources required to undertake climate change planning. Such an approach is applicable to coastal adaptation planning to help determine the method and resources required for a coastal adaptation planning project.

Key questions to ask

- What past coastal adaptation planning and management has been done?
- What have been the positive and negative impacts of past work(s)
- Based on past coastal adaptation planning and management, what level of detail is required for the proposed project?
- What is the purpose or driver of the project?
- What is enabling or preventing coastal adaptation in your region?
- What unique features of the local context should be factored into the design of the project, including from a physical, social, cultural, economic or environmental perspective?
- Is the data required to undertake hazard assessment available?
- What historical information can be compiled to build the case for the proposed project?

4.3. Minimum requirements

It is recommended that as a minimum, councils undertake the following:

1. seek agreement and approval from decision makers within council to develop and implement coastal adaptation plans;

[4] The Legatus Group is a regional local government organization consisting of District Council of Mount Remarkable, District Council of Orroroo Carrieton, District Council of Peterborough, Regional Council of Goyder, Wakefield Regional Council, Port Pirie Regional Council, Light Regional Council, Adelaide Plains, Barunga West, Clare and Gilbert Valleys, Copper Coast, Northern Areas, The Barossa, The Flinders Ranges, and Yorke Peninsula Councils (https://legatus.sa.gov.au/)

2. prepare a scoping report that identifies the extent and scale, current conditions and information gap analysis, and schedule of activities for approval by decision makers; and

3. conduct a self-diagnosis before your organisation commences further adaptation work to determine what level of adaptation is required next and whether there are any specific barriers that should be addressed first.

It should be noted that the data requirements for coastal hazard risk modelling in particular can be extensive and that its absence should not be considered a barrier to starting coastal adaptation planning for a given region, settlement or asset.

4.4. Further reading

Further reading on how to undertake a stocktake can be found in the following documents:

- Climate Adaptation Planning Guidelines (20)
- A Climate Change Adaptation Framework for South Australia (21)
- Guidelines for Climate Action (22)
- Climate Compass: A climate risk management framework for Commonwealth agencies (19)
- Coastal Hazards and Climate Change: Guidance for NZ local government (23)
- Developing a Coastal Hazard Adaptation Strategy: Minimum Standards and Guideline for Queensland Local Governments (24)

5. Engaging with stakeholders

5.1. Purpose

Engagement with internal and external stakeholders is essential to raise awareness and build shared understanding of the risks of coastal hazards and seek input to the responses that local government undertakes to manage impacts on built and natural assets.

During this stage, a stakeholder engagement strategy would assist councils to outline how and when stakeholders will be engaged during a project. Preparing a stakeholder engagement strategy at the start of the project will ensure that opportunities for engagement can occur throughout the lifecycle of the project.

Identifying stakeholders to include in the engagement process is an essential first step and should include consideration of engagement with First Peoples, especially in area of high cultural significance.

The objectives of this phase could include:

- identifying relevant external and internal stakeholders including the community;
- determining the level of engagement that will occur with different types of stakeholders;
- identifying engagement activities that are suitable for the desired level of engagement; and;

- developing a schedule of engagement activities and identifying resource availability and responsibilities.

5.2. Process

Whether developed by council staff or a consultant, the approach to stakeholder engagement should be summarised in a strategy or plan developed at the start of a project. While the broad approach should be internally approved before a project commences, it is likely that the engagement strategy or plan will continue to evolve during the project as feedback is received, especially where the engagement process involves external stakeholders. Councils capacity in community engagement can be varied depending upon available resources and staff, with a dedicated community engagement officer in some large and metropolitan councils, and limited resources or lack of dedicated community engagement officer in small and regional areas.

When developing a stakeholder engagement strategy and plan the following should be undertaken:

Stakeholder mapping

Whether undertaken informally or formally, the range of stakeholders to be involved with a project should be mapped. This can be done using stakeholder mapping software, however, in most instances this can be achieved with a stakeholder database in spreadsheet form.

Internal stakeholders will include elected members and those council staff who have a role in supporting council's responsibilities to manage coastal hazards. This could be narrowly focused on built asset managers, but more often involve a range of staff from assets, planning, finance, sustainability and engagement.

External stakeholders are either representatives of key stakeholder groups or the general community. Key stakeholders could include:

- First Peoples or Traditional Owners, particularly in areas which are recognised as being of high cultural significance;
- beachfront property owners and businesses eg caravan parks, cafes;
- fishing, aquaculture and mariculture industries eg lobster fishers, oyster farms
- local progress associations;
- sporting and recreation clubs eg surf lifesaving;
- local environment groups like Landcare, Coastcare, Friends of Shorebirds;
- home and land owners;
- government agencies (advisory and referral bodies, land owners/managers, planning authorities, resource management agencies); and
- utility providers.

These stakeholders may be influenced by, contribute to or have interest in decision outcomes and have an ability to contribute to the development and implementation of adaptation. It is important for councils to identify key influencers who can influence the views of a wide variety of stakeholders and attract more people into the process. The decision about whether external stakeholders should be involved with the project will depend on the scope, as determined during the stocktake. This is explored further in **Box 2**.

Box 2. When should a council involve key stakeholder representatives and the community?

Individual council policies will inform when to involve external stakeholders such as the community or representatives of business and resident groups. A key consideration will be whether the information being generated during a project is considered private and confidential or for general awareness and capacity building.

Where the information generated is private and confidential it is likely that engagement in the first instance will be with internal stakeholders, and potentially selected external stakeholders directly impacted by coastal hazards.

Where the purpose of the information generated during a coastal adaptation plan is intended to build broader public awareness about coastal hazards and to build capacity amongst the community to contribute to planning processes, it is more likely that a broad range of external stakeholders will be involved. Engaging stakeholders early and throughout the process is likely to improve efficiency, save time, reduce litigation costs and, through development of a shared understanding of social values and interests (25), can help reach decisions that can be implemented (26). The timing of when to commence engagement will be determined on a council by council basis, noting that in some instance it will be important to have sufficient data to support detailed planning discussions.

Level of engagement

Once stakeholders have been identified for a project it is necessary to determine the level of engagement or "participation". The most common framework for determining the level of engagement in the local government sector is the IAP2 Public Participation Spectrum. This recognises five levels of "participation" (Figure 4).

		Inform	Consult	Involve	Collaborate	Empower
						
Goal		To provide balanced and objective information in a timely manner	To obtain feedback on analysis, issues, alternatives and decisions	To work with the public to make sure that concerns and aspirations are considered and understood.	To partner with the public in each aspect of the decision-making.	To place final decision-making in the hands of the public.
Commitment		"We will keep you informed"	"We will listen to and acknowledge your concerns"	"We will work with you to ensure your concerns and aspirations are directly reflected in the decisions made"	"We will look to you for advice and innovation and incorporate this in decisions as much as possible"	"We will implement what you decide"
Methods	One-way information	Media release, reports, social media, factsheet, TV or VDOs, brochures, webpage, advertisements, publications, events				
	Feedback collection	Workshops, surveys, public meetings, feedback forms, interviews, public submissions				
	Dialogue & partnership facilitation	Workshops, online discussion, citizen juries, simulation games				

Figure 4 Goal and commitment to stakeholders for five levels of engagement based on the IAP2 Public Participation Spectrum. Examples of potential methods of engagement relevant to each level are also provided. Source: Adapted from iap2.org.

There is no requirement for councils to offer the highest level of participation for all stakeholders, although it is generally accepted that the greater the level of participation, the more likely that stakeholders will have ownership of the process and its outputs, such as the identification of response options to coastal hazards.

The type of response in each local area will vary with community perception and expectation. Stakeholder interests and values can be varied and can differ significantly between different stakeholder groups. Therefore, each project or each stakeholder group may require different levels of engagement. It is up to individual council to decide who, how and when to engage.

It is important to take into consideration community values, issues and priorities for collaborative action on coastal hazards, while promoting sustainable approach. Long-term perspective of risks, strategic and statutory planning processes, asset management business planning and budget allocation is key for management of community expectations. It provides potentially impacted stakeholders information of future hazards and local adaptation challenges and opportunities.

Engagement activities

Engagement activities provide a way for stakeholders to participate in a project. Different engagement activities support different levels of participation and hence should be tailored for each project and in some case for each stakeholder group (eg **Error! Reference source not found.**). Engagement may be a single activity or event, but is more often a process comprising a series of activities and events that combine and build towards making a decision. Examples of engagement activities that have been used for coastal adaptation projects in South Australia include:

- Surveys – Conducted in hard copy form or online using a web-based survey platform, surveys provide a way to collect information from a large group of people simultaneously. While they provide a rapid of way of accessing large amounts of information, they do not provide an easy way to ask follow up questions for specific points of interest.

- Interviews – Phone or face-to-face interviews provide an opportunity for detailed discussion either to share or obtain information for a project. They are well suited to projects requiring high levels of participation because of the significant time that may be required to undertake an interview.

- Workshops – Workshops can involve a combination of internal and/or external stakeholders. They are effective for reviewing and refining information that is collected during desktop study stages of a project and provide an opportunity to build consensus around issues or actions relevant to a site or region.

Tip: Think about how to communicate the findings of hazard and risk assessment or adaptation options analysis during the initial design of engagement activities. This can be assisted by explaining coastal processes in the local context.

Engagement schedule

Once engagement activities are identified for a project a schedule outlining the timing for delivery should be prepared. While the time required to undertake some project phases may be relatively short (e.g. one month) sufficient time is required to notify stakeholders of engagement activities, and then if

multiple activities are required, time should be allowed between activities so that stakeholders are not rushed.

Risk assessment

A risk assessment of the engagement process can help to identify whether any barriers exist that may prevent delivery of the engagement activities within the agreed timeframes or that may result in risks to project delivery. Key risks to consider include:

- availability of project team members;
- external stakeholder response to release of hazard information; and
- resource availability for undertaking activities.
- natural disaster
- pandemic or epidemic
- approval timeframes

How to have difficult conversations?

Even where there is significant effort invested in developing an engagement process, communicating the outcomes and response options from coastal adaptation planning can be confronting for some stakeholders. In many instances it can involve a series of "difficult conversations" given that the long-term impacts of coastal hazards on private property can be significant and the response options costly.

Issues to consider when approaching hard conversations include:

1. Create the link between stakeholders' values and coastal hazard risks. Key questions that may help initiate conversation will be what are the values of stakeholders and is there common ground between council's own values and stakeholder concerns?
2. Focus on the timeframes for impacts and response options. At some location's impacts may not occur for decades, potentially well after the useful design life of an asset.
3. Consider using an adaptation pathways approach (see section 8.2 for further details) to communicate how response options can be sequenced in the future. This can help to demonstrate that the timing of implementation may be well beyond the timeframes of concern for stakeholders.
4. Consider how coastal hazard maps are presented and communicated, specifically paying attention to the timeframe of modelled impacts.

Key questions to ask when designing the engagement process:

- Who are the key internal and external stakeholders (including indigenous group?
- What level engagement is necessary and appropriate?
- Based on past experience what approach has proven to be successful in engaging key stakeholders in your region and at state/national levels?

- Are there any key issues that might encourage people to participate in the process, such as a problem that needs to be managed like loss of dunes or access to beaches for recreation?
- Is there good imagery available of previous impacts from coastal hazards that internal and external stakeholders can relate to?
- Are there key influencers that are important to involve with the process to maximise buy-in to the outcomes of the planning process?
- Are the results of other recent engagement processes conducted by council or other key stakeholder organisation relevant to the engagement processes or the desired outcomes of the project?

5.3. Minimum requirements

It is recommended that as a minimum, councils undertake the following:

1. stakeholder mapping to identify the different types of internal and external stakeholders to be involved with the process;
2. determine the level of engagement required as informed by the IAP2 Public Participation Spectrum;
3. identify engagement and communication activities at the start of the project based on an understanding of how similar successful or unsuccessful processes have been conducted in the past; and
4. capture the approach in an engagement strategy or plan and review regularly throughout the project.

Ideally, the engagement process for an individual project should be part of a broader discussion with stakeholders about the impacts of coastal hazards on assets that are locally or regionally important. The notion of an “ongoing conversation” is important because observations and learnings about the impacts of coastal hazards and the effectiveness of response options is dynamic and will continue to change in the future.

5.4. Further reading

Further reading on how to undertake engagement processes for adaptation planning projects can be found in the following documents:

- Co-development of a climate change decision support framework through engagement with stakeholders (27)
- Stakeholder Engagement Plan (28)
- How to engage with stakeholders or the community over coastal hazards (29)
- Noosa Shire Council Stakeholder Management (30)
- International Association for Public Participation (IAP2): resources (31)

6. Identifying coastal hazards

6.1. Purpose

Identifying coastal hazards is an essential step in undertaking coastal adaptation planning and should as a minimum consider hazards as they relate to coastal flooding and enhanced coastal erosion.

During this stage, councils could take the opportunity to determine the extent of future hazards by combining an understanding of natural coastal processes with enhanced coastal flooding and erosion as a consequence of sea level rise. In some areas, other hazards like coastal acid sulfate soils, sand drift and ecological hazards (eg loss of seagrass and intertidal reefs, cracking soils and drying of coastal vegetations) may be relevant and could exacerbate impacts associated with coastal flooding and erosion. In this case, such type of hazard should be recognised and also included into the scope of 'coastal hazards'.

The objectives of this stage could include:

- establishing historical hazards to determine baseline conditions and previous strategies and works;
- collecting information on the underlying geomorphology and topography;
- understanding natural flooding and erosion impacts; and
- determining potential future extent of coastal flooding and erosion as a consequence of high mean sea level, storm surge, sea level rise and land subsidence (where relevant)..

6.2. Process

Coastal hazard assessments are an essential component of identifying and understanding coastal hazard risk in the context of overall risk management. Site specific factors need to be taken into account, and consistent approach and clear understanding around identification and quantification of coastal hazards across the State is necessary.

Coastal risks are defined by describing a combination of hazards, impacts and consequences. The primary coastal hazards that are most often of interest to the local government sector are the erosion of the shoreline and flooding of low-lying areas. Other relevant hazards include salinisation of soils, acid sulfate soils, sand drifts, loss of intertidal reefs and seagrass, loss of coastal vegetation, ground and surface water, and impeded drainage of stormwater discharge infrastructure.

To explore the potential future impact of coastal hazards, it is necessary to establish baseline conditions and develop projections for future potential erosion and flood risks.

6.2.1. Erosion

Sandy shorelines

The long-term erosion of sandy beaches can be caused by the net loss of sand driven by the natural longshore sediment transport rate. Alternately some beaches may be naturally accreting, which means that they are building up sand.

The short-term erosion of beaches is influenced more directly by storm surge, which can cause a significant loss of sand from a beach over a short period of time (less than a day) as a result of wave action directly on the beach or dunes. When projecting future erosion, both the short and long-term erosion potential should be considered.

In South Australia, historical rates of erosion and accretion on sandy beaches can be determined using data from cross-shore profiles that have been recorded by the Coast Protection Board over the past 40 years. While not as accurate, local scale or community monitoring can also be useful to build an understanding of erosion rates amongst the community using a combination of stakes and photo points. Understanding the potential for impacts of storm surge events on short term erosion requires use of coastal modelling tools.

Modelling the potential impact of sea level rise on the erosion of sandy shorelines most commonly draws on the “Bruun Rule” (Bruun, 1962). This suggests as a rule of thumb that a 1 cm rise in sea level will lead to a 1 m retreat of the coastline. For example, this would mean that:

- 10 cm of sea level rise could lead to 10 m of erosion on sandy shorelines;
- 50 cm of sea level rise could lead to 50 m of erosion; and
- 1 m of sea level rise could lead to 100 m of erosion.

It should be remembered that the Bruun Rule is a general guide and that depending on local conditions, the rates of erosion as a consequence of sea level rise could be greater than or less than 1 m retreat for every 1 cm rise in sea level. Other methods in addition to Bruun Rule can be used to improve the accuracy of the assessment, but these will generally be more complicated and require more data

Estuaries, lagoons and tidal flats

Wave exposure in estuaries, lagoons and tidal flats tends to be significantly lower than along sandy, soft rock and hard rock shorelines. As a result, erosion caused by wave action occurs less frequently. The primary cause of erosion in estuaries, lagoons and tidal flats is likely to be the dieback of more freshwater dependent fringing vegetation, which is not able to tolerate more frequent and deeper flooding with sea water.

Soft rock shoreline

Soft rock shorelines are susceptible to erosion but not to the same extent as sandy shorelines. The main cause of erosion is the impact of wave action. Historical rates of soft rock shoreline recession are a useful indication of potential future rates. This can be assessed where historical aerial imagery is available.

Soft rock shoreline retreat rates are expected to increase with rising sea levels, primarily because of reduced wave attenuation as water deepens over the near shore profile, allowing stronger wave attack (32).

Modelling of soft rock recession suggests that with continuation of the sea-level rise acceleration now being observed, recession rates in clay soft rock shores may be 1.5 to 2 times greater over the next century than they were in the last 100 years. Noting this, Sharples et al. (2013) have suggested that a conservative allowance of 2 x historical recession rates can be applied when assessing soft rock coastal erosion hazards across Tasmania (33).

Hard rock shorelines

Hard rock shorelines will typically be the least susceptible to erosion. The rate of erosion of rocky shorelines is determined by the type of rock, wave exposure, the slope of the rock face and the presence of rock material near or above the water line that has detached from the slope as a result of wave action. Slope analysis will most often provide the greatest insight to erosion potential, with gentle to moderate sloping coastlines having much lower rates of erosion than moderate to steep slopes. If erosion of hard rock shorelines is considered locally important, techniques exist for mapping potential slump hazard zones and rate of retreat.

6.2.2. Flooding

Coastal flooding can occur over the short term as a result of higher sea levels due to tide, waves and storm surge events. In the long term these can be exacerbated by sea level rise.

Is there any record of historic coastal hazards in your area?

Identifying the impact of historical flooding and erosion events can be helpful to generate stakeholder input to a project. This can include the sharing of photos, news articles or written descriptions of impacts. An example of a statewide database of images is the Witness King Tides initiative managed by Green Cross Australia.

https://www.greencrossaustralia.org/latest-news/news-archive/2014/south-australia's-king-tides.aspx

Further examples of storm damage along South Australia's coastline over the past 90 years are summarised and portraited at:

https://www.environment.sa.gov.au/goodliving/posts/2019/06/coastal-storm-damage.

Developing projections of coastal flooding under current and future conditions requires a combination of topographical information describing the elevation of coastal land and an estimate of sea levels.

The BOM maintains an array of monitoring stations which measure sea levels very accurately as part of the Australian Baseline Sea Level Monitoring Project (34). The sea level monitoring array consists of 15 sea level monitoring stations operated by the Bureau of Meteorology around Australia. Of these, only one site is located in South Australia at Thevenard on the West Coast.

Other methods for determining the height of historical water levels include using flood markers installed during high water events, or observing the height of seaweed strand lines. When combined with knowledge of the water height reached for a given event, it is possible to then determine the extent of flooding that can occur for a given average return interval.

The May 2016 storm surge: A high impact year in recent memory

Linking impacts from storm surge events with coastal hazard mapping projects can provide an important connection between observations and modelled data. In May 2016, South Australia experienced a low-pressure weather system, which coincided with high autumn tides. The result was that many coastal locations across the State experienced significant impacts from storm surge events, either from erosion of sandy beaches and dunes or flooding of low-lying areas. Analysis undertaken by the Department for Environment and Water suggests that the exceedance probability of this event differed across the State, due to local conditions either enhancing or dampening impacts.

As described in Section 2.2, there are various projections of future sea levels, which differ depending on the extent of climate change that occurs in the future and the timeframe of the projection. Although there is some variability in projections, the Coast Protection Board provides clear guidance for the extent of sea level rise that should be allowed for coastal planning and development (15). The Board states that it:

- is satisfied that sea level is presently rising at a rate of approximately 1.5 mm/year at most parts of the South Australian coast;
- is accepting that there will be global warming due to increases in greenhouse gases and that this will result in a more rapid rise in sea level;
- on the basis of the IPCC projections, the Coast Protection Board recommends that a mid-range sea level rise of 0.3m by the year 2050 should be adopted for most coastal planning and design;
- has adopted a 1 m rise to 2100 for coastal policy; and
- is of the view that in most coastal flooding applications the 100-year average return interval (ARI) standard is appropriate, where the ARI is the average interval in years between events equalling or exceeding a given magnitude.

To predict the extent of future flooding on the coast, sea level information needs to be combined with information on the height of the land. This requires the preparation of a digital elevation model (DEM). Determining the elevation of the land surface can be done using traditional surveying equipment or various forms of remote sensing such as aerial photogrammetry and LiDAR (laser detection and ranging). LiDAR is widely regarded as the highest quality type of information for developing a DEM. Remotely sensed data has traditionally been expensive to acquire, however, the increasing availability of lower cost unmanned aerial vehicles (UAVs) with high resolution cameras of LiDAR equipment means that small areas can be assessed for a lower cost.

Historically, a bathtub or bucket-fill approach has been used to assess coastal flooding risk from rising sea levels (35). This is appropriate for initial assessment of coastal flooding hazards, and assumes that (for example) a 1 m rise in sea level could inundate all land along the coast that is up to 1 m above sea level plus the highest astronomical tide and an allowance for storm surge. While useful for providing general guidance on flooding and whether more complex assessments are needed, this approach does not account for how water moves across the ground, barriers to water movement, future changes to landform though uplifting, coincident flood risk from inland sources or the variety of factors that influence sea level variations.

Other approaches to modelling future sea levels are considered to be “dynamic”, because they consider the broader range of factors that can influence flooding. There are two primary classes of models for predicting coastal flooding and erosion; these are empirical, or data driven, and process-based numerical models. A discussion of these model types and options is provided in CoastAdapt (https://coastadapt.com.au/use-modelling-tools-assess-local-scale-inundation-and-erosion-risk).

Due to the modelling complexity and large-scale requirements for data, dynamic modelling approaches are most likely to be used for local scale modelling needs. Further, due to cost they are most likely to be restricted to areas with high value coastal assets, such as urbanised areas of the coast or where there are high value commercial assets such as in ports and harbors.

Tip: Whether a lower cost “bathtub” model or more expensive “dynamic” model is required to assess future coastal flood risk depends on a range of factors, including a council’s available budget, data and the potential market and non-market value of the assets at risk. For scan and some plan levels of assessment (see Section 4), a bathtub model approach is entirely appropriate.

The results of modelling should be used to generate coastal flood maps. Given the direction provided by the Coast Protection Board, these should be for current conditions and for an allowance of 0.3 m sea level rise by 2050 and 1 m by 2100. Maps can also indicate the change in mean sea level as well as the potential heights of sea levels as a consequence of storm surge events.

There are several local factors that may enhance the extent of flooding especially during storm surge events, these include:

- Stormwater drain blockage – During king tides or storm surge events stormwater drains discharging to coastal areas may become closed or have water push backed up the drainage network. This can lead to localised flooding with rainfall generated runoff not draining properly or sea water pushing back into low lying areas.
- Rainfall exacerbated flooding – Rainfall as a result of storms can cause localised flooding. When this interacts with elevated sea levels at the coast due to storm surge events water levels can be higher than anticipated.

6.2.3. Groundwater systems

Coastal groundwater systems can vary widely in terms of how water moves through them and their connection to coastal waters. A groundwater system, or aquifer, may consist of alluvial sediments, sedimentary rocks, fractured rocks or fissures in limestone (karst). The volume of water held within the aquifer, or the speed at which water moves through the system, is primarily influenced by the pore spaces or porosity.

Depending on the connection with coastal waters and the type of groundwater system, rising sea levels could result in elevated groundwater inland, potentially causing higher salinity water to move closer to the land surface or pool in some areas. This can cause damage to built and natural assets. For example, higher salinity groundwater can kill vegetation that has low tolerance to salt, which can result in the establishment of salt tolerant vegetation.

Understanding whether coastal groundwater systems will be impacted negatively by sea level rise requires investigation of local geology and determining what type of aquifer is present. This could be impacted on by the availability of drill hole information that describes the hydrogeological nature of the site.

Key questions to ask when identifying coastal hazards:

- What are the baseline rates of erosion and historical extent of flooding during king tides and storm surge events with a recurrence interval of 1 in 100 years?
- What historical examples exist of storm surge events that have resulted in significant erosion and flooding?
- How will the extent of erosion and flooding be influenced by 0.3 m sea level rise and 1.0 m sea level rise?
- Is dynamic flood modelling required or will the results of a bathtub style analysis be sufficient?
- What level of erosion hazard assessment is required - will the Bruun rule be sufficient or will a different method be required?
- Is the data available to undertake the assessment?
- What are the other coastal or non-coastal hazards may be applicable?
- If you have access to coastal hazard data, is the risk of not releasing the data greater than the risk of releasing it?
- How to effectively communicate the results to the community?

6.3. Minimum requirements

It is recommended that as a minimum, councils undertake the following:

1. establish baseline conditions based on historical coastal hazards data through desktop research and stakeholder engagement;
2. understand regional and local geomorphology and topography and its response to coastal hazards;
3. use the Bruun Rule combined with an understanding of existing topography to develop projections of future erosion extents;
4. develop projections of coastal flooding under current and future conditions aligning with the Coast Protection Board's recommendation of 0.3 m sea level rise by 2050 and 1 m by 2100, considering mean high water spring tide and 1-in-100 (ARI) storm surge scenarios; and
5. discuss the implications of releasing or not releasing hazard data, and the most effective methods for releasing the data.

6.4. Further reading

Further reading on how to identify coastal hazards can be found in the following documents:

- The use of modelling tools to assess local scale flooding and erosion risk (35)
- Coastal hazards and technical guide: Determining coastal hazard areas ((23)
- Background to sea level rise scenarios and Digital Elevation Model (DEM) (40)
- CoastAdapt: Assess risks and impacts (41)
- How coastal hazards impact coastal development (42)
- Developing a Coastal Hazard Adaptation Strategy: Minimum Standards and Guideline for Queensland Local Governments (43)
- Coastal Hazards and Climate Change: Guidance for Local Government (23)

7. Assessing risks

7.1. Purpose

Assessing risk is required to determine how the community, business and the environment may be directly and indirectly impacted by coastal hazards under current and future conditions. Risks should be considered as a minimum in relation to flooding and erosion for built and natural coastal assets.

During this stage, councils could determine the risk of coastal hazards to assets and services under current and future conditions. These may include built assets, regional coastal towns and settlements, services, culturally sensitive areas and natural assets such as beaches, dunes, estuaries and coastal wetlands. It is important to note that councils play a role in strategic planning for land use planning and open space planning, in addition to physical assets.

The objectives of this stage could include to:

- agreeing upon a risk management framework;
- assessing the likelihood and consequence of risks and assign risk ratings; and
- identifying priority risks.

7.2. Process

Coastal hazards and risks may change over time. Ongoing monitoring and review is essential to ensure that the selected risk treatment option remains relevant and appropriate. Factors such as new knowledge about climate change, improved understanding of physical systems and processes, or changes in land use may affect the likelihood and consequences of a selected treatment or action.

Framework

The risk management framework used for the project should align with national and international standards for risk management, specifically:

- ISO 31000:2018, Risk management – Guidelines; and
- AS 5334-2013 Climate change adaptation for settlements and infrastructure - A risk-based approach.

AS5334 is especially useful for coastal climate adaptation planning because it has a stronger focus on climate change related risks than the more generic ISO 31000. Also useful in a South Australian context is the DPTI Climate Change Adaptation Guideline for Asset Management (44), which assesses climate risk in accordance with the department's overall risk management framework (DP086).

Before assessing risks, a council's existing risk team/officer should be consulted to determine the extent of alignment with corporate risk assessment and reporting and potential implications for asset renewal priorities and long-term financial planning.

Taking a three-tier assessment process to coastal adaptation planning

The ease of following climate change risk assessment guidelines within organisations can be influenced by a number of factors, including financial and human resources, availability of in-house climate expertise, and challenges with sufficient stakeholder. To address this Tonmoy et al. (2019) propose a three-tier risk assessment process, essentially building up from a rapid to detailed level of risk assessment. Key features of each tier are:

1. First-pass risk screening – A rapid and qualitative process that can be used for resource-constrained organisations with limited data and information, who seek awareness of the risks they face from climate change.
2. Second-pass risk assessment – Involves conducting a risk assessment workshop with relevant stakeholders to identify and evaluate specific climate change risks, their likelihood and consequences. This should align with ISO31000 and existing organisational risk management frameworks, helping with internal uptake.
3. A third-pass risk assessment focuses on mode detailed investigation of prioritised, short-listed and site-specific risks identified during a second-pass assessment stage. It is highly resource intensive and is mostly likely to be required to underpin risk mitigation or adaptation actions that will need expensive, long design and/or controversial solutions.

Risk management frameworks are typically set up in spreadsheets, enabling the tabulation of risk scores. The key steps in establishing the risk management framework are to agree to the following key components:

- Identify relevant hazards – Noting the local context, an assessment is required of what hazards are relevant to the site, area or region. In the case of coastal adaptation planning, this should come directly from the identification of coastal hazards as identified in Section 6.

- Risk statement – The risk statement should combine aspects of the hazard, impact and consequence. This could include impacts as they relate to built and natural assets and service delivery. Exploration of other types of assets or features of value to a council and its residents should also be explored at this stage, such as cultural assets and community connectedness.

- Description and scoring of likelihood – The likelihood descriptors describe the frequency with which the risk could occur in the future. The probability of an event should include the following levels: almost certain, likely, possible, unlikely, and rare. For built assets, it is important to differentiate between the likelihood of a risk occurring during the construction phase as opposed to the full design life.

- Description and scoring of consequence – The consequence of a risk describes the outcome of an event. Consequence descriptors typically range from “Insignificant” through to “Catastrophic”. Consequence criteria for climate change can include:

    - damage and service loss for infrastructure;
    - social and cultural value;
    - governance;
    - legal;
    - financial cost;
    - environmental;
    - economy; and
    - safety.

Consequence criteria should be applicable to council's local context and assets, ensuring the descriptors align with those used in the corporate risk register. For example, financial consequences should align with that of the council and will therefore vary depending on its capital and operational expenditure.

- Risk rating matrix – The risk rating matrix is used to describe the overall rating for a risk based on the combination of its likelihood and consequence.

Physical, transition and governance climate risks – What's the difference?

As the process of climate change risk assessment has evolved, there is greater differentiation between different types of climate risk. Physical risk describes the risks associated with extreme weather events or long-term changes in climate leading to changes in temperature, rainfall and sea levels. Transition risk describes the legal, regulatory, technical and reputational risks associated with a move toward a low carbon economy. Governance risk describes the risk associated with the way in which decision are made by an organisation that relate to climate change.

For most councils undertaking a local coastal climate adaptation planning project, the primary focus will be on physical risk which is encapsulated by coastal hazards. Governance risk is also relevant and relates to how current and future coastal hazards are addressed in council decision making.

For further reading see: *Final Report: Recommendations of the Task Force on Climate-related Financial Disclosures* (45).

Typically, the use of a risk management framework results in a semi-quantitative process of assigning scores based on assessment of likelihood and consequence. For more detailed risk assessment requirements in the coastal zone, the consequences of a risk occurring can be further quantified by describing:

- the number of public assets at risk from coastal erosion or flooding hazards such as stormwater pumping stations, pipes and drains, jetties and boat ramps, roads;
- the number of private properties at risk, either directly to the house or the general parcel boundaries; and
- length or location of roads impacted and the type eg seal or unsealed.

These risks can be monetised where information on the value of public assets is available, or where the average house price can be determined and assigned to affected properties. There has been dramatic increase in council's expenditure in managing risks from coastal erosion and flooding hazards, particularly on protection and damage repair of beach access, jetties and boat ramps. The expenditure trend in damage repair can be similar for private properties owners, particularly after the State government's decision to freehold shack settlements, allowing them to be exposed to predicted sea level rise, coastal flooding and erosion.

Timeframes

Risks related to climate change will typically increase in the coming decades as changes in the climate intensify. This is especially the case for erosion and flooding as they increase in response to sea level rise, which will continue over the coming decades. Because of the changing nature of coastal hazards in response to climate change, the timeframe of the risk assessment should be considered. In South Australia, given that the Coast Protection Board advises that 0.3 m of sea level rise should be allowed for by 2050 and 1 m by 2100, climate risk assessment timeframes should as a starting point consider 2050 and 2100. Alternately, climate risk assessments could align to the timeframes of common data sources for sea level rise projections in Australia, which typically refer to 2030, 2050, 2070 and 2090.

The design life of an asset should also be factored into the selection of the timeframe. For example, if the assets of interest have a design life of 50 years or less then the timeframe for the risk assessment should align with this duration. Experience in most coastal settings in South Australia with settlements and infrastructure suggest that timeframes of 50 – 100 years are more typical. In contrast, most natural systems will not have a “design life” and as such as climate risk assessment that include natural assets should consider timeframes to the end of the century.

Responding to risk

Risk assessment processes will identify risks that are low through to very high (depending on the agreed risk rating matrix). In determining how to respond to risks, councils need to explore their willingness to accept risk or whether they prefer to mitigate the risk This should align with a councils existing approach to risk management. This could result in councils accepting low and medium risks but requiring action to address high and very high risks. The actions that can be taken to address risks are described further in Section 8.

This can be addressed by developing a risk tolerance scale based on what ‘society would reasonably accept, tolerate or find intolerable’ (43). If individuals and society can live with a particular risk without feeling the necessity to reduce the risks any further, this risk is considered “acceptable”. If the society can live with a risk but believe that the exposure will continue and treatments or actions will be required to reduce the risk, this risk is considered “tolerable”. Whereas, if a risk is so high that society feels actions will be required to avoid or reduce the risk, this risk is considered “intolerable”. Using this approach a risk tolerance scale can be developed to inform identification of adaptation options.

In some instances, communities living in high socio-economic areas and property owners with high value assets can be vocal in supporting or opposing to particular adaptation option. It is important that councils recognise this challenge and seek appropriate treatments or actions that deliver benefits to wider community, and that cost of adaptation options are reasonable.

Recording risk

Councils in South Australia are required to develop and maintain risk registers. Where a local coastal adaptation planning project identifies high or very high risks, these should be considered for inclusion on the corporate risk register. As such, it is preferable that council staff with responsibility for risk assessment and maintain risk registers are involved in the risk assessment process.

Climate risk assessment or vulnerability assessment?

Councils wanting to understand how climate change could impact their built and natural assets and service delivery may want to undertake a **vulnerability** or **risk** assessment. While both approaches can be used to understand the impact of climate change, they are different.

Vulnerability assessments were common in South Australia over the period 2012 to 2016 and followed on from the IPCC's Fourth Assessment Report where vulnerability was a core concept. A vulnerability assessment combines an understanding of the exposure and sensitivity for a feature of interest to a climate change variable to determine the potential impact of climate change. The influence of its adaptive capacity to the proposed climate change variable is then factored in to determine vulnerability.

Compared with AR4, the IPCC's Fifth Assessment Report (AR5) replaced vulnerability with the concept of risk, which is described as result of the interaction of vulnerability, exposure and hazard.

Key questions to ask when assessing risks:

- What level of risk assessment is appropriate given the resource, inhouse expertise and stakeholder engagement?
- Is there a clear process by which high and very high risks can progress to being recorded on the corporate risk register?
- Do you need to quantify the risk, such as in monetary terms, or is a qualitative rating sufficient?
- Does the approach to risk assessment for the project align with how risks are assessed at a whole of council scale?
- Have the staff who are involved with risk assessment and maintaining the corporate risk register reviewed the assessment results?
- Who owns the assets at risk?

7.3. Minimum requirements

It is recommended that as a minimum, councils undertake the following:

1. determine level of risk assessment to be undertaken considering the resource, expertise and stakeholder engagement;
2. establish risk management framework using risks rating matrix which cross-tabulates likelihood and consequence of coastal hazards;
3. assign risk rating score and discuss internally and with stakeholders whether the risk is tolerable or intolerable, considering timeframe of built and natural assets; and
4. identify priority risks that require new treatments or actions to reduce or eliminate risks.

7.4. Further reading

Further reading on how to identify coastal hazards can be found in the following documents:

- IPCC Reports (14)
- A local government framework for coastal risk assessment in Australia (46)
- Guidelines for developing a coastal hazard assessment (47)
- Developing a Coastal Hazard Adaptation Strategy: Minimum Standards and Guideline for Queensland Local Governments (43)
- Coastal Hazards and Climate Change: Guidance for Local Government (23)
- Final Report: Recommendations of the Task Force on Climate-related Financial Disclosures (43).

8. Identifying adaptation options

8.1. Purpose

Identifying and assessing adaptation options is required to ensure that coastal adaptation planning leads to on-ground action that builds resilience to current and future coastal hazards. It should be done in the context of a council's broader strategy regarding risk reduction.

This stage would assist councils to identify adaptation options that address priority risks to coastal hazards. This ought to consider the different strategies for coastal adaptation, which are to delay action, undertake managed retreat, accommodate hazards, defend assets or accept impacts.

The objectives of this stage should include:

- identifying risks to address and agree on the level of risk to accept;
- identifying options available and assess the suitability of options;
- considering the timing of planning and implementation; and
- reassessing risk.

8.2. Process

Identify potential options

Risk assessment processes identify risk mitigation measures, which are actions that reduce the exposure to a risk or the likelihood of it occurring. In coastal adaptation planning, these risk mitigation measures are more commonly referred to as adaptation options.

The focus of identifying adaptation options will be for risks that are either rated as high or very high, (or intolerable depending on the framing) although this decision needs to be made by each individual council.

Adaptation options for addressing risks to coastal hazards typically fall into a small number of general categories. CoastAdapt described these as follows:

- Avoidance – Avoid the impacts of coastal hazards by ensuring that assets or services are not in areas that could be impacted now or in the future;
- Managed retreat – Progressively move assets or services away from areas that could be impacted by coastal hazards now or in the future;
- Accommodate – Reduce the impact of coastal hazards by modifying construction of assets or how services are delivered;
- Hold the line – Install protection or defence infrastructure that reduces the impact of coastal hazards, especially during extreme events such as storm surge; and
- Loss acceptance – Accept that coastal hazards will cause negative impacts on assets and services and that when this occurs, they will not be replaced.

Within each of the first four categories there is a range of potential adaptation options in the areas of planning, engineering, environmental management and community awareness and education. Examples of actions under each of these areas are described further in a series of CoastAdapt guidance documents (48). In practice, a combination or sequence of these types of adaptation options will be needed as communities transition from increasingly affected coastal areas as the sea level rises. Improved education and awareness of community around coastal hazards, risks and available response options is one factor that is widely seen as a preventative measure and facilitative tool to improve adaptive capacity in the society.

Key principles for adaptation are avoiding actions that will make it more difficult to cope with coastal hazards and climate risk in the future, and identifying options that provide multiple benefits or outcomes across sectors (e.g. protection, tourism, health, sport and recreation, environment). In doing so, councils have opportunity to collaborate with other public and private sectors and share costs associated with coastal adaptation planning, implementation, monitoring and evaluation processes.

An example of the types of options that could be used for coastal adaptation are presented in Table 3. The table also outlines benefits and risks of implementing each adaptation option, and provides examples of coastal areas, councils or projects that have implemented such options.

How are coastal hazards treated by the insurance sector?

While it varies depending on the policy, household or business insurance typically covers the damage caused by natural hazards such as rainfall induced flooding, hail and fire. Impacts caused by coastal flooding and erosion (as 'actions of the sea') are typically not included in standard household insurance policies although they may be included on request (also known as bespoke policies), potentially attracting higher premiums.

The categories described here are not universally referred to, and councils may wish to choose other framings. This could be because of better alignment with other risk mitigation measures or because of a preference for a different framing of risk management. An approach applied by Townsville Council groups coastal hazard adaptation options into four themes to assist in identifying and evaluating potential response options (49):

- *Regenerative options* mimic natural processes and design to either improve or create existing coastal ecosystems and landforms to reduce the risk of coastal hazards on human settlements. These include beach nourishment and dune restoration.
- *Coastal engineering options* are designed to reduce the risk of coastal hazards on human settlements through control of coastal erosion and protection from storm tide flooding. These include a range of structures for erosion and flood control such as seawalls, groynes and levees.
- *Human settlement design options* covering building and infrastructure retrofitting and design, and the raising of land levels to improve the resilience of current buildings or to apply new design standards for future developments.
- *Planning options* are designed to reduce the risk of coastal hazards on existing and future human settlements by controlling development in coastal hazard areas and preventing development in high hazard risk areas. These include development setbacks, buy-backs schemes, land swap and land-use change.

Assess and prioritise adaptation options

"Appraising" options or "Optioneering" is the process of screening, assembling and prioritising adaptation options. A range of methods are available for appraising adaptation options, which vary substantially in terms of resource requirements (e.g. time and money) and outputs.

Factors that can influence a council's choice of method include the:

- requirement for quantitative versus qualitative data or analysis;
- amount of focus on economic costs and benefits; and
- extent of engagement required.

Emerging practice suggests undertaking an initial prioritisation or screening using a series of principles. The following principles have been developed for Queensland coastal councils to guide coastal adaptation planning (43):

1. avoid placing new assets into hazard areas and transition existing assets out over time;
2. build resilience by protecting or reinstating natural coastal ecosystems;
3. build community resilience by providing the means to strengthen their capacity to absorb stress and maintain economic, social and cultural functions;
4. adapt existing and future assets to accommodate identified coastal risks and timeframes; and
5. defend existing assets to the impacts of a defined event/s.

After initial screening is completed a more detailed prioritisation may be required. Quantitative, economically focused outputs require techniques such as Cost-Benefit Analysis (CBA), Cost-Effectiveness Analysis (CEA) and Cost-Utility Analysis (CUA) might be considered relevant. These are already common place in councils, especially CBAs. Further discussion on decision making tools is contained in Step 5 of the LGA SA's Adaptation Planning Guidelines.

Table 3 Examples of coastal adaptation options relevant in a South Australian context.

Adaptation options	Description	Category	Benefits	Risks	Examples
Regenerative adaptation options or 'soft' engineering options					
Beach nourishment	Moving sand from other sources (i.e. terrestrial sources, offshore marine deposits, coastal deposits) and depositing it into the eroded beach to compensate sand loss.	Protect (reduce the likelihood of coastal hazard)	Maintain the sandy foreshore, build up dune buffers and protect coastal infrastructure. Reversible and can be easily modified to the actual rate of sea-level rise.	Expensive and must be repeated periodically. Since storms are unpredictable, the nourished beach lifetime is not guaranteed.	- Sand carting from Semaphore to West Beach and Henley Beach South. - Whyalla - Robe Town Beach - Victor Harbour
Dune restoration and management	Providing natural protection to sea-fronting properties and assets against wave impact and storm surge flooding. Also a natural "trap" for wind-driven sand which can otherwise clog the stormwater drainage network.	Protect (reduce the likelihood of coastal hazard)	Like other natural buffers (e.g. mangroves, saltmarshes), dunes help mitigate the effects of sea level rise, erosion and flooding.	A low risk option but in some areas is sacrificial recognising that in the long term dunes will recede due to erosion.	- Revegetation and dune weeding program by Dune Care Group - Tennyson Dune - Goolwa Dunes and Tokuremour - North Beach Wallaroo
Saltmarsh and mangrove protection and restoration	Providing natural protection to sea-fronting properties and assets against wave impact and storm surge flooding.	Protect (reduce the likelihood of coastal hazard)	Like other natural buffers (e.g. sand dunes), saltmarsh and mangrove ecosystems help mitigate the effects of sea level rise, erosion and flooding.	A low risk option, but can be expensive and sacrificial in the long term.	- South Australia's Blue Carbon Strategy 2019
Seagrass protection and restoration	The roots system help stabilise the seabed by holding sand together and reduce the wave and current actions.	Protect (reduce the likelihood of coastal hazard)	Protect shoreline from erosion and provide potential for carbon sequestration (Blue Carbon Strategy).	The success of seagrass restoration is highly dependent upon quality of stormwater run-off and sediment resuspension.	- South Australia's Blue Carbon Strategy 2019 - Restoration project between Largs Bay and Hove
Coastal engineering adaptation options or 'hard' engineering options					
Groynes (onshore protection)	Hard structures constructed at angle to the shore to interrupt the wave driven longshore sediment transport resulting in accretion of sand on the updrift side of the groyne.	Protect (reduce the likelihood of coastal hazard)	Prevent long shore drift, which means less sand will be washed away.	Interrupt recreational beach use and can cause the coast on one side of the structure to become starved of sand. Detailed modelling of the wave and sediment dynamics may be needed, depending on the scale.	- Somerton Park - Port Vincent - Beachport - Tumby Bay

Adaptation options	Description	Category	Benefits	Risks	Examples
Levee (or flood barriers)	Reducing flooding along along low energy coasts, estuaries and coastal streams.	Protect (reduce the likelihood of coastal hazard)	Reduced flooding of built up areas. This not only addresses sea level rise but also changes in rainfall.	The structure transfers flood risk to other areas and can cause a disconnect between estuary and surrounding wetlands.	- Port Augusta - Point Parham - Brownlow
Seawall or revetment (onshore protection)	Longshore solid artificial structures that often act as the last line of defence in protecting coastal infrastructure and beachfront property during storm events. Installation of a seawall may be supplemented by beach nourishment.	Protect (reduce the likelihood of coastal hazard)	Effective at preventing damage to infrastructure during extreme events for some locations. They can also help to ensure beach access.	Inadvertently discourage the adoption of other risk-reduction measures. Regular monitoring is required. Risk of debris left on the beach if erosion breaches the seawall. Can exacerbate erosion to adjacent areas.	- Witton Bluff revetment - Pt Broughton seawall - St Kilda seawall - Wyomi Beach seawall
Coastal settlement design					
Building retrofitting and improved design	Incorporating sea-level rise and storm tide in design standards to retrofit existing properties (e.g. lifting existing dwellings), and for new climate ready precincts.	Accommodate (reduce vulnerability)	Flexibility to manage future coastal flooding through innovative designs when redeveloping or upgrading existing building and infrastructure, adopting modular homes & removeable dwellings.	If the surrounding infrastructure is not as resilient, it could leave residents isolated during extreme events. This also add upfront development cost.	*To be included in final version*
Land use planning outcomes					
Avoid high risk areas	Prevent new development in areas at high risk of coastal flooding and/or erosion.	Avoidance	The most cost-effective long term response in undeveloped or rural areas. This option saves communities from future costs of coastal protection.	A low risk option already in place	Hazard risk minimisation policy in Development Plans and the Planning and Design Code (Coastal Areas Overlay) ensures new land division provides a suitable buffer to allow for natural coastal process. Some coastal zones and zone boundaries also provide appropriate buffer areas.
Managed retreat	Existing Development Plan (and pending Planning and Design Code) policy can enable and/or require managed retreat of development in high risk areas, if practical to do so and land is available.	Retreat (reduce exposure)	Maintains beach access, reduces environmental impacts and avoids or delays the need for costly protection options.	Applies in limited circumstances. May not receive community support in some cases.	Respective Development Plan zone policy at Black Point and Kellidie Bay enables the managed

Adaptation options	Description	Category	Benefits	Risks	Examples
					retreat of foreshore shacks to adjacent land.
Improved Design outcomes	Planning policy can provide alternative design options to minimise coastal flood hazard risks. Coast Protection Board policy allows elevated homes as a substitute for the importation of fill in some cases.	Accommodate (reduce vulnerability)	Enables infill development in vulnerable locations, while accommodating the flood hazard risk at the property level.	Applies in limited circumstances, notably low lying shack settlements. If the surrounding infrastructure is not as resilient, it could leave residents isolated during extreme events. Does not resolve whole of settlement considerations.	Many site specific examples of elevated homes within existing shack settlements (Thompsons Beach, Pine Point etc.).
Protection requirements	Existing Development Plan and Planning and Design Code Planning policy can ensure new development (dwellings, land division etc.) is contingent on the implementation of coastal adaptation strategies that include hard engineering solutions if required (i.e. seawalls and levee banks).	Protect (reduce the likelihood of coastal hazard)	Minimises risk to property and ensures protection costs are not incurred by the broader community at a later date, through local government or state government contribution.	Can be a difficult process to ensure infrastructure design and ongoing maintenance responsibilities are addressed prior to development approval. With risks noticeably exacerbated by storm surge events and sea level rise, this upfront requirement is likely to become more common.	Some low lying shack settlements are examples where development (infill/replacement dwellings) should be contingent on the implementation of protection works.

Box 3. LGA SA Coastal Adaptation Guidelines 2012 – Financial analysis technique.

The 2012 Guidelines (Chapter 7) recommended a series of financial models to assist coastal councils identify the most cost-effective adaptation options. The models were generic in structure and allowed users to input climate variables and then select defend, retreat, accommodate or delayed action options for the financial analysis. The cost for each option is tested against three strategies – act now, sense and respond or predict and respond. Outputs quantify the most cost-effective option for action and are considered in the context of the decision map (CADP - Chapter 6). These include:

- Real Option Analysis;
- Model Flow Chart - Flood Model;
- Flood Calculations in the Model;
- Financial Calculations in the Flood Model;
- Model Flow Chart - Erosion Model;
- Erosion Calculations in the Model;
- Financial Calculations in the Erosion Model;
- Protection Calculations in the Financial Model;
- Damage Calculations in the Financial Model; and
- Calculation of Total Costs for Each Option.

Of these methods, Multi-Criteria Analysis (MCA) has emerged as a preferred technique.

MCA uses a variety of criteria to assess alternative options and is suitable when quantification and valuation in monetary terms is not possible. Furthermore, MCA's can be used to identify a priority ranking for adaptation options as a starting point for more detailed assessments and analyses. In cases where benefits cannot be quantified and valued (e.g. the benefits of preserving biodiversity, environmental services), MCA is preferred to CBA (50).

Sequencing options - A pathways approach

A key challenge of coastal adaptation planning and management is knowing when to implement adaptation options given that increasing sea levels over the coming century will mean that the options required at different points in time may differ. The choice of when to act has a major impact on investment decisions on the one hand, and potential risk exposure on the other (51).

Traditional economic analysis methods are not well suited to dealing with variation in coastal hazard projections because they do not work when applied to multiple future scenarios. In response, some councils have adopted an "adaptation pathways" approach which is an approach to planning that sequences a set of possible actions that are based on external developments over time (52).

Adaptation pathways approaches are being increasingly used around Australia to assist with developing coastal adaptation strategies. While they have been considered as an alternate to risk based approaches by some, there are also examples of where they are integrated with traditional risk

based adaptation planning approaches. This is demonstrated by the use of adaptation pathways in the regional climate change adaptation plans in South Australia and more generally as described in CoastAdapt.

Regardless of the specific methodology, the common elements of pathways approaches applied in an Australian context are as follows:

1. a goal or area of decision making;
2. built on a broad concept of sequencing the implementation of options;
3. incorporated the concept of triggers and thresholds;
4. defined a multi-step methodology rather than general principles;
5. generated a visual pathways map or table; and
6. advocated for the monitoring and evaluation of indicators that describe triggers and thresholds.

Key questions to ask when assessing options:

- With respect to built assets, does council have a “defend at all costs approach”?
- Under what conditions is managed retreat appropriate compared with accommodate or defend?
- What adaptation options should be ruled out for the given location and what should be retained, even if unpopular?
- How can the implementation of adaptation options be sequenced through time?
- Who has responsibility for implementing the priority adaptation options?

8.3. Minimum requirements

It is recommended that as a minimum, councils undertake the following:

1. align the prioritisation processes, especially where it uses economic analysis techniques, with existing council processes;
2. identify a broad range of adaptation options for initial discussion, including options that may not be preferred by all stakeholders;
3. recognise existing engagement policies and strategies and ensure that they are adhered to where available and applicable;
4. agree to how public funding will be allocated to protection of private assets or assets that deliver mostly private benefits;
5. ensure that the approach to prioritisation allows consideration of social, economic and environmental factors as a minimum;
6. explore the potential sequencing of adaptation options through time;

8.4. Further reading

Further reading on how to identify adaptation options can be found in the following documents:

- Adaptation options for managing coastal risks under climate change (48)
- Developing a Coastal Hazard Adaptation Strategy: Minimum Standards and Guideline for Queensland Local Governments (43)
- Coastal Hazards and Climate Change: Guidance for Local Government (23)
- Climate change decision support framework and software for coastal councils (53)
- Adaptation pathways: A playbook for developing options for climate change adaptation (54)
- A user guide for applied adaptation pathways (55)

9. Plan development and review

9.1. Purpose

The development of a plan or strategy as an output of a local coastal climate adaptation planning process needs summarise the outcomes of the assessment process and present the future direction of the council to internal and external stakeholders. The focus on implementation should consider resourcing requirements and a commitment to monitoring, evaluation and review.

During this stage, the focus should be to identify priority adaptation options for implementation, outlining broad timing and resource requirements. The plan should clearly communicate the nature and extent of current and future hazards and how the impacts of these on built and natural assets and services delivered by council will be managed.

The objectives of this stage could include:

- finalising a plan that outlines tangible actions and a schedule for implementation;
- embedding the outcomes of the planning process into key corporate governance documents (eg asset register, asset management plans, planning code);
- identifying resourcing requirements;
- developing an approach to monitoring and evaluation including indicators that can be monitored in relation to key risks; and
- finalising engagement with internal and external stakeholders.

9.2. Process

Plan development

The development of the plan is a key output from the local coastal climate adaptation planning process. When determining the structure of the plan consideration should be given to its scope and whether it is intended to be strategic and set a broad direction for implementation over a longer period of time, or if it is action oriented with a discrete set of deliverables for immediate adoption.

Noting the scope of the plan, it should describe as a minimum:

- regional values and site context;
- current and projected coastal hazards;
- priority risks and potential impacts;
- potential and prioritised adaptation options;
- necessary approvals;
- implementation timeframes;
- resourcing requirements and responsibilities; and
- monitoring and evaluation.

If the intended audience of the plan is external, there should be an opportunity provided for stakeholders, especially residents and business to view and comment on the plan. This can be facilitated using tools such as YourSAy, or by making hard copies of the draft Plan available. Further discussion on the general approach to engagement is provided in Section 5.

Embedding the outcomes of the planning process

To ensure that the plan is used to drive on-ground action, either immediate or in the future, key outcomes should be embedded in council corporate governance documents.

Specifically, these are:

- Council risk register – Councils in South Australia are encouraged to adopt and maintain robust risk management practices. This includes the establishment and maintenance of a risk register. Priority risks identified as a result of coastal hazards, such as those rated as high or very high, or intolerable (depending on the risk terminology adopted), should be recorded in the council risk register.

- Asset management plan – Asset management plans outline a council's approach to the management of assets (and services provided from assets), compliance with regulatory requirements, and communicating the funding required to achieve required levels of service. Any priority risks resulting from coastal hazards that need to be managed through modification to current assets and infrastructure, or through the construction of assets and infrastructure in the future, should be identified in the relevant asset management plan.

- Long-term financial management plan – The purpose of a council's long-term financial plan is to express, in financial terms, the activities that the council proposes to undertake over the medium to longer term to achieve its stated objectives (56). Where climate risks are identified in the asset management plan that require implementation in the coming 10 years, these should be identified on the long-term financial management plan.

Monitoring, evaluation and review

A broad principle that underpins these Guidelines is adaptive management, which involves regularly reviewing management practices based on learnings from implementation. This is often done passively, through individuals learning from what has worked and what has not. Instead, an active adaptive management approach is required, supported by systematic monitoring and evaluation.

There are multiple aspects of monitoring and evaluation that should be considered as part of developing a coastal adaptation plan. Unfortunately, these are often not fully implemented because of a lack of resources to undertake monitoring, or insufficient agreement to responsibilities.

There are several types of monitoring and evaluation that should be considered in support of coastal adaptation plans. These are:

- Progress with implementation of actions – This involves periodic review of whether adaptation options that were identified in a plan have been implemented or not. Where this is undertaken, additional information regarding effectiveness, actual costs, and barriers and enablers for implementation should also be recorded.

- Monitor changes in risks caused by coastal hazards – These Guidelines identify the primary risks of concern in the coastal zone as being erosion and flooding. Erosion can be monitored in a range of low-cost ways to inform general community understanding of changing risk through to detailed and technically robust methods involving the capture of aerial imagery or coastal profile surveys. Monitoring of flooding can equally include a variety of low technology through to advanced approaches. Methods of monitoring erosion and flooding risks are described further in Section 7.

- Changes in community attitudes – Community attitudes will have a large influence on the types of adaptation options that can be implemented, especially across broad categories of defend, accommodate, retreat or accepting loss. Periodic assessment of community attitudes can help inform long term implementation of coastal adaptation plans. This is best done using interview or survey techniques as described in Section 6.

- Extreme events – Extreme events in the coastal zone, especially storm surge, provide an excellent source of information about the consequences of infrequent but high impact coastal hazards. These can be used to provide further local context for implementation efforts or to support current or future reviews of coastal adaptation plans. As a minimum, monitoring during these events could involve capturing photos from council staff and community, incidents reported to councils via their reception, news articles.

- Monitor triggers or thresholds – As identified in Section 8, adaptation pathways, also referred to as decision pathways, provide a useful method for determining how to sequence the implementation of adaptation measures through time. The timing of implementation though should be informed by when thresholds or triggers are met. Where an adaptation pathways approach has been adopted, monitoring should be undertaken for determining when triggers and thresholds are met. This could be reviewed following extreme events, on an annual basis or as part of periodic reviews.

Periodic reviews of the results of monitoring and evaluation from councils is encouraged, at least at a regional scale. This can facilitate sharing of learnings from across councils regarding the effectiveness of adaptation options.

Resourcing and responsibilities

The level of engagement, funding and support to Councils and communities around coastal management varies across the State. Over the last ten years expenditure by Local Government on coast protection, management and infrastructure has nearly doubled[5], whilst the level of income to support this (ie grants) has remained largely static.

The 1995 South Australian/Local Government Accord on Coastal Management recognised there are both local and state benefits in sustainable coastal management, and that taken overall, these benefits are approximately equal (57). Therefore, expenditure by State and Local Government should overall, be approximately equal, with each sphere of government funding the tasks they can achieve most efficiently.

There are a variety of funding sources that may be available to councils for funding coastal adaptation options. These are summarised in **Box 4**.

[5] Data from Local Government Grants Commission codes 71, 72, 94, 2007/08 to 2016/17

Box 4. Sources of funding for implementing coastal adaptation plans.

South Australian Coast Protection Board - The board receives an annual budget allocation of which around 75% is provided to coastal councils for priority works through a grant program. A co-contribution of a minimum 20% towards the cost is expected from Councils. Projects typically funded include levee banks, revetment and seawalls, general foreshore protection, flood mitigation works, erosion control, cliff stabilisation, groynes, regional beach replenishment, coastal settlement adaptation strategies. The Coast Protection Board also provides grants for monitoring, data collection and coastal research initiatives.

Natural resource management levies – NRM levies are collected by Councils on behalf of the State Government for allocation and expenditure by each regional NRM Board. Example of expenditure of NRM levies on coastal works includes the Adelaide Living Beaches sand transfer scheme, which was funded by the Adelaide/Mt Lofty Ranges NRM levy.

Under the *Landscape South Australia Act 2019*, regional NRM Boards have been replaced by regional Landscape Boards and metropolitan Green Adelaide. Potential funding support from July 2020 onward will be available under Landscape Priority Fund. A new statewide Landscape Priorities Fund will enable investment in large-scale integrated landscape restoration projects to address sub-regional, cross-regional and statewide priorities, and will be administered by Green Adelaide.

Boating Facilities grants – These grants are managed through the Department of Planning, Transport and Infrastructure. Councils and community groups can apply for grant assistance to establish and improve boating facilities, including boat ramps; temporary mooring facilities or wharves; channel improvements; aids to navigation; or emergency marine radio services. Councils are responsible for the operation and maintenance of these facilities.

State Government commitments – Periodically, the State Government provides funds for coastal work, often in the wake of extreme events. For example, following the 2016 storms the State Government provided $3.5 million (www.pir.sa.gov.au) to repair a number of recreational jetties, including state managed jetties and those under council care and control, where costs were not covered by insurance.

Federal funding programs and grants - The availability of funding for coastal management depends on the extent to which the Federal Government sees this as a state issue. Historically, Federal funding programs have been used to support initiatives like CoastCare. Some annual grant programs have been used to support projects that contribute to the development of coastal adaptation plans, such as the National Disaster Resilience Grant Scheme.

In order to implement adaptation options and commit to monitoring and evaluation, an agreed resourcing schedule should be developed. This needs to outline resources required for immediate and future actions, covering both human and financial resources. Key resourcing issues to discuss in a council include:

- What is the desired funding ratio between local-state-federal government for an agreed adaptation option?
- What is the responsibility for local government to provide resources to protect private assets?
- What funding is required to encourage and facilitate multiple outcomes for the coast, including protection, tourism, health, recreational and environmental benefits and minimise unintended or cumulative impacts?

With respect to funding adaptation options that protect private assets, these Guidelines include a principle as a default position for decision making that the local government sector should not fund adaptation measures designed to primarily protect private assets or deliver private benefits. This default position should be assessed on a case by case basis for individual councils, with consideration being given to co-funding models in instances where the majority of benefit is for private assets.

Key questions to ask when developing a plan or undertaking a review:

- Who is the audience for the plan? Is it within council, external to council or both?
- How will the priority risks and adaptation options be embedded into key corporate governance documents?
- Have sufficient resources been allocated to undertake monitoring and evaluation?
- Have the necessary approvals been obtained or applied for?
- Has a timeframe for review of the plan been agreed to?
- What is the funding ratio between local-state-federal government for agreed upon adaptation measures?
- What level of resourcing should your council provide to protect private assets from future coastal hazards?

9.3. Minimum requirements

It is recommended that as a minimum, councils undertake the following:

1. develop a plan that summarises the outcomes of the coastal adaptation planning process;
2. identify actions that can be delivered within 12 months of completion of the Plan. This will help to demonstrate progress and build momentum for ongoing implementation;
3. incorporate priority risks in the corporate risk register, recognise current and future works that may be required to address priority risks in the asset management plans; and
4. identify current and future resourcing required to support implementation of adaptation options.

9.4. Further reading

Further reading on how to develop and coastal adaptation plan and ensure sufficient monitoring and evaluation is being undertaken can be found in the following documents:

- A User Guide for Applied Adaptation Pathways (55)
- Adaptation Pathways: a playbook for developing robust options for climate change adaptation in Natural Resource Management (54)
- Coastal Adaptation Decision Pathways Investigative Framework (53)
- Developing a Coastal Hazard Adaptation Strategy: Minimum Standards and Guideline for Queensland Local Governments (43)
- Coastal Hazards and Climate Change: Guidance for Local Government (23)

List of Acronyms

AHD - Australian Height Datum

AR4 - Fourth Assessment Report.

BOM - Bureau of Meteorology.

CADP - Coastal Adaptation Decision Support Pathways Guidelines

CPB – Coast Protection Board

CSIRO - Commonwealth Scientific and Research Organisation.

DEM - Digital Elevation Model.

GCM - Global Climate model.

GIS - Geographic Information System.

HAT - Highest Astronomical Tide

IPCC - Intergovernmental Panel on Climate Change.

LAT - Lowest Astronomical Tide

LGA SA – Local Government Association of South Australia

LiDAR - Light Detection and Ranging

RCP – Representative Concentration Pathway

Glossary

This glossary has been developed based on the following documents:

- Prospering in a changing climate adaptation framework for South Australia (58)
- Towards a resilient state: South Australia Government's climate adaptation action plan (59)
- Climate Compass: A climate risk management framework for Commonwealth agencies (19)
- Flooding versus inundation (60)
- Managing the coast in a changing climate (61)
- Developing a Coastal Hazard Adaptation Strategy: Minimum Standards and Guideline for Queensland Local Governments (43)
- Coastal Hazards and Climate Change: Guidance for Local Government (23)

Adaptation

Adaptations are practical actions taken to help communities and ecosystems moderate, cope with, or take advantage of current and future risks from climate impacts.

Adaptive capacity

In relation to climate change impacts, adaptive capacity is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. This also include the resources available for adaptation, and the ability of a system to use these resources effectively in the pursuit of adaptation.

Climate

Climate summarises the average, range and variability of weather elements, e.g. precipitation, wind speed, air temperature, humidity, and sunshine hours (solar radiation), observed over many years (typically > 30 years) at a location or across an area.

Climate change (global warming)

Climate change refers to shifts in the mean state of the climate or in its variability, persisting for an extended period (decades or longer). Contemporary climate change refers to anthropogenically driven changes in the climate as a result of changes to the composition of the atmosphere via the addition of greenhouse gases.

Climate projections

A forecast of expected climatic changes into the future based on scientific modelling and greenhouse gas emissions scenarios. Projections provide a sense of the range of future climate conditions that may emerge, for which planning must occur. (By contrast a 'prediction' aims to describe what will actually happen, like a weather forecast).

Climate variability

Climate variability refers to variations in the mean state of climate on all temporal and spatial scales beyond that of individual weather events. Examples of climate variability include extended droughts, floods, and conditions that result from periodic El Niño and La Niña events.

Coastal flooding

Although "flooding" and "inundation" often have been used interchangeably, some authors (Flick et al, 2012) suggest that "flooding" better describes normally dry areas that become wet, but then eventually dry again. Coastal flooding occurs when seawater inundates usually dry land, which can occur when sea level exceeds the land elevation or when barriers are overtopped or breached.

Coastal hazards

Subset of natural hazards covering tidal or coastal storm flooding, rising sea level, tsunami or meteorological tsunami flooding, coastal erosion (shorelines or cliffs), coastal acid sulfate soils, sand drift, loss of coastal habitats, rise in groundwater levels from storm tides and sea-level rise, and salinisation of surface fresh waters and groundwater aquifers.

Estuary

A partially enclosed coastal body of water that is either permanently, periodically, intermittently or occasionally open to the sea within which there is a measurable variation in salinity due to the mixture of seawater with water derived from on or under the land'. It also encompasses the ecosystem processes and associated biodiversity within estuaries and their adjacent habitats.

Intertidal foreshore

The coastal zone measuring from the lowest to the highest tide mark. The intertidal zone is subject to alternating periods of flooding and drying.

Inundation

The term "inundation" is used to denote the process of a dry area being permanently drowned or submerged. Flooding is and has been dominant along open coasts. However, inundation is likely to become ever more important in the coming decades and centuries and may itself eventually become a dominant physical coastal process.

Maladaptation

Maladaptation occurs when you implement an action that reduces your climate risk in one area or in the short-term, but increases risk in other areas, on other groups, or in the medium- to longer-term. For example, you may build a sea wall to decrease erosion locally, but the sea wall may actually increase erosion on neighbouring beaches. Maladaptation occurs when interventions may achieve a narrow aim but result in unintended negative side effects.

Mitigation

Mitigation is action to reduce sources of greenhouse gases, or to enhance the removal of these gases from the atmosphere. This term is also sometimes used in relation to risk mitigation, which describes actions taken to reduce the likelihood or consequence of a risk.

Nearshore

The area extending from the low water shoreline to the generally less than 10m depth or beyond the breaker zone.

Sea level rise

Sea level rise occurs when ocean water expands upon heating or when land-based ice (glaciers or ice sheets) melt as a result of warming. The rise will not be uniform at all locations as ocean circulation, gravitational effects and land subsidence can modify the sea level.

Risk

Risk is the product of consequences and likelihood - what can happen, and what are the odds of it happening. Both of these factors are important in determining whether and how we address specific risks.

Supratidal

The shore area above the high tide level.

Vulnerability

Vulnerability to the impacts of climate change is a function of exposure to climate conditions, sensitivity to those conditions, and the capacity to adapt to the changes.

Weather

Weather describes atmospheric conditions at a particular place in terms of air temperature, precipitation, wind speed, pressure, and humidity. While weather varies day to day and describes conditions in the short term, climate is the long term average of the weather patterns, usually taken over 30 years or longer.

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