Triggers and thresholds

Adaptation planning in Coastal Management Programs

**Department of Climate Change,
Energy, the Environment and Water**

NSW GOVERNMENT

Acknowledgement of Country

Department of Climate Change, Energy, the Environment and Water acknowledges the Traditional Custodians of the lands where we work and live.

We pay our respects to Elders past, present and emerging.

This resource may contain images or names of deceased persons in photographs or historical content.

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Published by:
Environment and Heritage
Department of Climate Change,
Energy, the Environment and Water
Locked Bag 5022, Parramatta NSW 2124
Phone: +61 2 9995 5000 (switchboard)
Phone: 1300 361 967 (Environment and Heritage enquiries)
TTY users: phone 133 677, then ask for 1300 361 967
Speak and listen users: phone 1300 555 727, then ask for 1300 361 967
Email info@environment.nsw.gov.au
Website www.environment.nsw.gov.au

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1. Background and context

1.1 Purpose of this guidance

This guidance for addressing triggers and thresholds provides strategic advice for managing risks related to coastal-specific natural hazards across the coastal zone. It provides guidance for coastal managers and planners, across all levels of government, to help them prepare and develop considered strategies and responses to dynamic coastal management issues, including when there is uncertainty about future conditions, climate change, or disagreement about what course(s) of action should be taken and when.

The purpose of the guidance is to inform effective, long-term management of the New South Wales (NSW) coastal zone through application of an adaptive pathways approach for management of current and future coastal hazards. One of the key benefits of the adaptive pathways approach is that it facilitates a more adaptive approach to management that is proportionate to the risks a community faces at that future time.

While this guidance can be considered standalone, it is intended to be used in the development and implementation of coastal management programs (CMPs), which provide the basis for achieving long-term adaptation. CMPs identify priority strategies for the coordinated and sustainable management of the coastal zone, with the aim of achieving the objectives of the *Coastal Management Act 2016* and land-use planning under the *State Environmental Planning Policy (Resilience and Hazards) 2021*.

The guidance first looks at triggers and thresholds in the context of coastal management and the importance and benefits of adopting an adaptive pathways approach.

Section 2 provides an overview of existing guidance on setting triggers, including an overview of other jurisdictions, general considerations and more specific information on trigger pathways and approaches, and measuring and monitoring.

Section 3 provides guidance on how to incorporate triggers and thresholds into NSW coastal management and planning frameworks, including CMPs, coastal zone emergency action subplans, environmental planning instruments and other planning documents.

1.2 Triggers and thresholds in the context of coastal management

Concepts of ‘triggers’ and ‘thresholds’ were first introduced by Holling (1973; cited in Munson et al. 2018), who used the terms ‘thresholds’ and ‘tipping points’ in relation to ‘critical transitions’ to refer to sudden changes in the integrity or state of an ecosystem caused by environmental drivers.

In the context of coastal management in New South Wales, triggers and thresholds are not terms that are specifically defined by the Coastal Management Act. Generally, these can be defined as:

- a **trigger** is defined as 'an act or event that serves as a stimulus and initiates or precipitates a reaction or series of reactions'
- a **threshold** is defined as 'the magnitude or intensity that must be exceeded for a certain reaction, phenomenon, result, or condition to occur or be manifested'.

When considering these definitions in a coastal management context, and in particular management of coastal hazards, the guidance considers triggers to represent an occurrence, incident or event that is the impetus for some form of intervention, action or response. Thresholds, relate to a value or condition — often defining the trigger itself — that can be measured, quantified or observed.

Thresholds can also be used to represent an end point when irreversible change is likely to occur, risks become unacceptable and/or a perception that the current management response will no longer be effective. For example, a physical threshold may be a point where natural defences are no longer effective in managing the risk of coastal erosion, such as the loss of a coastal sand dune or other natural barrier. In a community context, a threshold could be the point where a building becomes uninhabitable due to safety concerns from landslip or following a flooding event. However, there may also be a number of thresholds along a continuum of time that act as alerts or warnings prior to an impact occurring.

From a temporal perspective, triggers and thresholds can relate to both acute and chronic impacts from coastal hazards. That is, actions can be planned and implemented depending on whether they are triggered by the impacts of a single hazard event or by a more progressive or incremental impact or longer term change to conditions such as sea level rise.

Generally, physical rather than time-based triggers are preferable to use for coastal hazards. This is because they are based on actual events that are measurable in real time (for example, the distance of a structure to an erosion escarpment), rather than on uncertain temporal predictions, which may or may not eventuate within a given period. However, employing both physical and time-based triggers may still be warranted in order to appropriately address uncertainly surrounding factors such as climate change.

1.3 Integrating triggers and thresholds into coastal management programs

Under the NSW coastal management framework, CMPs are prepared by local government in accordance with the *Coastal management manual* (OEH 2018a, b)), herein referred to as the manual.

The adoption of triggers and thresholds concepts is relevant not only to the development and implementation of CMPs, including associated coastal zone emergency action subplans (CZEAS), but can also be more broadly applied in strategic

planning documents, including local environmental plans (LEPs) and site-specific planning decision-making related to coastal hazards.

While the Coastal Management Act does not specifically identify application of triggers and thresholds, the manual (Part A) sets out the mandatory requirements (MRs) for CMPs relevant to the Act and provides key linkages to concepts of triggers and thresholds.

The requirement that directly links to triggers and thresholds is MR 8:

> A CMP must: ...
>
> ix identify a proposed monitoring, evaluation and reporting program in relation to the CMP, including by identifying key indicators, **trigger points and thresholds** relevant to the CMP

The manual also outlines requirements for CMP implementation as follows in MR 16:

> When implementing a CMP, a council must:
>
> i carry out the monitoring, evaluation and reporting program in the CMP (MER); and
>
> ii monitor key indicators, **trigger points and thresholds** identified in the MER.

Preliminary guidance and applications relating to triggers and thresholds are also provided in the manual (Part B, Stage 3, Section 3.9.2). This preliminary guidance is reflected and has been expanded upon as part of this document.

Furthermore, where CMPs also entail the preparation of a CZEAS, the associated guidelines for preparing a CZEAS (DPE 2019) also recommend considering triggers and thresholds for emergency responses:

> The CZEAS should be prepared to facilitate effective emergency responses by:
>
> - defining a coastal emergency and **triggers** for emergency response actions ...

1.4 Adopting an adaptive pathways approach

1.4.1 Setting triggers and thresholds to manage coastal hazard risks

An adaptive pathways approach represents approaches that are designed to sequence or schedule decision-making. They identify the decisions that need to be taken now and those that may be taken in the future, while supporting strategic, flexible and structured decision-making (Coast Adapt 2017).

Setting triggers and thresholds is considered an important component of a successful adaptive pathways approach. Triggers and thresholds signal both the timing of when management interventions should be implemented, as well as the type(s) of interventions, even where a number of options are still possible at future points.

Thresholds may be set in relation to:

- a single trigger point for one-off intervention (a more precautionary approach)
- defining an overall level of acceptable risk that is tolerated (a so-called 'limit of acceptable change')
- as part of an iterative adaptive pathways approach (or managed adaptive approach).

The coastal management manual (Part B, Stage 3, Section 3.9) provides a high-level conceptual diagram to illustrate these 3 different approaches to setting thresholds, which can be applied in isolation or in combination. This diagram from the manual is reproduced in Figure 1.

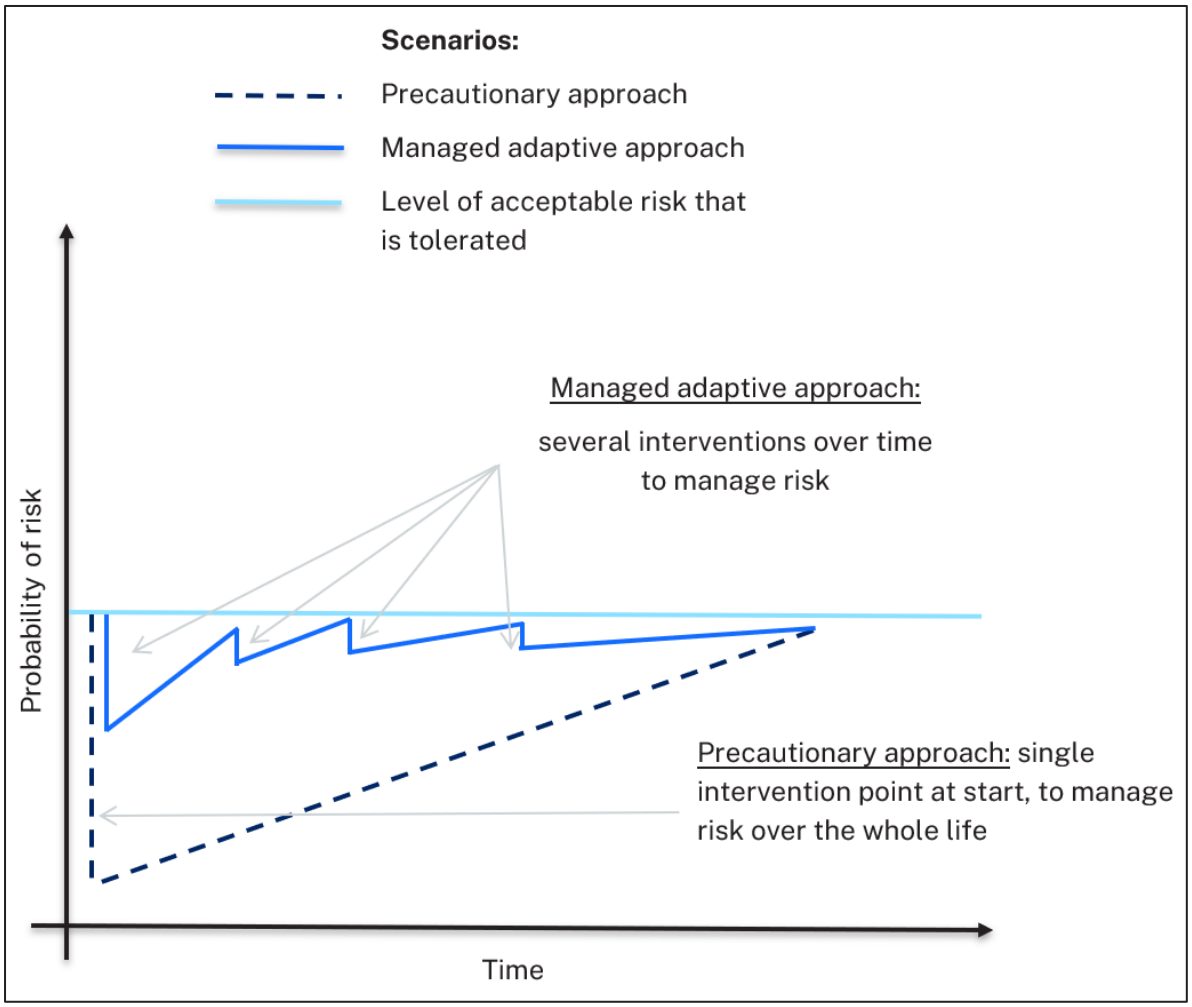

Figure 1 **Approaches to setting thresholds for coastal hazard management (Source: DEFRA 2009)**

Firstly, a threshold may be set for a single trigger point for intervention (see **dark blue dashed line** in Figure 1). The manual notes that use of this more **precautionary approach** with a one-off intervention may be necessary where, for example, it is not possible to adapt with multiple interventions due to technical feasibility, or where adaptive management is too complex to administer.

Secondly, a threshold value may also be used to define an overall **risk tolerance level** for an issue over time (as shown by the **light blue line** in Figure 1). This is also referred to as the 'upper bound' of risk or the 'limit of acceptable change'. Risk tolerance thresholds can provide a more tangible and measurable definition of what a coastal manager or decision-maker deems to be an unacceptable or intolerable risk of impact. Such thresholds are commonly used for siting new development, such as standards set for flood hazard areas (for example, the 1% annual exceedance probability [AEP]).

Finally, under an **adaptive pathways** approach (**mid blue line** in Figure 1), there is recognition of the potential for several interventions, for example, trigger points with potentially different threshold values over time, to assess and treat the coastal hazard risk and to implement appropriate management responses before an intolerable risk is reached. The intolerable risk in this case will vary depending on the hazard and local circumstance. It could include, for example, dwellings that are no longer habitable due to imminent erosion risk, or public facilities that can no longer be reliably accessed or maintained due to frequent saltwater inundation associated with high tide flooding.

An adaptive pathways approach is well suited to the management of coastal hazards through the development and implementation of CMPs, given that CMPs should address uncertainty around the location, timing and consequence of impacts from coastal hazards, as well as considering management responses that relate to factors such as existing and future development and population growth.

However, adaptive pathways approaches require some level of monitoring and review of the effectiveness of management interventions or against expected performance. This is done to allow coastal managers and decision-makers to refine any management action(s) and maximise environmental, social and economic benefits as information and knowledge is gained over time.

1.4.2 Dealing with uncertainty and avoiding maladaptation

Adaptive approaches using triggers and thresholds can be particularly important when considering larger, complex and/or more costly management actions. They can assist coastal managers and decision-makers to ensure appropriate actions and responses are only implemented when and where they are required. In contrast, maladaptive responses typically occur when management actions are implemented either too early or too late in relation to the risks, are ineffective and/or have unintended adverse impacts.

In applying the concept of adaptive approaches to coastal hazards, the benefits include:

- allowing for additional time to collect further data and information and establish or confirm a clear trajectory of potential impacts before determining the most appropriate action response solution(s)
- avoiding cost imposts on current and future generations from hazard risk treatments, until such treatments are absolutely necessary
- reducing political and community dissatisfaction with coastal hazard risk treatment solutions that may be seen as overly conservative, too costly and/or ‘overkill’ by some stakeholders
- delaying environmental and social impacts and associated loss of benefits to coastal communities that can arise from some coastal hazard risk treatment solutions until they are absolutely necessary
- avoiding inadvertently increasing the risk of hazard impacts or introducing other adverse outcomes from proposed treatment measures.

Importantly, setting appropriate trigger points and thresholds also allows time for coastal managers and decision-makers to refine and prepare for actions to be implemented in advance of an unacceptable or unintended impact being realised. These could include, for example, actions to:

- undertake a more detailed assessment of alternative options to treat the risk (such as a decision between soft or hard engineering solutions and the design of such a solution)
- undertake additional consultation and engagement with affected landowners or communities about management options and any implications
- provide appropriate time to obtain any statutory consents and/or approvals such that when actions need to be initiated, they can be implemented relatively quickly
- identify areas that will likely be subject to future hazard risks and ensuring appropriate considerations are put in place at a future juncture.

In a planning context, triggers and thresholds can also be critical to signalling to both key stakeholders and the broader community what the future management intent is for an area subject to coastal hazards by:

- identifying the trigger and/or threshold that, if reached or exceeded, signals a specific action(s) to be taken
- identifying the action(s) that will be taken to address the trigger or the exceeded threshold
- identifying the circumstances or timing for when the actions will be implemented
- forming the basis for monitoring and evaluation programs to determine and monitor triggers and thresholds over time.

The above is particularly important given both the intermittent and long-term nature of many coastal hazards and future sea level rise. It allows for the consideration of trigger points during both the life of a CMP, as well as forming a basis for future risks and adaptation pathways as they are revised as part of the CMP lifecycle process.

1.5 Hazards considered in this guidance

This guidance specifically examines applying the concept of coastal management triggers and thresholds to the 7 coastal hazards as defined under the Coastal Management Act. These 7 coastal hazards are listed and described in Table 1. Detailed definitions for each of these terms are provided in the NSW *Coastal management glossary* (OEH 2018c).

Table 1 Types of coastal hazards and description

Hazard type	General description
Beach erosion	Refers to landward movement of the shoreline and/or a reduction in beach volume, usually associated with storm events or a series of events, which occurs within the beach fluctuation zone. Beach erosion occurs due to one or more process drivers; wind, waves, tides, currents, ocean water level, and downslope movement of material due to gravity.
Shoreline recession	Refers to continuing landward movement of the shoreline, that is, a net landward movement of the shoreline, generally assessed over a period of several years. As shoreline recession occurs the beach fluctuation zone is translated landward. Recession can occur on open coast beaches and in estuaries, particularly where there may be limited opportunity for deposition and shoreline recovery.
Coastal lake or water course entrance instability	Refers to the variety of potential hazards and risks associated with the dynamic nature of both natural and trained entrances. Coastal lake and watercourse entrances are highly active environments with their shape constantly changing in response to processes such as alongshore sediment transport, tidal flows, storms and catchment flooding. Entrance conditions affect a range of factors, such as berm height, water levels, flushing, water quality, salinity and sediment dynamics in coastal lakes and lagoons. High water levels behind a closed entrance may exacerbate the impacts of catchment flooding on residential properties, roads, stormwater and sewerage systems, public access and recreational use of foreshores and natural assets such as coastal wetlands and floodplains.
Coastal inundation	Coastal inundation occurs when a combination of marine and atmospheric processes raises the water level at the coast above normal elevations, causing land that is usually 'dry' to become inundated by sea water. Alternatively, the elevated water level may result in wave run-up and overtopping of natural or built shoreline structures (e.g. dunes, seawalls). Coastal inundation generally relates to storm events. Storm surge and powerful waves can also penetrate estuaries giving rise to strong currents or seiching.
Tidal inundation	Refers to the inundation of land by tidal action under average meteorological conditions and the incursion of sea water onto low-lying land that is not normally inundated, during a high sea level event such as a king tide or due to longer-term sea level rise. In some scenarios, the risk associated with tidal inundation may be exacerbated when a king tide coincides with coastal inundation or catchment flooding.
Coastal cliff or slope instability	Geotechnical or slope instability hazard occurs on the headlands and bluffs within and separating coastal sediment compartments.

Hazard type	General description
	The differing degree of instability often relates to the interaction of weathering and erosion processes on different geological formations and rock types. Geotechnical hazards present risks both to property and to life, such as rock falling from headlands and cliff faces, collapse of unconsolidated materials (such as high dune escarpments), reduced foundation capacity, and the collapse of cliffs under houses and development.
Erosion and inundation caused by tidal water and waves, including the interaction of those waters with catchment floodwaters (e.g. coincident event)	This hazard relates to the interaction of different coastal hazards as well as consideration of anthropogenic contributing factors. For example, inundation around estuaries may occur due to coastal or catchment flooding, operating independently or due to a combination of both, derived from the same meteorological event (a coincident event). The interaction of catchment flooding and coastal processes is an important consideration in determining overall flood and inundation risk in coastal waterways.

Source: OEH (2018).

Coastal erosion from storm surges. J Turbill/DCCEEW

2. Overview of existing guidance on setting triggers and thresholds and its application for coastal hazards

2.1 Overview of guidance from other jurisdictions

Conceptual approaches and practices related to setting triggers and thresholds as part of coastal and other natural hazard planning are relatively recent but not new.

Internationally, one of the earliest case studies using trigger-based approaches to natural hazard risk was the United Kingdom (UK) Environment Agency in association with developing a long-term tidal flood risk management plan for London and the Thames Estuary (Environment Agency 2009). Similar trigger-based approaches have also been developed in the context of climate change adaptation by the City of New York (Bloomberg et al. 2010), as part of the climate adaptation strategy for Greater London (London Assembly 2011) and as part of 'adaptation paths' to support flood management in the Netherlands (Deltares n.d.).

Domestically, trigger-based approaches in coastal management have been considered in New South Wales through current and previous coastal zone and estuary management plans and programs, and similarly interstate within various coastal management frameworks and strategies prepared by other Australian states and territories.

This section of the guidance provides an overview of existing and well-documented guidelines that explore setting triggers and thresholds specifically for coastal management. This includes documentation published by the New Zealand Government, and the state governments of Queensland and Western Australia.

2.1.1 New Zealand

New Zealand has adopted a dynamic adaptive policy pathways approach as part of its national guidance to local governments on coastal hazards and climate change (Ministry for Environment 2017). The approach draws on an adaptation policy model developed by Deltares in the Netherlands and further refined as shown in Figure 2 (reproduced from Ministry for Environment 2017).

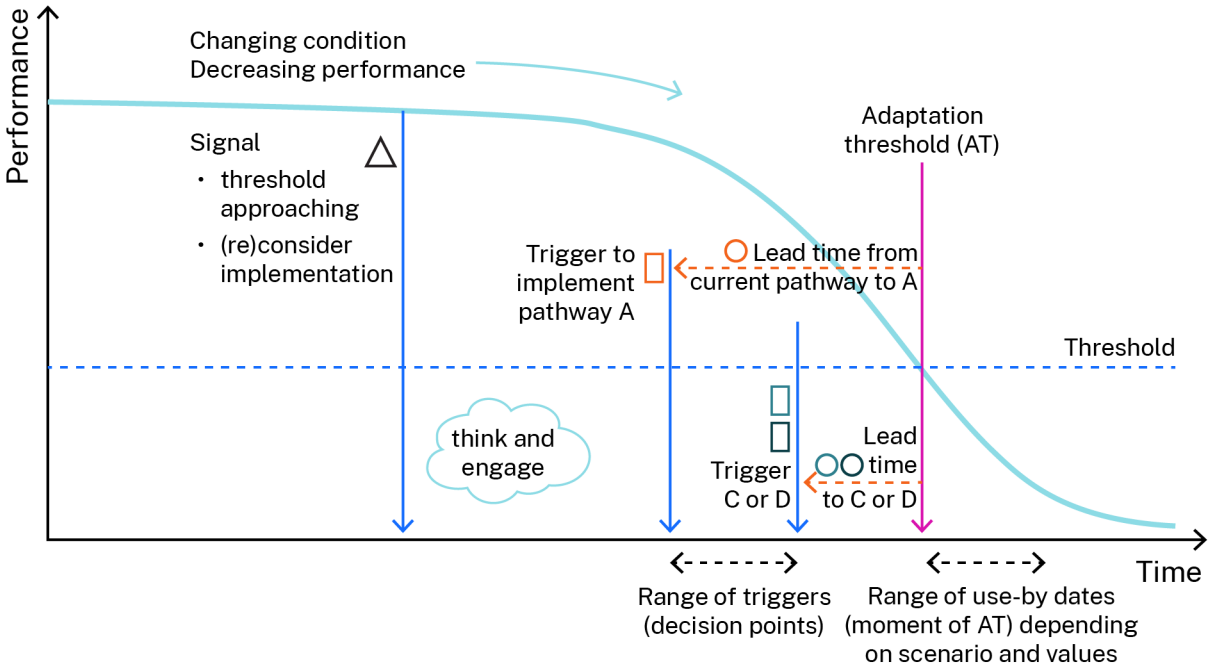

Figure 2 **New Zealand dynamic adaptive policy pathways approach, including signals and triggers (decision points) up to an adaptation threshold (Source: Ministry for the Environment 2017)**

The dynamic adaptive policy pathways approach incorporates the concept of changing conditions or decreasing performance (shown in the **sloping cyan line** on Figure 2) that approaches a predetermined threshold level (shown by the **dotted blue** line). The intersection of the trajectory line with the threshold line represents the adaptation threshold or 'AT' (shown as the **vertical pink line**), which signals the implementation of adaptation actions. Along the way are a series of adaptation strategy pathways each of which can have defined trigger points. This alludes to an important concept that there may be multiple adaptation pathways that a coastal manager or decision-maker wants to consider before reaching the adaptation threshold — each of which should be tracked over time.

Figure 3 (reproduced from Ministry for the Environment 2017) shows an example of an adaptation pathways map. Similar to a metro train map, the adaptation pathways map presents alternative routes for getting to the same point (that is, an objective or desired outcome) in the future.

Under this approach, adaptation trigger points (shown as squares) are preceded by adaptation signals (shown as triangles). Circles in the diagram (equivalent to train stations) represent the start or transfer points to a new action or pathway shown as the coloured horizontal lines that moves through time. Ultimate thresholds are shown as vertical dashes and represent 'the end of the line' in terms of tolerable risk and/or effectiveness of actions.

The metro train map approach is useful to show a range of adaptation strategies and how they potentially interrelate as a tool to track adaptation over time.

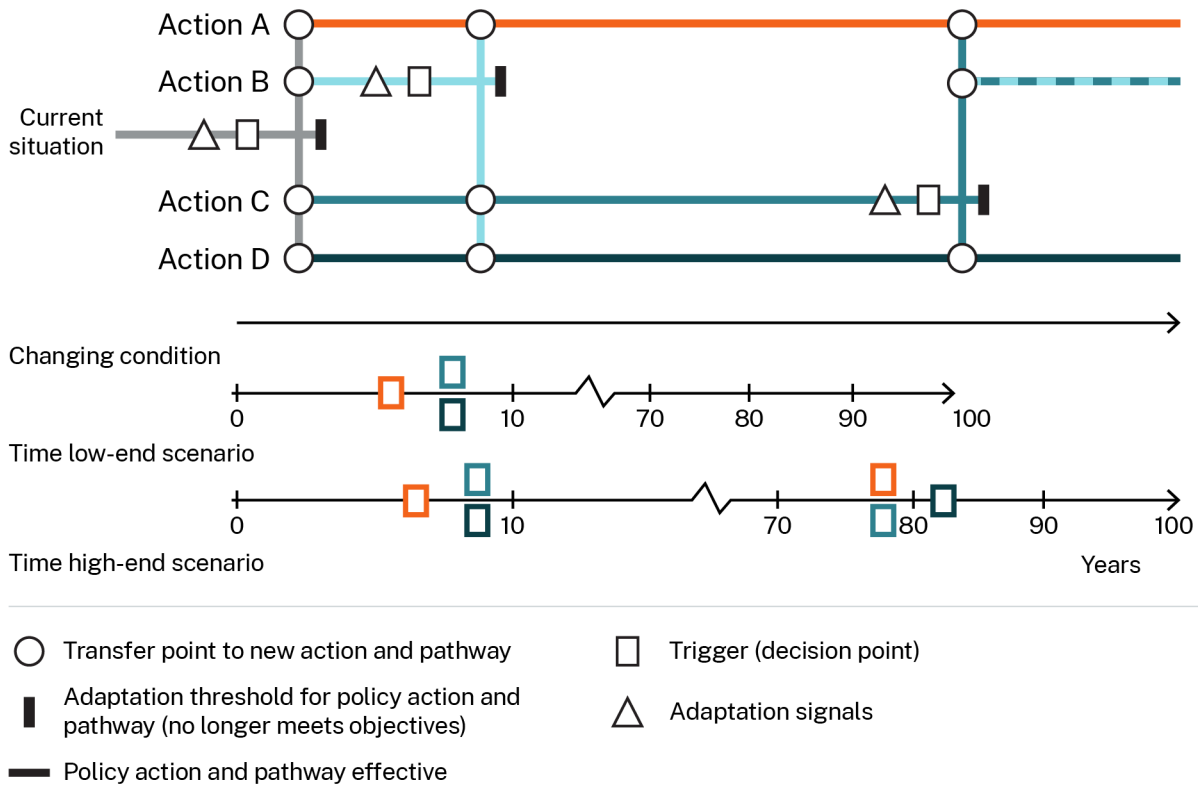

Figure 3 **New Zealand example adaptation pathways map (Source: Ministry for the Environment 2017)**

2.1.2 Queensland

As part of guidance on minimum standards for coastal hazard adaptation strategies [CHAS] under the QCoast 2100 program, the Local Government Association of Queensland (LGAQ 2016) reproduced a trigger framework 'continuum' (see Figure 4) originally developed by Fisk and Kay (2010).

The continuum model represents a more simplified version of the New Zealand dynamic adaptive policy pathways approach shown above. However, it shares common themes around setting an adaptation threshold based on an unacceptable or intolerable risk, and then working back to set trigger points for action implementation to ensure this undesirable end point is avoided or minimised.

The continuum model is based around an understanding that if flexible adaptation (as opposed to inflexible adaptation, maladaptation or no adaptation) is pursued, then risk can potentially be kept below or otherwise never reach the unacceptable level.

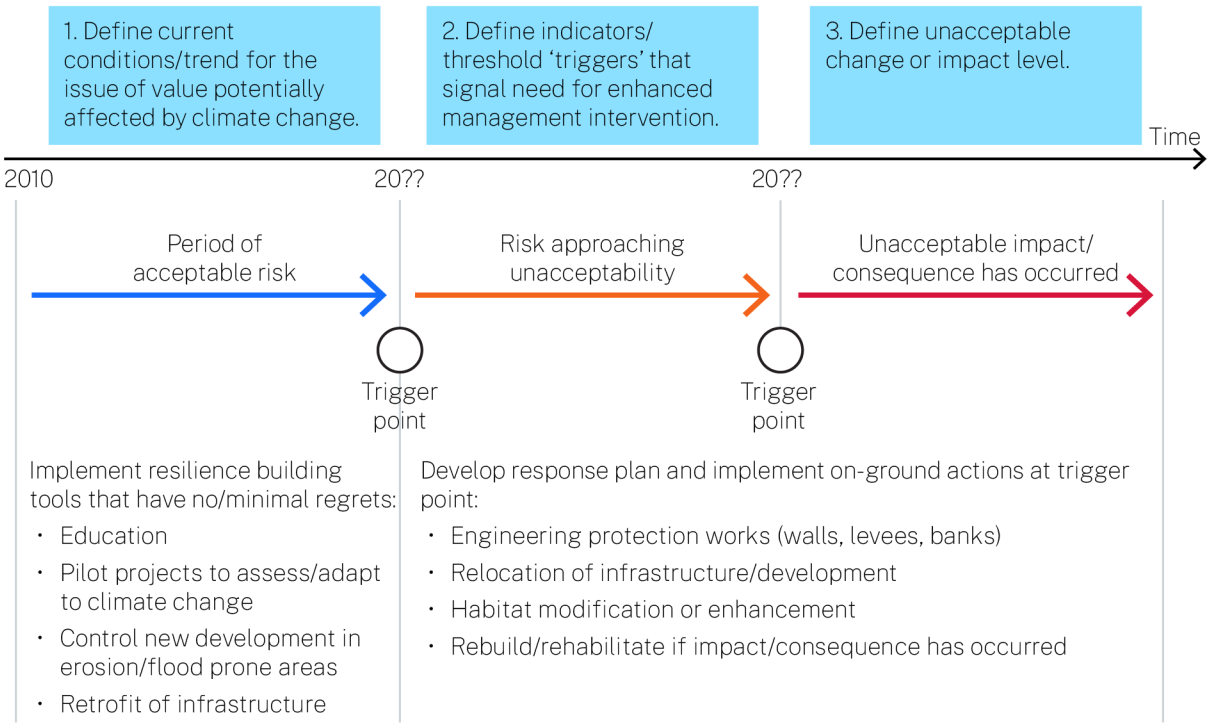

Figure 4 **Queensland continuum model for adaptation pathways (Source: Fisk and Kay 2010, reproduced in LGAQ 2016)**

The continuum model also incorporates an important distinction around the lead time that may be required to implement adaptation actions after a trigger point is breached or a threshold is exceeded. During the period of acceptable risk (shown as **blue arrow** in Figure 4), no regrets or low-cost resilience building actions may be sufficient to address coastal hazards. But as the risks become greater and the threshold of unacceptable impact becomes clearer over time, the adaptation response is likely to be more complex, costly and contested.

During this period where the risk is approaching unacceptability (but where the unacceptable impact has not yet occurred) shown as **orange arrow** on Figure 4, there needs to be sufficient lead time for the coastal manager or decision-maker to seek increased public involvement and consultation in review of potential solutions, to undertake a detailed design and/or cost evaluation of a particular solution or options, acquiring land or similar — all of which will take time before action can be instigated to control the risk. In this way, having a trigger 'to plan' and then a second trigger 'to act' may be warranted if the decision is significant, difficult or contentious (such as a decision to protect a coastal community with a protection structure or a managed retreat strategy).

2.1.3 Western Australia

The Western Australian (WA) Government has re-issued its *Coastal hazard risk management and adaptation planning guidelines* (DPLH 2019) to support the *State Planning Policy 2.6 – Coastal Planning*, which provides for the long-term sustainability of Western Australia's coast.

The WA risk and adaptation trigger model (as shown in Table 2 below), adopts a more tabular approach to setting pathways and triggers. It defines an adaptation toolbox related to the class of coastal asset being managed, for example, undeveloped land, minor public works, major public works, private land, and public beaches and dunes. It then relates the pathways and triggers to particular timeframes, which can be inferred to be representations of short term (up to 2030), medium term (up to 2070), long term (up to 2120) and beyond (2120+).

In the WA model, the adaptation pathway is essentially a planning and development performance outcome (for example, keep land undeveloped), with the trigger acting as either an 'acceptable solution' or else a specific threshold for action (for example, if a property lies seaward of the 100-year erosion hazard this is a trigger to instigate the 'planning for managing retreat' pathway).

Many pathways and triggers are not time-bound in the example presented in the model in Table 2, although it does illustrate a sequential approach (similar to the LGAQ model) that could be employed. For example, it sets out that 'dune care and beach nourishment' should be used to manage erosion in the short term (up to 2030), followed by protection strategies (up to 2100), and then ultimately moving to removal and relocation of assets in the longer-term timeframe (2100+).

It is worth noting that this tabular approach in the WA guideline brings a whole range of concepts together into a single framework (essentially a 'plan on a page') and provides a further point of difference by seeking to sort pathways and triggers into the different asset classes that typically occur across coastal hazard areas or zones.

The codes in Table 2 relate to a trigger (T) and an associated decision and management action. For example, T5 refers to assets damaged, destroyed or unsafe due to coastal erosion, monitored by public, camera and inspections with a potential measure to remove assets and relocation to less hazardous areas if possible. Further explanation of each trigger is in the WA guide (DPLG 2019) Table 19.

Table 2 **Western Australia risk management pathway including triggers, decision-making and measures**

Planning timeframe	2015–2030	2030–2070	2070–2120	2120–future
Assets	**Undeveloped land**			
Pathway	Avoid development			
Trigger(s)	Undeveloped land lies within hazard extents (T10)			
Assets	**Minor public infrastructure and residential property**			
Pathway	Leave unprotected/repair, remove/relocate (Managed retreat)			
Trigger(s)	Asset damages (T5)			
Pathway	Emergency plans and controls (Accommodate)			
Trigger(s)	Horizontal shoreline datum (HSD) within 1%AEP Storm Erosion setback distance (T1)			
Assets	**Major public infrastructure and residential property**			
Pathway	Planning controls, emergency plans and controls (Accommodate)			
Trigger(s)	HSD within S1 distance (T1), Property lies seaward of 100-year erosion hazard (T4)			
Pathway	Planning for managed retreat			
Trigger(s)	Property lies seaward of 100-year erosion hazard (T4), Assets predicted to be vulnerable in 15-20 years (T5)			
Pathway	Dune care/sand management, beach nourishment (Protect)	Protect (Planned retreat)		Remove/relocate (managed retreat)
		Remove/relocate (Managed retreat)		
Trigger(s)	Diminished beach and foreshore reserve (T9)	Tigger number: T1, T7, T8, T9		T1, T2, T3, T5, T7, T8, T9
		T1, T2, T3, T5, T7, T8, T9		
Assets	**Beach and dunes**			
Pathway	Dune care/sand management, beach nourishment			
Trigger(s)	Diminished beach and foreshore reserve			

Source: Cardno (2018, reproduced in DPLH 2019, Table 20).

2.2 Trigger and threshold indicators

There are a wide range of triggers and thresholds that can be set by coastal managers and decision-makers to monitor and then act in relation to coastal hazards.

In synthesising this information, Table 3 sets out examples of trigger and threshold indicators that could be considered for treating risks from the different coastal hazards in New South Wales as identified in the Coastal Management Act. It should be noted that this is not an exhaustive list of all possible triggers and thresholds and that not all indicators will be relevant to all circumstances.

These trigger indicators should also be considered in relation to a timeframe for their measurement, noting that many of these triggers will be influenced by both acute (for example, increased storminess) as well as chronic (for example, sea level rise) impacts under climate change given their impacts on the coastal zone.

Other triggers could also include financial related triggers, such as when a current action, or repair or maintenance of an existing structure becomes cost prohibitive to continue.

The Basin Campground, Ku-ring-gai Chase National Park. Photo: J Spencer/DCCEEW

Table 3 Examples of trigger/threshold indicators by coastal hazard type

Hazard type	Trigger/Threshold indicators	Notes/Commentary
Beach erosion	Width/buffer from an asset[1] to the midpoint/toe of frontal dune, storm bite/erosion scarp or dune vegetation line Width/buffer from an asset[1] to the midpoint/toe of frontal dune 12 months[2] post a defined erosion event[3] Condition/functionality of any defence structure[4] built for erosion Condition/functionality of any access way or access structure to the beach or foreshore Loss of beach amenity, environmental value, recreational value or tourism use[5]	1. Asset could be defined as, for example: a. essential infrastructure – such as sewage pump stations or roads b. other public assets such as a surf club building c. privately owned built assets such as homes. 2. '12 months' (or another time period) can be selected here to ensure that the erosion has a long-term effect and is not reflecting an outlier or one-off event. 3. 'Event' could be defined as a particular magnitude of storm event or something more observational such as where a buried revetment is exposed. 4. 'Defence structure' could include, for example, a seawall. 5. Beach amenity/use value would need to be considered on a beach-by-beach basis. This could include natural (habitat) or social (recreation) values; or a tourism value such as the ability of a beach to host a specific tourism event or activity (based on required width).
Shoreline recession	Position of an asset relative to a defined distance[6] from a (likely) coastal hazard line (current + 'x' years), where x = proposed or expected remaining practical life of asset Encroachment of shoreline on or distance between shoreline and high value ecosystems/habitat (e.g. incipient foredune, wetlands, littoral rainforest)	6. Distance could be within 'x lineal m', or at the time an asset, ecosystem or habitat is impacted (depending on the type of asset). Note that this trigger would likely be initiated or need to be reviewed by periodic redefinition of the hazard line.

Hazard type	Trigger/Threshold indicators	Notes/Commentary
	Ability of beach to continue to provide particular recreation or tourism uses (based on beach presence/width) Cost-based threshold based on the cost of beach nourishment/replenishment to maintain beach presence/width	In applying this trigger to existing or future development, consideration would need to be given to the asset's practical design life (in relation to the future hazard line) and the extent to which the asset is temporary, sacrificial or relocatable.
Coastal lake or water course entrance instability	Proximity/buffer distance[7] to a physical asset measured from the centreline[8] of the entrance channel Cost-based threshold based on the cost of works to stabilise or maintain a lake or water course entrance	7. In determining an appropriate distance, the risk to be managed is that significant sediment transport and/or erosion within the entrance area could threaten assets located within proximity of the entrance. 8. A channel centreline may be difficult to measure without a survey. The width of the mouth/entrance and/or patterns of historical migration may be easier to measure from historical imagery. For trained entrances this could also include scour and geotechnical assessments.
Coastal inundation (short-term storm tide flood impact)	Minimum vertical difference[9] between elevation of asset and peak inundation level Frequency of occurrence of vertical difference between elevation of asset and peak inundation level within a defined level Width/buffer to an asset measured from the horizontal inundation extent or wave runup[10] Wave runup is affecting safe access to public land, such as council reserves at the back of the beach and beach access ways	9. Minimum vertical difference could also be expressed as a 'minimum freeboard allowance' or similar to ensure consistency with approaches to flood inundation. 10. When considering use of wave runup as a trigger, consideration will also need to be given to a tidal datum (e.g. wave runup at low tide).

Hazard type	Trigger/Threshold indicators	Notes/Commentary
	Condition/functionality of any defence structure built for controlling inundation (or wave runup) and associated replacement cost or cost of maintenance	
Tidal inundation (long term)	As per coastal inundation but based on impact from longer term tidal inundation impacts[11]: • current or future extent of inundation • depth of tidal inundation (above ground level) • frequency of inundation • duration of inundation • condition/functionality of any defence structure built for controlling tidal inundation Position of an asset relative to a defined (likely) tidal inundation line (current + x years), where x = expected remaining practical life of asset Frequency/severity of inundation on high value ecosystems/habitat (e.g. wetland, freshwater lakes, littoral rainforest) Cost-based threshold based on the cost of defending assets against long-term inundation (could be based on replacement cost or maintenance cost)	11. The overarching trigger here will likely be observed sea level rise, and its relationship to tidal inundation on a subject land or area. This can include future tidal water extent, frequency and duration of inundation. Assessments need to forecast these impacts and link them back to different sea level rise projections, for example based on relevant representative concentration pathways (RCPs) or shared socioeconomic pathways (SSPs) related to climate change set out in IPCC assessment reports (see IPCC 2021) and/or downscaled climate projections (in NSW refer the NSW and Australian Regional Climate Modelling [NARCliM] dataset).
Coastal cliff or slope instability	Long-term indicators[12] for stability: • width/buffer to top of dune or cliff • movement in land as detected by cracks (> x mm) within masonry structures or within overlying soil strata • incidence of landslides, erosion or landslip events • material changes to topography of cliff face	12. The indicators presented for cliff or slope instability are split between longer term indicators (that can be assessed and measured over time) and short-term indicators which would be more observable following specific events or as part of more regular (periodic) monitoring.

Hazard type	Trigger/Threshold indicators	Notes/Commentary
	• material changes to drainage channels and drainage mechanisms on or near the cliff face • loss of vegetation from cliff or slope face Short-term indicators[12] for stability: • open cracks, or steps, along contours • observed groundwater seepage, or springs • bulging in the lower part of the slope • trees leaning down slope, or with exposed roots • debris/fallen rocks at the foot of a cliff • tilted power poles or fences • cracked or distorted structures. Cost-based threshold based on the cost of stabilisation or other remediation works to prevent cliff or slope instability	
Erosion and inundation caused by tidal water and waves, including the interaction of those waters with catchment floodwaters (e.g. coincident events of compound flooding)	Largely covered by a combination of the above trigger indicators but with specific consideration of: • incidence and frequency of coincident flooding events based on a probabilistic assessment[13] Extent of areas or assets affected by flooding not identified in either flood hazard or coastal hazard mapping[14]	13. Triggers should be based on the outcomes of specific assessments such as a probabilistic hazard and damages assessment (PHA) to determine the probability of overland or river/lake flooding together with ocean flooding. 14. Larger compound flooding events may affect areas and locations that are not mapped as hazard zones in either flooding or storm tide mapping layers. Within existing hazard areas, larger compound flooding events may increase the depth of inundation, velocity of flood flows and duration of flood inundation.

Notes:

IPCC = Intergovernmental Panel on Climate Change (IPCC); NARCLiM = NSW and Australian Regional Climate Modelling.

2.3 General considerations around setting triggers and thresholds

While Table 3 provides guidance around the types of triggers and thresholds that could be set for each coastal hazard, there are also some general considerations for coastal managers and decision-makers to evaluate when setting triggers or threshold values and their implications.

These considerations are outlined below and include:

- process for investigating exceedances
- differentiating a trajectory of impact versus natural variability
- physical versus time-based triggers
- employing a stepwise trigger approach
- signalling and communicating intent
- considering resourcing implications.

2.3.1 Process for investigating exceedances

In setting thresholds, consideration should be given to how a coastal manager or other management entity would be able to measure and confirm the exceedance, and the extent to which the exceedance is attributable to the coastal hazard and not some other factor or combination of factors.

Investigations can range from review of monitoring information through to a detailed site visit and observations; but should also consider impacts and attributes of surrounding sites. For example, if a trigger is set based on potential damage from a coastal hazard on a structure, consideration would need to be given to the event that caused the damage, the design specification of the infrastructure on the site, and the condition of neighbouring areas or structures to confirm they also experienced damage or impact.

2.3.2 Differentiating a trajectory of impact versus natural variability

When dealing with impacts associated with climate change, it may also be important for triggers to differentiate between what is a one-off acute event versus what constitutes a trajectory of longer term impact or change. This can usually be addressed through adding a temporal component to triggers, for example, basing the trigger on an average or median value defined over a period of time or setting a trigger that is measured after a defined period of time, say after 6 to 12 months. However, care should be taken to avoid triggers that require significant hindcasting or rolling averages as they can preclude the proactive implementation of corrective actions before an intolerable risk or event has occurred.

2.3.3 Physical versus time-based triggers

As outlined already, physical rather than time-based triggers are preferable as they are based on actual events that can be measured and validated rather than uncertain predictions. However, as outlined above, a time-based component embedded within a

physical trigger may need to be considered to ensure that triggers are not responding to one-off or outlier events. They can also help to effectively distinguish impact from natural variability, for example, a one-off storm erosion event versus an underlying shoreline recession trend.

2.3.4 Employing a stepwise trigger approach

Depending on the context and nature of coastal hazard, triggers can be developed using a 'stepwise' or hierarchical approach. A stepwise approach will generally employ 3 types of triggers:

1. **Early warning/investigation triggers** – these are triggers for coastal hazards that are set to capture an acute event, or at the early stages of the formation of a potential trajectory of chronic impact. Early warning triggers should be designed to be observable well before a management action(s) needs to be taken. They should generally accord with some level of investigation by a coastal manager that determines the cause and significance of the event and/or context of impact that has been observed. Investigation triggers do not necessitate a coastal manager or decision-maker taking immediate action; but they may precipitate increasing monitoring (for example, to keep a watching brief) or to implement low regret/cost actions.
2. **Management action triggers** – these are clearly observable impacts where the coastal manager or decision-maker needs to implement some form of action or intervention, but still has time to do so before an impact trigger (see below) is reached. The concept here being that the coastal manager may be able to avoid or otherwise mitigate an impact trigger from occurring through action(s) implemented as a result of the management action trigger exceedance. For cumulative or chronic impacts, the timing associated with the management action triggers should precede the impact trigger level in order to allow the coastal manager time to determine and then implement the best course of action to avoid or reduce the impact from occurring. For more complex interventions, such as construction of coastal protection structures, this lag may be significant so that structures can be designed, approved and constructed prior to the impact trigger being reached.
3. **Impact triggers** – these generally relate to the intolerable risk threshold or else a definition of the significant impact from the coastal hazard that is trying to be avoided. The impact trigger would occur after thresholds associated with early warning and management action triggers have been exceeded. While impact triggers may also precipitate specific management actions or responses, such as disaster recovery, it would be assumed that impact trigger actions would be more significant than earlier trigger points, such as a decision to implement a scheme of protection works or implementing a planned retreat process.

A stepwise trigger approach works particularly well as part of local area adaptation planning approaches, such as for a particular beach compartment or estuary. At this scale, specific trigger values can be more readily observed and measured over time, and management actions can be implemented, tracked and communicated to the local community.

2.3.5 Signalling and communicating intent

Clear communication during the adaptive management process can help reduce resistance and prepare the community for change, by linking management decisions to evidence that agreed thresholds have been met. Triggers and proposed management responses can sometimes be controversial and community members may have different views about where the trigger should be set and the 'best' responses. As such, engagement is necessary to identify all views to achieve an acceptable balance.

The preferred adaptive pathway(s) may be specified in advance, for example, when a certain threshold is passed the relevant management entity is committed to implement a predetermined management response. Or they may be left open and subject to a review closer to a time when a threshold is approaching, but should always allow an appropriate lead time determine the most appropriate or preferred response.

For these approaches to be effective, some level of continuity of management responsibility is required, to enable changes in the risk to be monitored and for intervention to occur as triggers are reached.

However, it will always be important to identify and communicate:

- when affected owners or the community will be notified that a change of management may be required
- when to start preparing for a new management response, allowing sufficient lead time for analysis, design, consultation and allocating funding
- an indication of when the new management response will or may be implemented and how it is intended to be funded.

Coastal erosion management, Kingscliff Beach. Photo: P Davies/DCCEEW

2.3.6 Considering resourcing implications

Where exceeding a threshold is likely to have significant resourcing implications, it may be important to consider its likely occurrence within resourcing strategy and delivery program review cycles. In particular, triggers may be useful to recognise and take into account the lead time needed to work through complex cost-sharing arrangements between governments and stakeholders, and to allow for an appropriate amount of time for funding to be considered as part of future budget cycles.

In determining resource implications, consideration can also be given to the potential cost of inaction, that is, the cost of not taking action in response to the trigger exceedance. This approach can highlight a 'value proposition' to decision-makers around the higher costs associated with damage and recovery post-event compared to the cost of the trigger response action that is designed to avoid or minimise the hazard impact.

2.4 Trigger action/response pathways and approaches

2.4.1 Overview of strategic risk management approaches

As outlined earlier, an adaptation pathways approach accepts that there are a sequence of management actions and/or adaptation options, as well as decision points, that are intended to be tracked over time. On this basis, it is critical to proactively understand what tools may be available to inform planning and decision-making once a threshold is exceeded, as opposed to simply waiting for the impact to occur and then reacting.

The *coastal management manual* notes and endorses a strategic risk management approach for coastal vulnerability areas where coastal hazards are present, as illustrated in Figure 5. The application of the manual's risk framework is further extended upon in the guidance, in considering its application across all 4 coastal management areas (coastal wetland and littoral rainforest, coastal vulnerability, coastal environment, and coastal use). This guidance also incorporates concepts from other recognised planning hierarchies, including avoid, minimise, mitigate from a planning and environment context, and protect, accommodate, retreat from a coastal management context.

The approach seeks to 'reduce risk and create opportunities' through consideration of a mix of prospective actions and activities, which include:

- alert – through implementation of low regret and/or best practice actions including communication of risks to communities
- avoid risk – through land-use planning, siting and design
- active intervention – minimising or reducing risk through coastal protection works and potentially through upgrades of existing designs and approaches
- planning for change – through relocation of assets and taking opportunities to build back better to withstand hazards through redevelopment
- emergency response – principally through the provisions of a coastal emergency action subplan.

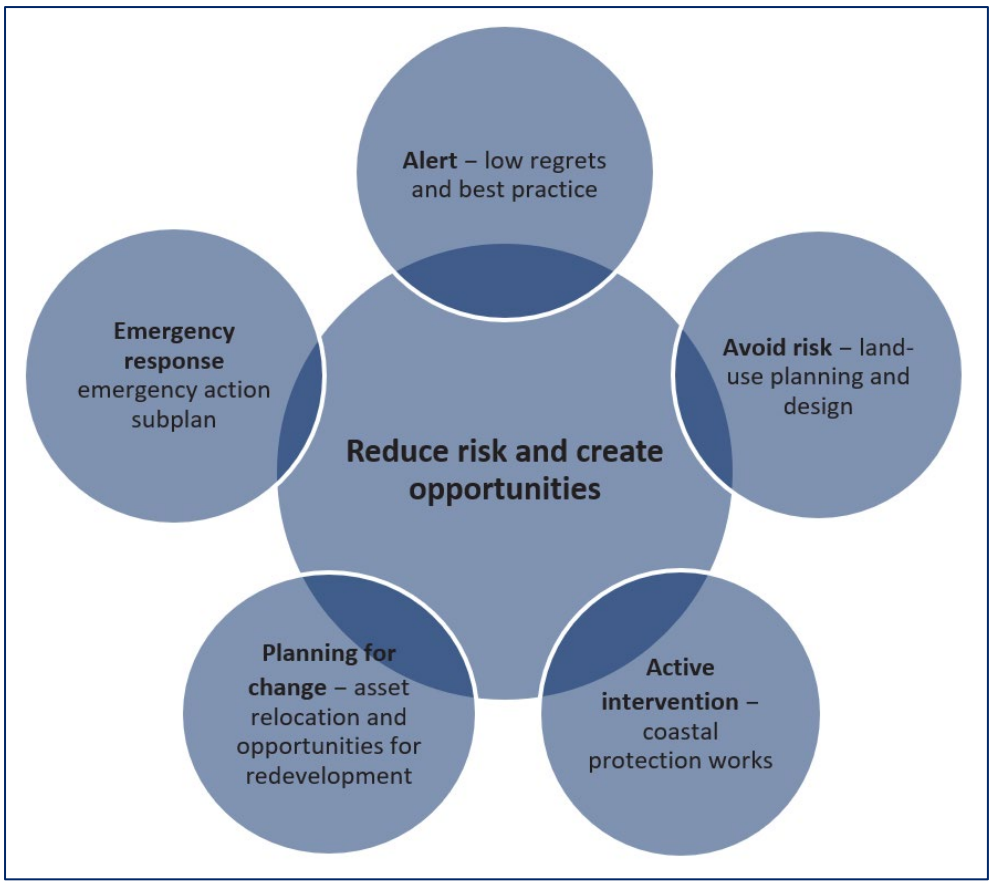

Figure 5 **Strategic risk management approach (Source: OEH 2018b)**

2.4.2 Potential actions to 'alert' risk

Triggers and thresholds related to 'alert' action responses should be, by their nature, related to low regret actions, including actions to communicate risk. In a coastal hazard context, responses to alert triggers could include the following actions (in no particular order of importance):

- implementing a baseline monitoring program or applied monitoring and observation program in a specific area in response to a coastal hazard trigger being exceeded
- implementing site-based investigations following a hazard impact or consequence set by a trigger
- implementing increased public education (signage, information sheets, notifications, automated texts and alerts) in response to a coastal hazard trigger being exceeded
- implementing (or amending) a disaster management and emergency management plan following an event or coastal hazard trigger being exceeded
- ensuring planning certificates are updated and/or other forms of notification are made following the review of hazard information or following major events to inform property owners of current or future risk (see also Section 3.6)

- undertaking targeted research programs or investigations around the likelihood and consequence of coastal hazards and adaptation options for a particular site or locality following a coastal hazard trigger exceedance
- undertaking a more detailed assessment of options in response to a coastal hazard trigger exceedance, including for example investigating sand sources for future nourishment, developing a concept design for coastal protection schemes, and implementing dune management or improvement works
- investigating insurance coverage for assets following a coastal hazard event or trigger exceedance (coverage, extent or value of coverage, premiums and affordability, claim history, ability to redesign or improve designs under current insurance provisions). While hazards covered by 'acts of the sea' are generally not covered by insurance schemes, in some cases premium cover may be available for 'storm damage' under certain circumstances.

2.4.3 Potential actions to 'avoid' risk

Triggers that precipitate changes or amendments to planning instruments are examples of where actions to 'avoid' risk can be implemented.

Some examples of management responses to 'avoid' triggers could include:

- setting triggers to change or update local planning instruments (and associated mapping) in relation to reviews and updates to mapped coastal hazard and associated vulnerability areas as part of coastal management studies and periodically as part of CMP reviews
- changing design requirements or acceptable solutions in a planning instrument for assessing new development or works in an area in relation to a coastal hazard trigger being exceeded, such as:
  - requiring raising erosion protection or levee structures
  - requiring higher design fill levels, piled foundations or relocatable development
  - requiring emergency management plans or similar to be developed
- requiring changes to planning instruments to facilitate a managed retreat or realignment solution following a coastal hazard trigger level being exceeded.

In terms of prospective changes to zoning in relation to triggers, it should be noted that the *Local Planning Directions, Section 4.2 Coastal management* (DPHI 2023), provides overarching policy direction on the issue of rezoning and/or intensification of development if the subject land is identified within the coastal vulnerability area or otherwise identified as land affected by a current or future coastal hazard.

Direction 4.2(2), notes that:

> A planning proposal must not rezone land which would enable increased development or more intensive land-use on land:
>
> (a) within a coastal vulnerability area identified by chapter 2 of the *State Environmental Planning Policy (Resilience and Hazards) 2021*; or

(b) that has been identified as land affected by a current or future coastal hazard in a local environmental plan or development control plan, or a study or assessment undertaken:

i. by or on behalf of the relevant planning authority and the planning proposal authority, or

ii. by or on behalf of a public authority and provided to the relevant planning authority and the planning proposal authority.

Therefore, the fundamental 'trigger' for these provisions will be inclusion and reflection of updated coastal hazard mapping in local planning instruments, and ensuring these are periodically reviewed and amended to ensure risks from coastal hazards are avoided as far as practicable.

2.4.4 Potential 'active interventions'

'Active intervention' response actions are best aligned to triggers and thresholds because they tend to deal with response actions for existing development and/or assets.

Active intervention may include a range of possible actions along a continuum of:

- avoidance or minimisation of the risk — interventions that largely avoid or prevent the risk from occurring
- accommodation of the risk — interventions that provide protection up to a defined level of acceptable risk or for a defined period of time but that do not fully avoid the risk
- acceptance of risk — essentially no or minimal intervention and allowing coastal processes to occur unhindered.

As modern coastal management practice dictates, active intervention should not automatically default to hard engineering works, such as seawalls or revetments, and can include a broad range of potential solutions. Some of the management responses to an 'active intervention' trigger could include:

- nature-based solutions such as protecting and augmenting dunes, revegetating foreshore buffers or undertaking rehabilitation of natural coastal habitats such as mangrove, saltmarshes and salt-tolerant transitional vegetation
- beach nourishment via importation and placement of suitable sand on the beach, sand back-passing or bypassing
- hard engineering structures and works, for example, seawalls and groynes
- extending or expanding existing coastal protection structures, such as raising levee heights
- placing sand associated with any overburden from new development seaward of a declared coastal building line
- increasing buffers between existing structures and development and coastal hazards by relocating development landward as far as practicable on the current lot

- requiring upgrading or relocation of existing structures or development in an area following a coastal hazard trigger level being exceeded.

As discussed, active intervention triggers may also relate to a planned sequence of responses that can rely on set trigger points to be implemented over time. For example, a long-term management intervention strategy for a beach or estuary could involve a hierarchical combination of active interventions as shown in the example in Table 4, from initial monitoring, through to soft and hard engineering interventions, up to eventual relocation or retreat.

Table 4 Example long-term management intervention 'combination' table

Planning unit	Active intervention type	Trigger (examples)	Expected timing
Beach 'A'	Dune management and beach monitoring	Status quo: post-event monitoring with replenishment or re-profiling after damage	Now
	Instigate active beach nourishment regime	When the beach width or volume recedes to a defined level	Short term: 10-year planning horizon (i.e. 2030)
	Design and establish a coastal defence structure	Unable to meet defined width and volume of beach even with sand nourishment Nourishment becomes cost prohibitive	Medium term: 30 to 50-year planning horizon (i.e. 2050)
	Relocation of critical assets landward	Risk of loss of human life and/or property not tolerable with current defence structure Defence structure cannot be improved to avoid or accommodate hazard risk due to impacts to neighbouring areas Costs of maintaining or improving defence structure prohibitive	Long term: 80 to 100-year planning horizon (i.e. 2100)

2.4.5 Potential 'planning for change' actions

'Planning for change' triggers will represent more significant and/or complex responses to coastal hazard impacts. As outlined in the manual, these options are generally considered when mitigation and intervention measures are no longer technically feasible, financially viable or acceptable to the broader community.

Examples of where this situation may arise include where coastal recession or permanent tidal inundation is occurring and existing coastal assets, infrastructure, public safety, liveability and environmental values are being progressively lost or degraded, or lives are at risk.

These actions could include the following in relation to a coastal hazard trigger being exceeded:

- limiting the redevelopment and/or the acceptability of certain land uses in an area following a major coastal hazard event, or else implementing revised design standards to 'build back better'
- identifying areas not currently mapped in coastal hazard areas that are considered likely to be affected by longer term hazards like permanent inundation, and ensuring appropriate planning controls are considered to reduce future risk
- progressive acquisition of assets into public ownership and then leasing back to occupants for temporary use until hazards become intolerable (with lease conditions including cessation of occupancy based on a trigger condition or threshold)
- partial or strategic acquisition or buy back over time and repurposing to open space or a similar land use that does not have habitability or public safety concerns
- levying additional fees or rates for enhanced coastal protection works (if the constraint to additional protection is financial and/or the benefit is private)
- requiring habitation of a particular structure to be abandoned, removed or relocated following a coastal hazard trigger level being exceeded or if the trigger is following a specific hazard event, where it is not prudent or feasible to reconstruct and/or maintain the structure
- signalling that the provision of council services and infrastructure will be limited to or ceased on an area following a specific coastal hazard trigger being exceeded
- setting out a planned relocation or planned abandonment strategy or declaring buildings and development that will not be protected or renewed at the end of their design life (sacrificial development).

As shown in the example in Table 4, when employ planning for long-term change strategies it is best appropriated when it precedes a staged intervention approach that moves from accommodation and protection to long-term relocation or realignment strategies over time, once a predetermined and critical threshold has been reached.

Where temporary or time-limited development is proposed, the manual reaffirms the importance of having a clear plan for implementation, developed with and understood by the community.

Having clearly defined steps, thresholds and stages towards the removal or relocation of temporary development will assist community understanding and acceptance of the approach and assist to reduce socioeconomic impacts.

2.4.6 Potential 'emergency response' actions

The *Guideline for preparing a coastal zone emergency action subplan* (DPIE 2019) sets out a tiered approach to possible emergency response actions under the headings of Prevention, Preparation, Response and Recovery as illustrated in Figure 6.

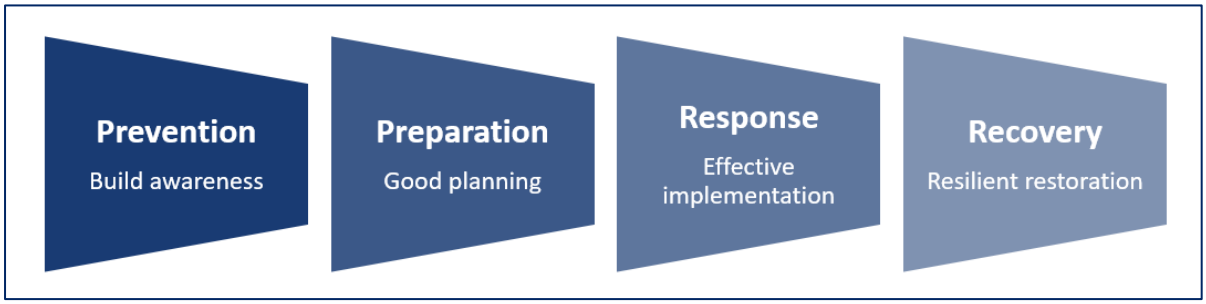

Figure 6 Emergency response in a coastal management context (Source: DPIE 2019)

While any or all of the actions listed in the CZEAS guidelines are potentially relevant to consider in the context of triggers and thresholds, the most applicable would be **Response** actions, which have been reproduced in the box below.

These Response actions correspond with emergency actions generally taken immediately before, during or immediately after an acute coastal hazard event.

Table 5 provides an example of the coastal emergency actions to be undertaken through the 4 phases of emergency response, which apply to the locations at risk along the Kiama coastline, as part of the Kiama CMP (2024).

Phase 3 – Response

Response actions may include:

- Implement the communication protocol in conjunction with the combat agency (NSW State Emergency Service) to advise landowners, residents, public authorities and other organisations that a coastal emergency is likely or is occurring and that actions in the CZEAS are to be implemented.
- Alert land managers about access requirements.
- Increase surveillance of beach erosion and inundation hazards.
- Place appropriate equipment on stand-by.
- Install emergency coastal protection works to address beach erosion, coastal inundation or cliff instability, in compliance with the Coastal Management Act and State Environmental Planning Policy (Resilience and Hazards). These works include the placement of sand or sandbags (which must be removed in accordance with timing as specified in the State Environmental Planning Policy [Resilience and Hazards]) on a beach or sand dune adjacent to a beach:
    - the council is the lead agency for this work, the NSW State Emergency Service (SES) may assist with coordination
    - works must only be implemented when it is safe to do so.
- Install emergency works for coastal emergencies that may arise without the presence of storm conditions, such as beach erosion and inundation associated with high water level anomalies that are not storm driven (extreme or irregular events).
- Install temporary fencing and/or signage on council-managed land (e.g. foreshore reserves and beach access ways) affected by beach erosion, coastal inundation or cliff instability resulting from major storm activity or an extreme or irregular event, where this has resulted from unsafe conditions.
- Close council-managed roads affected by beach erosion, coastal inundation or cliff instability hazards. Liaise with other agencies (e.g. Roads and Maritime Services, Crown Lands in New South Wales, NSW National Parks and Wildlife Service) if debris from coastal hazards creates a safety hazard in adjoining areas (or liaise with road owners to enable closure).
- Close water and sewer infrastructure affected by beach erosion, coastal inundation or cliff instability hazards (or liaise with asset owners to enable shut down).

(Source: DPIE 2019, Table 2)

Table 5 Kiama coastline CZEAS emergency response actions

Prevention Actions	Responsibility	Trigger	Relevant Locations
Assess threats to life and property arising from a coastal emergency through the CMP process. Make the public aware of the hazards and risks and intended erosion emergency responses through publication of the Kiama Coastline CMP and this CZEAS, and associated education campaigns.	NSW SES and council	CZEAS and CMP finalisation and further updates	All locations
Preparation Actions	**Responsibility**	**Trigger**	**Relevant Locations**
Monitor conditions during events to assess whether triggers are reached that will activate the Response Phase.	NSW SES, BOM and council	Severe Weather Warnings declared	All locations
Response Actions	**Responsibility**	**Trigger**	**Relevant Locations**
Undertake Emergency Coastal Protection Works by placement of sand bags as protective barrier. Sand bags be filled to only two-thirds of their capacity and under no circumstance should they be overfilled. This allows for overlap, which assists in locking sand bags together. Where possible, sand bags to be placed stretcher-bond style, or alternatively can be placed randomly at the toe of the scarp or asset under threat. Emergency coastal protection works are to be placed in consultation with a suitably qualified coastal or geotechnical engineer. Works to be carried out only if safe to do so. Plant and equipment should access the works area from the closest suitable beach access pathway, avoiding disturbance to surrounding areas, in particular to any dune vegetation.	Council	Erosion scarp (>0.8m) within 5 metres of asset. With respect to the Black Beach promenade seawall, undermining of structure, or visible signs of wall movement, such as cracking in the façade.	Locations at risk as identified in Table 3.1, and by textboxes inside Figure 3.1, in particular structures along Surf, Kendalls and Easts Beach, as well as the Black Beach promenade seawall

Prevention Actions	Responsibility	Trigger	Relevant Locations
Recovery Actions	**Responsibility**	**Trigger**	**Relevant Locations**
Remove emergency coastal protection works once the beach has sufficiently recovered, or within 90 days of installation, whichever the sooner.	Council	90 days following installation of emergency coastal protection works or following beach recovery	Where emergency coastal protection works have been established

(Source: Kiama coastline CMP 2024, Table 5.1 to Table 5.4)

2.5 Evaluating the implications of various actions

When setting triggers and deciding on actions, coastal managers and decision-makers need to consider various factors related to the local context and the short-term and long-term effects of different adaptation strategies. This process is often called 'stress testing' (see Ministry for the Environment 2017).

Based on general guidance used in other jurisdictions, Table 6 provides a checklist tool for typical 'stress test' considerations for evaluating the implications of response actions depending on whether they are critically important, somewhat important or not important. Consideration of these matters can be an important step in setting the 'right' trigger or threshold for the context.

Table 6 Checklist tool for review of response actions that result from exceedance of triggers and thresholds

Consideration	Description	Critically important	Somewhat important	Not important
Flexibility	Is the response action precipitated by the trigger or threshold able to be adjusted with minimum transfer cost to other options, or the same option adjusted?	Y/N	Y/N	Y/N
Path dependency	Does the response action result in lock-in and/or path dependency that reduces or removes future flexibility in decision-making? Does the response action lock-in a chain of events that could lead to maladaptation or other externalities?	Y/N	Y/N	Y/N
Feasibility of implementation	Is the response action feasible in terms of approvability, constructability, reliance on current technology, reliance on materials (e.g. sand sources for nourishment)?	Y/N	Y/N	Y/N
Flow-on implications on essential services	Does the response action affect interdependencies between service-related infrastructure and development that is reliant on it (e.g. roads, water supply and sewerage systems)?	Y/N	Y/N	Y/N
Ability to meet community values and provide co-benefits	How is the response action likely to be received or perceived by the community? Are there co-benefits associated with the response action such as enhanced	Y/N	Y/N	Y/N

Consideration	Description	Critically important	Somewhat important	Not important
	social, economic or environmental benefits?			
Environmental and social effects	Are the environmental or social effects or impacts of the response action acceptable or approvable by regulatory agencies?	Y/N	Y/N	Y/N
Sensitivity to compounding impacts	Is the response action sensitive to or could it otherwise be compromised by compounding, additive or cumulative impacts?	Y/N	Y/N	Y/N
Uncertainty of climate	Has the expected performance of the response action been assessed against a range of climate change scenarios?	Y/N	Y/N	Y/N
Sensitivity to discount rate	The discount rate refers to the rate of interest that is applied to future cash flows of an investment to calculate its present value. In this context, is the response action sensitive to a change in the discount rate? Can the future cost of the response action be afforded or does funding need to be set aside prior to the action?	Y/N	Y/N	Y/N
Evaluation and sensitivity to review date	Are there mechanisms in place to evaluate and review the response action? Will there be time for this evaluation to occur (and take action) before the consequences of the response action become irreversible?	Y/N	Y/N	Y/N
Costs and losses, to assess value for money	Is there a quantitative or semi-quantitative estimate of the costs or losses from the response action? In terms of consideration of other options, does the proposed response action provide best value or benefit for the money invested?	Y/N	Y/N	Y/N
Timing of options and solutions	When does the response action need to be implemented?	Y/N	Y/N	Y/N

Consideration	Description	Critically important	Somewhat important	Not important
	Does the response action meet its stated objectives over the time period sought?			

2.6 Measuring and monitoring triggers and thresholds

By definition, a trigger or threshold requires an essential link to some form of monitoring in order to verify when a trigger has been met or exceeded.

This threshold may be either:

- quantitative, for example, a trigger point based on a measured buffer distance
- semi-quantitative, for example, a trigger point based on a reduction of the service level or deterioration of the condition of a given asset based on a condition assessment
- largely qualitative, that is, based on an observation or informed opinion.

Monitoring for many triggers can easily be integrated into existing monitoring programs already undertaken by local government or as part of broader programs and data products. However, it is recognised that complicated, costly and/or intensive monitoring programs will be difficult to implement and maintain overtime. Therefore, it is important to leverage existing information wherever possible and/or to seek to partner across local government areas, with the state government and/or with local academic institutions to reduce costs and other practical constraints.

While the purpose of this guidance is not to provide technical advice on coastal hazard monitoring, some of the key methodologies that can be employed to measure triggers and thresholds are discussed below, including:

- shoreline mapping
- aerial photographs
- beach profiling surveys
- location specific photographs and videos
- remote sensing
- storm tide and inundation measurements.

2.6.1 Shoreline mapping

Because the shoreline is inherently dynamic, GIS-based shoreline mapping (both on the open coast and along the foreshores of estuaries) is a difficult venture.

State and local mapping products can draw accurate representations and often use analysis of historical trends and future predictions as well as surrogates (such as tidal vegetation limits) to approximate key tidal datums such as the high water mark (representing the level of mean high water spring tides), low water mark, highest astronomical tide and other datum as shown in Figure 7. These mapping layers are not

always verified on the ground, so they should not replace the accuracy of an on-site survey for confirming shoreline locations and measurements.

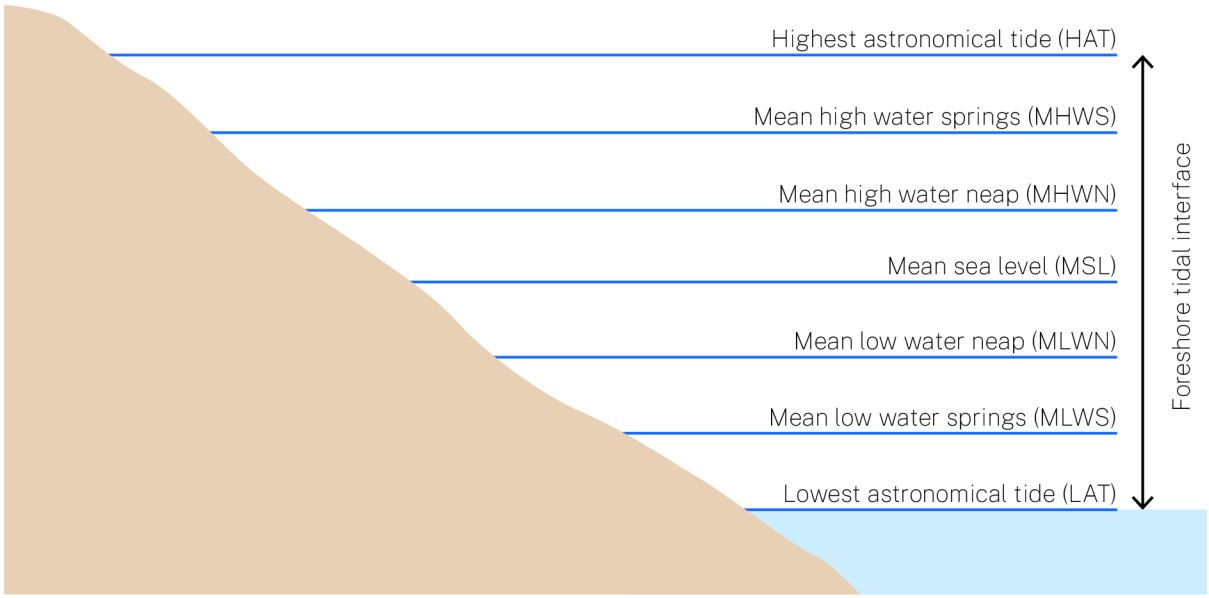

Figure 7 Typical tidal datums in Australia (Source: Collier and Quadros 2006)

2.6.2 Aerial photographs

Aerial photographs can be used to gather information about coastal erosion, recession and inundation trends over time.

Comparing photographs over a defined timescale is sometimes the simplest and most cost-effective and insightful way of determining how coastal hazards such as erosion and inundation have impacted a landscape over a long period of time. Moreover, historical photographs can also often provide an accurate representation of shoreline structure that other data sources simply cannot deliver.

The NSW Beach Profile Database uses NSW Government aerial survey data dating back to the 1930s to determine beach profile trends, and volumetric calculation changes can also be undertaken within the database. Coastal photogrammetric data is also available via the NSW Government SEED (Sharing and Enabling Environmental Data) data portal. Links to these and other online resources mentioned below can be found in the 'More information' section.

2.6.3 Beach profiling surveys

Beach profiling surveys can be undertaken to measure the short-term effects of coastal erosion and beach recession/accretion trends. Surveyors track fluctuations in shoreline position and beach volume, which can then be used to determine long-term effects.

Beach profiles comprise surveyed section lines perpendicular to either the shoreline or to a pre-determined baseline, and more recently, have been augmented with drone surveys. They are used to quantitatively establish beach response to storm events, beach recovery rates, long-term volume changes, areas of potential flood or erosion risk, and the potential envelope of cross-shore elevations.

If beach profiles are combined with nearshore bathymetric surveys, then morphological changes across the full zone of wave influence can be assessed.

Surveys should identify boundaries between the mobile beach toe and bedrock and the crest and seawall/cliff, if appropriate. Photographs of the beach should be taken from fixed positions in conjunction with surveys.

2.6.4 Location specific photographs and video

Photographs are particularly useful for identifying small-scale features which might influence the interpretation of data. They can also capture changes in beach areas near structures or places not covered by fixed lines, measure coastal or flood heights on gauges or structures, and show any damage or wear on natural or man-made features.

Video, timelapse or fixed point photography (such as CoastSnap) can also be used to gather more continuous information on the effects of coastal hazards. Fixed cameras of beaches and estuaries, along with the more recent use of drones, provide affordable and accurate means from which to observe both short-term effects and long-term trends.

2.6.5 Remote sensing

Airborne, satellite and on-land remote sensing equipment can also be used to monitor coastal hazards. These include microwave sensors, multispectral and hyperspectral imaging, global positioning systems (GPS) and airborne light detection and ranging technology (LiDAR).

Increasingly, remotely sensed data can provide robust information on coastal landform change, both in response to short-term storm events and to detect longer term trends. Accessible visual information from satellites, for example in Google Earth and NearMap, can provide useful baseline data. Data from high-resolution sources will likely become more cost-effective over time, such as LiDAR surveys of shoreline topography and ground-penetrating radar imaging. These products can help to understand the evolution of coastal landforms and their links to sea level.

Historic flood information and GIS data on flood studies is available through the Australian Flood Risk Information Portal, which can be searched by keyword.

The CoastAdapt website hosted by the National Climate Change Adaptation Research Facility also contains spatial mapping products based on remotely sensed data for both future sea level rise and historical inundation.

The Water Observations from Space dataset from Geoscience Australia is a particularly useful resource to identify historical distribution and occurrence of standing water from flooding. This data can be used to track historical flooding extents as well as to identify problem areas that have a history of inundation. For more information, visit the CoastAdapt and Geoscience Australia websites.

2.6.6 Storm tide and inundation measurements

Specialised scientific instruments are needed to measure the depth and duration of storm surge during coastal storms. The data these sensors collect before, during and after a storm, can help assess damage and improve computer models used to forecast storm surge and coastal change.

Post-event water marks and debris lines are also commonly used and can be recorded either on the ground or via drones. This data combined with instrumental data can be essential to improve the ability to predict the likely impacts from future inundation events.

The NSW Government is currently investigating the development of a water level inundation forecast tool for several estuary gauge locations. The key parts of this project are to:

- develop a 7-day total water level forecast for all locations
- develop a yearly total water level forecast for all locations based on harmonic tidal predictions
- present nuisance inundation forecasts on a webpage based on predicted inundation.

As an example, in terms of the inundation, this tool could be used to track how inundation or nuisance inundation is increasing over ‘x given years’ and hence when a trigger/threshold might become exceeded.

Coastal erosion monitoring, Wollongong Beach. Photo: P Robey/DCCEEW

3. Incorporating triggers and thresholds into the NSW coastal management and planning frameworks

This final section of the guidance outlines the mechanisms in which trigger and thresholds for coastal hazards can be incorporated into strategic and site-based planning and decision-making. These include the following delivery mechanisms, which are discussed in subsequent sections:

- inclusion in coastal management programs (CMPs)
- inclusion in coastal zone emergency action subplans (CZEASs)
- inclusion in environmental planning instruments
- inclusion in Part 5 review of environment factors (REF) processes
- inclusion in development assessment processes
- inclusion in planning certificates
- consideration in other planning documents and frameworks.

To augment the general guidance presented, the section includes a range of case studies from New South Wales and other states (as indicated). While many other case study examples could have been selected, the case studies included have been chosen to be representative of a mix of different trigger and threshold approaches that have been set for different coastal hazard types and in different types of documents and settings. The inclusion of these case studies is not to evaluate the merits or demerits of the approaches presented, but to show real examples of how triggers and thresholds have been referred to and used in coastal management documentation.

In applying this guidance in planning and decision-making, suggested measures and approaches presented here will need to be guided by the specific legal requirements, approved policies and directions of the NSW Government and local government that are in place at the time of implementation. It should be recognised that these will likely change over time and in the event of an inconsistency between a statutory requirement and this guidance, the statutory requirement shall prevail.

3.1 Inclusion in coastal management programs (CMPs)

Both Part A and Part B of the manual reference the consideration of triggers and thresholds in a number of stages of CMP preparation. These references are summarised in Appendix A.

Focusing on the Part A Mandatory requirements (MR), the principal touch points where triggers and thresholds can be demonstrated in a CMP include the following:

- informing evaluation and selection of coastal management options — MR6(iii)
- informing coastal management actions including any coastal protection works — MR8(iv, v, vii)
- informing the monitoring, evaluation and reporting program — MR8(ix).

3.1.1 Consideration as part of coastal management options

Informing evaluation and selection of coastal management options — MR6(iii)

Consideration of triggers and thresholds and associated response actions using the manual's risk assessment framework allows for evaluation and selection of a broad range of options from proactive risk communication (for example alert actions), through to much more significant adaptation responses such as active intervention or planning for change.

Developing a decision tree diagram can be useful in demonstrating this option evaluation process in a CMP. An example of this approach is shown in Figure 8 below (reproduced from BMT 2023).

Based on the example presented in Figure 8, it can be useful to show a conceptual split between the coastal management options for existing development (often within the scope of the CMP and non-statutory plans such as asset management plans and reserve plans of management), as opposed to new development which will be governed by statutory planning instruments such as the State Environmental Planning Policy (Resilience and Hazards), local environment plans (LEPs) and development control plans (DCPs).

As shown in Figure 8, for existing development the coastal management options can include actions relating to **alerting and monitoring risk**, implementing **active interventions** to manage the risk to existing assets and their values, **planning for change** over time, and maintaining or improving emergency response following incidents and impacts.

For new development there are greater opportunities for **avoiding** risk or at least to **accommodate** or minimise the risk through measures such as siting and design. Equally, an entity may want to **accept** the risk from future hazard to development by ensuring that the development is temporary, sacrificial or relocatable, or accept that the risk to the development is tolerable based on the overall risk profile of the area.

As outlined previously in this guidance, triggers and thresholds can be considered for each category of potential coastal management action and form an important part of the overall option consideration and evaluation process in the CMP.

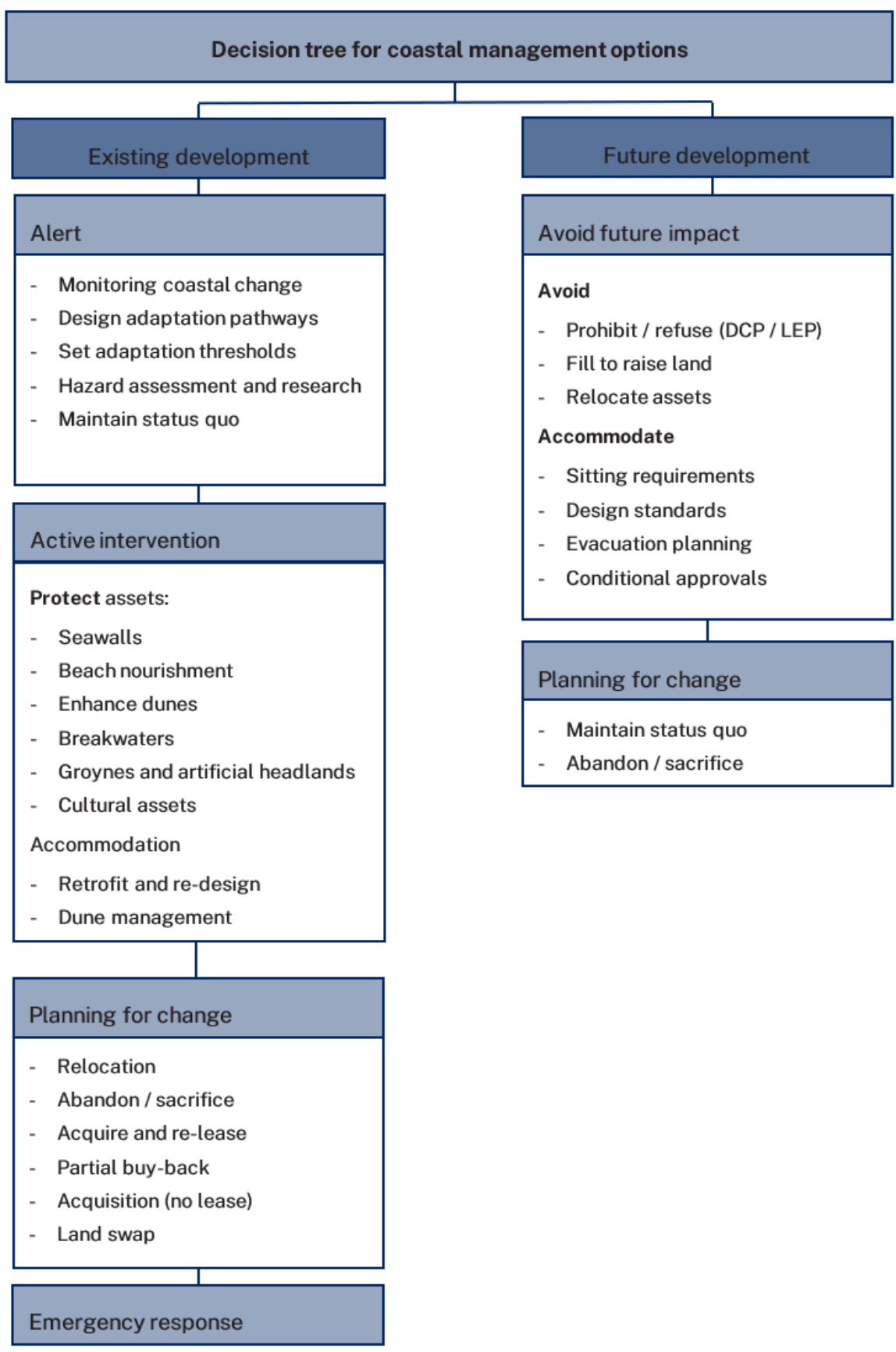

Figure 8 **Example decision tree for coastal management options**

3.1.2 Informing coastal management actions

Informing coastal management actions including any coastal protection works – MR8 (iv, v, vii)

In considering how triggers and thresholds can be incorporated into coastal management actions, 4 strategies that could be implemented are setting triggers and thresholds related to:

- a defined geographical area or specific site
- classes or types of development
- provision and/or maintenance of a specific asset or item of infrastructure, for example a seawall at a particular location
- a separate standalone table or section within a CMP.

Each is addressed below with case studies provided.

Area-based triggers

At a local or site-based planning level, such as a specific beach or estuary, there are opportunities to show the relationship between trigger points and management interventions over time.

Specifically, a CMP may:

- set out what and where trigger-based approaches will be applied, including providing guidance on the requirements for development applications and requirements that will be applied to development decisions
- set out a specific approach or policy position around the provision of protection for public or private asset(s) from coastal hazards using a trigger-based approach at a specific location
- require development in the coastal vulnerability area or coastal zone to be temporary and/or relocatable based on triggers pertaining to coastal hazards which include the imposition of conditions of consent on development approvals
- set out detailed design requirements for new development proposed in or adjacent to coastal vulnerability area or coastal zone
- set out requirements that existing defence structures must be reassessed and may require reconstruction or enhancement, in connection with any proposal in an area subject to coastal hazards (subject to restrictions set out in *Local Planning Directions, Section 4.2 Coastal management* [LPD 4.2], which already limits intensification of development in current and future hazard areas)
- set out special area management or locality-based planning provisions (such as long-term adaptation plans) that could include any or all of the following:
  - policies that inform rezoning of land adjacent to coastal hazard areas
  - policies about replacement, refurbishment or alterations to existing development in hazard zones (again, subject to restrictions set out in LPD 4.2 which limits intensification of development in hazard zones)

- policies that limit new development to being temporary, sacrificial or relocatable, including triggers for relocation or abandonment of such development
- policies about the type(s) and timing of when coastal protection works will be contemplated for the coastal vulnerability or other management area (based on a trigger-based approach)
- policies and requirements about redevelopment of buildings and structures following defined coastal hazard event(s), including if new or additional design requirements apply
- requirements that set aside land in community title or other form of common property for future protection or defence works to be constructed
- requirements for a one-off or ongoing financial contribution from proponents to fund monitoring, management actions or protection works to protect development or assets
- setting out where proponents will need to include additional requirements in development applications to address future coastal hazards, including for example an active intervention plan, emergency management and evacuation plans, dune management plan or similar to manage future risk of coastal hazards.

Some examples of area-based approaches are shown in case studies for Eurobodalla (NSW) Case study 1, Busselton (WA) Case study 2 and Bundaberg (Qld) Case study 3.

Case study1: Eurobodalla open coast coastal management program

The *Eurobodalla open coast coastal management program* (Eurobodalla Shire 2023) identifies that there are low-lying areas within Batemans Bay that have existing exposure to large ocean storms and will increasingly be at risk under sea level rise.

It states that:

- The coastal vulnerability modelling undertaken in Stage 2 of the CMP identified locations in Batemans that will be inundated several times a year by 2100 (i.e. these areas are below the 2100 High Water Springs (HHWS) tidal level).
- This frequency of inundation is an unacceptable level of risk, and would likely result in these areas being uninhabitable not only due to regular inundation, but sub-ground level impacts on structural foundations, underground assets etc.

The CMP recommends that adaptation planning should commence immediately for these areas to identify suitable approaches to continue occupation of this land. This may involve a combination of rezoning land, landform adaptation through filling and raising of assets and roads, and property development controls.

Specific threshold or trigger values

For this particular action, the CMP refers to setting future thresholds and triggers, noting the following:

> 'The timing for adaptation planning will be dependent on identifying the "Thresholds" and "Triggers" these would be established as part of the adaptation planning. However, for the purpose of CMP planning, it can be seen that frequent inundation of the low-lying areas of Batemans Bay will likely occur by 2065.
>
> This may be considered the threshold where these locations begin to lose their liveability. The trigger point for this threshold requires analysis of the timeline between when the threshold is reached and when a response is required to avoid losing liveability of the area. This analysis would include consideration of a monitoring period, response time, and a safety buffer for uncertainty.'

Case study 2: City of Busselton (WA) coastal hazard risk management and adaptation plan

The City of Busselton, WA, produced its *Coastal hazard risk management and adaptation plan* in 2022. The plan notes that adaptation pathways comprise a sequence of risk management options and tipping points triggered by the impact of coastal hazards over defined planning timeframes. The approach taken in the preparation of the plan seeks to establish a degree of flexibility in keeping options open and to avoid 'path dependency'.

There has also been an intention to apply an appropriate sequence of actions in the short term, followed by a longer term pathway. This is shown via a series of local 'profiles' across the planning area, which show preferential pathways related to planning response, infrastructure response, emergency management response and foreshore management/use response at defined timeframes (current to 2043; 2043 to 2073; and 2073 to 2123) for the local planning unit selected.

Specific threshold or trigger values

Triggers for the implementation of risk management options are identified in the plan as events or situations that occur as a direct result of natural coastal processes (for example, a severe storm combined with a high tide that causes significant coastal erosion). Trigger points are identified to lag pre-determined levels of change where decisions on agreed risk management measures must be implemented in order to reduce risk to acceptable levels. The plan sets the direction and timeframes for acceptable risk management, with appropriate triggers to be assessed and determined on an ongoing basis through the city's coastal management program for 2020 to 2030.

Figure 9 shows an example of the adaptation pathway for the Smiths Beach area.

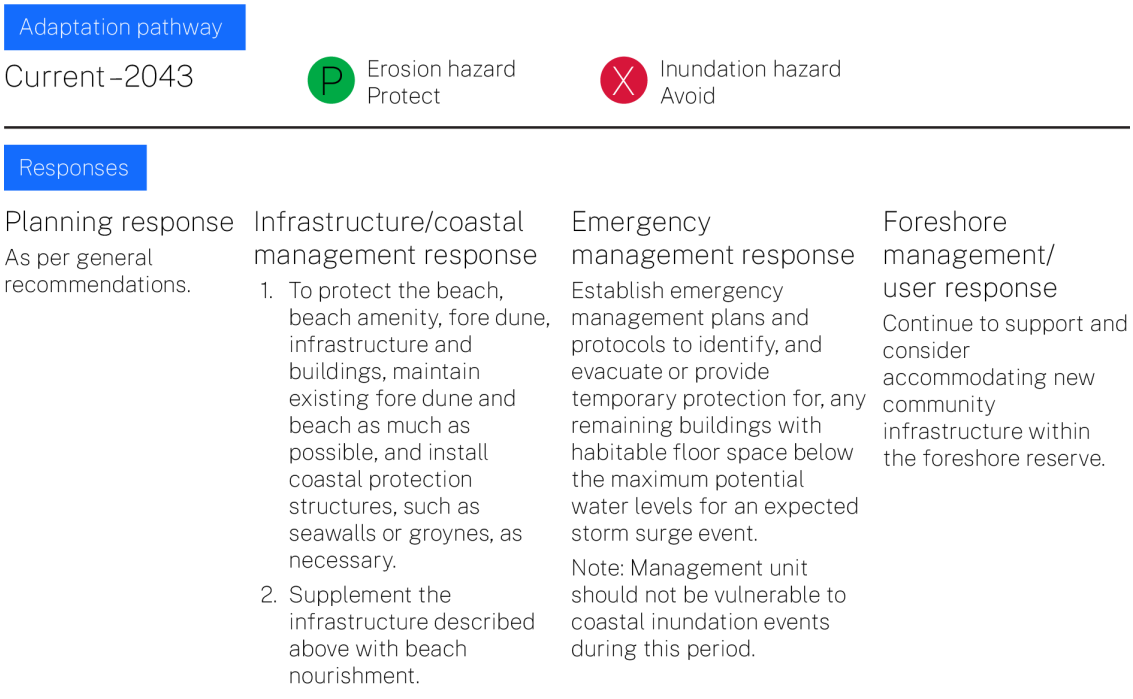

Figure 9 **Example adaptation pathway for the Smiths Beach area (Source: City of Busselton 2022)**

Case study 3: Bundaberg (Qld) coastal hazard adaptation strategy

The Bundaberg Region *Coastal hazard adaptation strategy: our coast* (BRC 2020) was prepared by the council under the auspices of the QCoast2100 program. The strategy looks at hazards, such as coastal erosion, storm tide inundation and sea level rise, and identifies adaptation options to reduce risks associated with these hazards.

Specific threshold or trigger values

As shown in Figure 10 for Kelly's Beach, the pathways map outlines a range of activities that can be undertaken over the period of time when sea levels are predicted to rise in the local area. Initial actions such as disaster management, education and monitoring are actions affiliated with an overall policy intent to 'Maintain' before signalling actions in the future that aim to 'Modify', such as beach nourishment and prospective hard engineering protection structures (for example, seawall, groynes, offshore reefs). Ultimately, it is recognised that with significant sea level rise (0.8 m) the actions will move to a 'Transform' phase, which will include changes to land use and tenure arrangements.

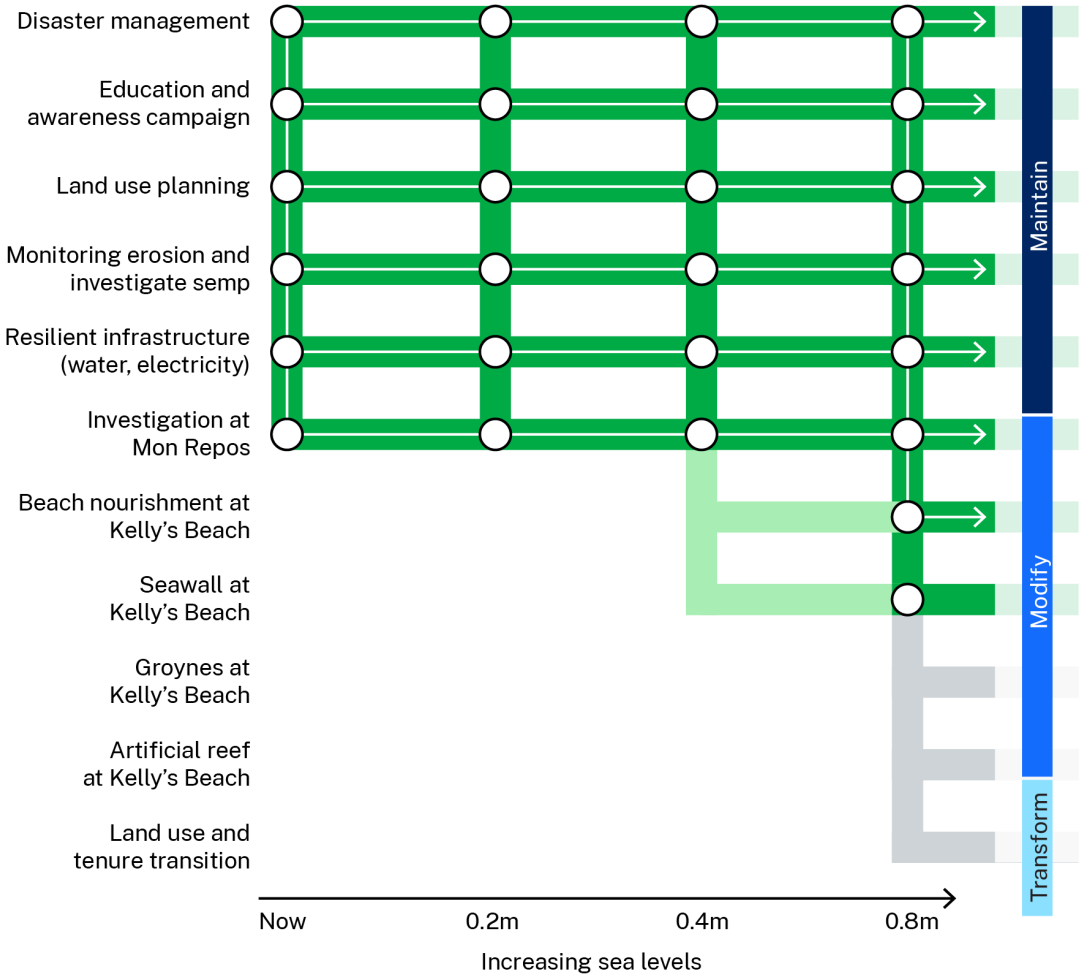

Figure 10 **Example pathway map for Kellys Beach, Bundaberg Shire, Qld (Source: BRC 2020)**

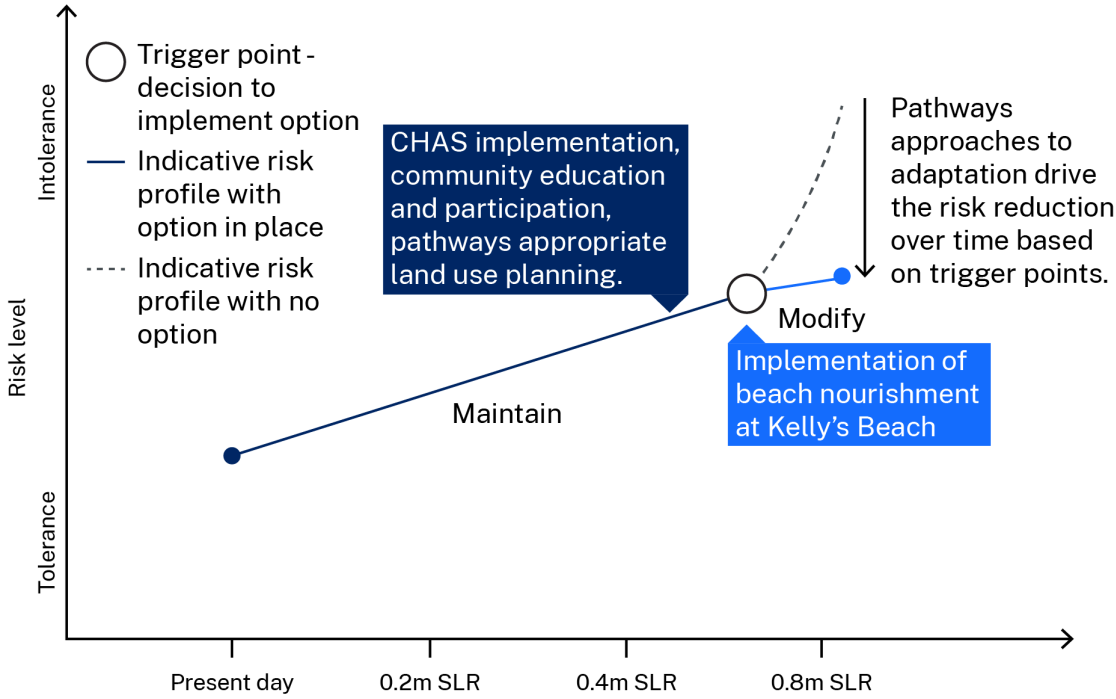

Figure 11 **Pathway approach with triggers at Kelly's Beach to reduce risk from sea level rise (SLR) (Source: BRC 2020)**

Figure 11 complements the pathways map in Figure 10 to show how this strategy could 'play out' over time. It sets a defined trigger point between the 'Maintain' actions and the 'Modify' actions based on the approach outlined in the pathways map. This is estimated to occur at or around a 0.6 to 0.7 m sea level rise (SLR) increase.

These graphics are good examples of how to show long-term intent under an adaptive pathways approach using an area-based approach.

Development type–based triggers

To ensure consistency in application of adaptation and resilience measures across the planning area, a CMP may wish to have provisions related to development types or classes as opposed to specific geographical areas (i.e. area-based triggers above). This approach generally applies to existing assets and infrastructure and facilitates integration of coastal hazard risk into asset management processes. An example from the Lake Macquarie (NSW) draft CMP is provided below in Case study 4.

Case study 4: Lake Macquarie coastal management program

The *Lake Macquarie coastal management program* (LMCC 2022) includes specific triggers for management intervention (e.g. planning management change and/or on-ground works) related to coastal erosion and long-term shoreline recession across different types and classes of development. These are shown in Table 7 (reproduced from the CMP).

Specific threshold or trigger values

Table 7 **Lake Macquarie coastline development type–based triggers for enhanced management intervention**

Type of development	Triggers for enhanced management intervention		Explanation
	Commence planning for management change (Risk is increasing)	Commence on-ground works (Risk of continuing current management is unacceptable)	
Major Infrastructure	Immediately, with reviews at 5-year intervals until the 'commence on-ground works' trigger condition is met.	When actual coastal recession reaches the 2050 Coastal Risk Planning Line (2050 'unlikely' hazard line) as currently mapped.	Long-term planning is required because of complexity of issues and significance to community wellbeing; extremely high investment required (e.g. for waste water treatment plant or Swansea Channel training walls), so long-term budget planning also required.
Local roads, water supply and sewerage reticulation	When actual erosion or recession reaches 2050 Coastal Risk Planning Line (2050 'unlikely' hazard line) as currently mapped.	When actual erosion and recession reaches the 2050 'rare' hazard line, or is no more than 15 m from the infrastructure alignment; or the infrastructure is inundated by marine processes during events estimated to have a one in 20-year recurrence interval; or infrastructure reaches its asset life.	These assets service existing development. The triggers are intended to recognise the costs of maintain functioning infrastructure in situ, as opposed to relocating or redesigning at the end of the asset's life.

Type of development	Triggers for enhanced management intervention		Explanation
	Commence planning for management change (Risk is increasing)	Commence on-ground works (Risk of continuing current management is unacceptable)	
Existing dwellings	When actual erosion or recession reaches the 2050 Coastal Risk Planning Line (2050 'unlikely' hazard line), as currently mapped; or the property is inundated by marine processes having a one in 20-year recurrence interval.	When actual erosion or recession escarpment is no more than 20 m from the dwelling; or the dwelling is inundated by marine processes at intervals of less than 2 years.	New dwellings can have consent conditions linked to the triggers. For existing development, the consent provisions cannot be used. However, a similar trigger for retreat would apply because the dwelling would cease to be occupiable.
Other existing buildings (commercial and industrial)	When actual erosion/recession reaches the 2050 Coastal Risk Planning Line; or the property is inundated by marine processes having a one in 20-year recurrence interval.	When actual erosion or recession is no more than 20 m from the building.	As above.
Recreation Infrastructure such as pathways, lookouts	Review of designs should commence immediately, to allow the seaweed toe of access ways to adjust. Emergency closures should commence immediately, when required for safety.	Review situation at intervals of 10 years or at asset life/major review. Relocate landward as necessary and feasible, when the erosion or recession reaches to no more than 5 m (along the beach) pathways and lookouts.	The triggers are linked to expected asset life of this infrastructure.
Recreation Infrastructure – facilities in coastal reserves	Review of landscape plans should commence immediately, to incorporate dune enhancement works and appropriate	Review landscaping plans and designs of facilities with asset life of these facilities – likely to be at 10-year intervals.	Trigger is linked to asset life of facilities in public reserves and to review periods for plans of management for reserves.

Type of development	Triggers for enhanced management intervention		Explanation
	Commence planning for management change (Risk is increasing)	Commence on-ground works (Risk of continuing current management is unacceptable)	
	access ways. Locate picnic facilities, new amenities etc. landward of the immediate Coastal Risk Planning Line.		
Private recreation – Belmont Golf and Bowls	Planning for fairway and green design and planting that accommodates coastal processes should commence now and be gradually introduced.	Seaward parts of the course would be abandoned when the cost of maintaining fairways and greens exceeds the value obtained from use. Likely to be linked to sand and/or wave inundation of the seaward part of the golf course at intervals of not more than 2 years. Indicatively, this could occur by 2050.	Trigger to be confirmed by golf club executive and members.

Source: LMCC (2022, Table 8).

Asset-specific triggers

Where there is a level of specificity required, a CMP may wish to provide guidance around triggers and future actions for a specific asset or item of infrastructure. An example associated with revetment works at Yamba main beach (NSW) is provided below in Case study 5, as well as an example of interim coastal protection works in Case study 6.

Financial-based triggers can serve as valuable components in setting triggers and thresholds approaches for specific assets or infrastructure, particularly when actions may require significant financial investment or where costs are intended to be shared among multiple parties.

For these approaches, an initial trigger may be to secure the appropriate financial commitment to ensure that the appropriate financial resources are available to implement the necessary action (as shown in the Yamba main beach case study).

Conversely, financial-based considerations can also be used as a trigger to discontinue an action, for example, a nourishment strategy that becomes too expensive to continue to implement owing to the cost of importation of sand or the frequency at which campaigns need to be repeated.

Case study 5: Yamba main beach seawall wall upgrade, Clarence Valley Open Coast coastal management program

The Clarence Valley Open Coast CMP (2024) under strategy Y1 seeks to mitigate the impacts of coastal erosion on infrastructure, through both interim sand nourishment actions and accompanying replacement/upgrade to the existing Yamba main beach seawall.

An earlier design has recommended a replacement rock armoured unit, which would seek to incorporate suspended concrete bleachers to provide for seating. This design would be reviewed and refined through community consultations and feedback, which would be completed through the implementation of the CMP. Subject to these actions commencing is the availability of funding.

Specific threshold or trigger values

The Clarence Valley Open Coast CMP outlines the follows triggers for the actions to be pursued under this strategy and illustrated in Figure 12:

Sand nourishment

- Based on the dredging strategy being developed by Transport for NSW – Maritime, and data collected from coastal hazard monitoring, the efficacy of any sand nourishment activities implemented will be assessed and triggers for introduction of alternative sand sources for beach nourishment will be developed
- Obtain any necessary approvals and licences
- Obtain funding for delivery of sand nourishment
- Delivery of sand nourishment in accordance with triggers developed and identified above.

Seawall replacement/upgrade

- By 30 June 2028:
  - review and update Yamba main beach seawall design in consultation with stakeholders
  - develop maintenance regime
  - obtain necessary approvals and licences
- Construct coastal protection works in accordance with design and approvals and identified source of funding.

Note: that sources for funding the actions identified within the CMP are to be determined by an overarching CMP action FS1-1. This action is considered to be the key financial-based trigger for the commencement of the above CMP actions.

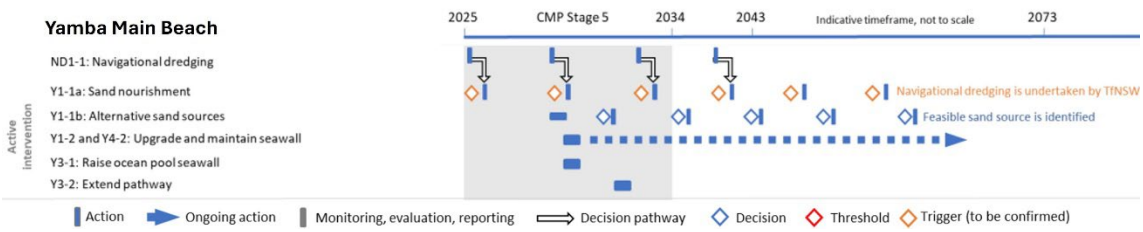

Figure 12 **Yamba Main Beach adaptive erosion mitigation strategy (adapted from Clarence Valley Open Coast CMP, 2024)**

Standalone trigger table

Finally, CMPs may incorporate triggers and thresholds as part of a broader action table or as part of a standalone section or chapter.

This could be achieved using the generic tabular format illustrated in Table 8. As identified previously, as part of this approach it would be important to include information about:

- the proposed monitoring approach and frequency for assessing if the trigger has exceeded
- the proposed action management response if the exceedance occurs
- who/what entity will take the response action (and when if relevant).

Table 8 **Generic standalone trigger table**

Trigger or threshold value	Monitoring of the trigger or threshold	Action(s) in response to trigger	Response action owner
Include the trigger or thresholds value including: • what coastal hazard it applies to • what assets or area it applies to • the timeframe it applies to (life of CMP; longer?)	Include how the trigger or threshold will be monitored. Include the frequency of monitoring – following event, annually, at 5- or 10-year increments, etc.	List the action or actions that will be taken in response to trigger being exceeded.	List who/what entity is responsible for taking the action and timing if relevant.

Case study 6: Interim coastal protection works, Kiama coastline coastal management program

The Kiama coastline CMP includes 3 interim trigger and threshold options for erosion coastal protection works at North Bombo Beach, Werri Beach, and Storm Bay (Kiama coastline CMP 2024, Annex E) to protect key assets (See Figure 13). The works are designed as an initial 'stop-gap' measures for managing coastal risk prior to the construction of permanent coastal protection works.

Specific threshold or trigger values

- Pacific Avenue, Werri Beach: active erosion scarp (more than 0.8m high) within 5 metres of the footpath edge adjacent to Pacific Avenue, including footpath in front of perpendicular parking bays.
- North Bombo Beach carpark access road: active erosion scarp (more than 0.8 m high) within 5 metres of the roadway edge.
- Storm Bay northern foreshore: active erosion scarp (more than 0.8m high) within 5 metres of the footpath edge behind the northern foreshore.

Figure 13 **Approximate locations of erosion scarp to reach trigger and threshold (to be confirmed through REF and approvals process) (Source: Google, Kiama coastal CMP 2024).**

Informing the monitoring, evaluation and reporting program — MR8(ix)

The explicit mention of triggers and thresholds in the context of the mandatory requirements (MRs) for identification of a monitoring, evaluation and reporting (MER) program for a CMP recognises 2 important points:

- That it is useful to set triggers and thresholds to guide any **baseline** coastal monitoring activity as this will help to ensure monitoring is targeted toward detecting a trajectory of change to inform management (as opposed to monitoring for monitoring's sake)
- That any triggers and thresholds that are set and embedded in other parts of the CMP, such as part of coastal management actions, or in relation to proposed coastal protection works, or as part of a CZEAS, **should directly guide the priorities** of the MER as those indicators will need to be tracked over time to determine if thresholds have been exceeded and if response action needs to be taken.

In this context, this guidance can be used as a starting template for setting triggers and thresholds for each hazard type under a MER as well as drawing from the guidelines and case examples presented.

Two case studies are presented below for Bate Bay (NSW) in Case study 7 and Bribie Island breakthrough (Qld) in Case study 8 showing how triggers and thresholds can be built into longer term monitoring programs related to coastal hazard issues.

Case study 7: Bate Bay coastal management program

Coastal hazards action 27 of the *Bate Bay coastal management program* (Sutherland Shire Council 2024) seeks to establish an annual and event-based cliff line and foreshore soil slopes stability monitoring program.

It identifies notable locations where cliff stability risks are present:

- Bass and Flinders Point lookout
- Glaishers Point lookout
- Cliff line above The Esplanade
- foreshore soil slopes above the crest of the cliff line between 25 Elizabeth Place and 12 Arthur Avenue.

Specific event trigger values

- Heavy rainfall: at least 100 mm of rainfall in one day.
- Prolonged rainfall: at least 150 mm of rainfall over a 5-day period.

In addition to these event-based triggers, more comprehensive geotechnical reassessment is proposed to be undertaken on a 10-yearly basis.

Case study 8: Bribie Island and Golden Beach (Qld) breakthrough plan

Bribie Island National Park, managed by the Queensland Government, is a sand barrier separating Pumicestone Passage from the Coral Sea. The northern extent of Bribie Island is a dynamic sand spit, constantly evolving in response to coastal and estuarine processes. In late 2013 the northern spit had narrowed to 25 m at some locations. There was concern within the local community that a breakthrough of the northern spit would cause undesirable impacts to the adjacent mainland shoreline, which is managed by the Sunshine Coast Council.

The Bribie Island and Golden Beach breakthrough - options, design, approvals and investment plan (Sunshine Coast Council 2015) provided a review of the risk to council-controlled assets and values associated with shoreline erosion and coastal inundation to mainland communities between Caloundra Bar and Bells Creak, northern Pumicestone Passage. Attention was given to better monitoring the threat of coastal inundation, with the risk profile for land-based assets expected to change over time due to a combination of a breakthrough of the northern spit, sea level rise, and the resulting morphological change within Pumicestone Passage.

Specific threshold or trigger values

The proposed management actions in the plan are linked to a coastal monitoring program and escalate following the realisation of the defined triggers, namely:

- the material required for beach nourishment exceeding the existing permitted volume of 10,000 m^3/year
- an unsustainable volume of sand required for ongoing beach nourishment to maintain shoreline position and mitigate coastal erosion and inundation risk (to be informed by shoreline monitoring)
- an observed increase to the mean high water spring level and/or the mean sea level greater than 0.2 m relative to 2014 levels, measured through installation of a permanent tide gauge to monitor water levels within northern Pumicestone Passage.

In early 2022, a breakthrough of the Bribie Island spit occurred and evolved to form a new permanent entrance to northern Pumicestone Passage. Aerial imagery showed a significantly larger entrance post-breakthrough in comparison to the pre-breakthrough condition (See Figure 14). This caused a rapid change to the tidal regime within northern Pumicestone Passage, with tide gauge data showing normal high tides were approximately 0.3 m higher at Golden Beach post-breakthrough.

As a result, the water level threshold was exceeded rapidly after the breakthrough, with little time to trigger the management response of additional nourishment. In this context, this case study is indicative of a well-intentioned trigger-based approach linked to monitoring, but where the natural occurrence exceeded the expected early warning trigger.

Figure 14 **Bribie Island with an intact spit (2014) (top) and breakthrough of the spit (2022) (bottom).**

3.2 Inclusion in coastal zone emergency action subplans

The *Guideline for preparing a coastal zone emergency action subplan* (CZEAS) (DPIE 2019) already addresses the issues of triggers and thresholds satisfactorily. It notes that:

> The CZEAS should be prepared to facilitate effective emergency responses by defining a coastal emergency and triggers for emergency response actions.

The CZEAS guideline provides example triggers for the following hazards:

> In addition to the 'severe storm' warning, councils may wish to consider specific triggers for when beach erosion requires an emergency response. These may include storm bite being within a set distance of:
>
> - essential infrastructure – such as sewage pump stations or roads
> - other public assets such as a surf club building
> - privately owned built assets such as homes.
>
> Another consideration may be where storm bite erosion is damaging and making beach access ways and access structures unsafe.
>
> Consideration may also be given to specific triggers for coastal inundation including:
>
> - wave runup at low tide is a set distance from essential infrastructure such as sewage pump stations or roads
> - wave runup is affecting safe access to public land, such as council reserves at the back of the beach and beach access ways
> - wave runup is likely to impact on public assets such as surf clubs or schools
> - wave runup and overtopping affects the safety of egress for vulnerable people
> - wave runup at low tide is a set distance of any residence.
>
> In considering geotechnical risks associated with cliff and bluff instability triggers may include:
>
> - open cracks, or steps, along contours
> - groundwater seepage, or springs
> - bulging in the lower part of the slope
> - trees leaning down slope, or with exposed roots
> - debris/fallen rocks at the foot of a cliff
> - tilted power poles or fences
> - cracked or distorted structures.

3.2.1 Incorporating triggers and thresholds

Case study 9 for Stockon Beach (NSW) provides an example of how triggers and thresholds can incorporated into a CZEAS through the different stages of emergency response.

Case study 9: Stockton Beach coastal zone emergency action subplan

The scoping study for Stockton Beach coastal management program identified that the central and southern sections of Stockton Beach are at risk of coastal inundation. Emergency response actions are detailed in the *Stockton coastal zone emergency action subplan* (CZEAS). The CZEAS is an accompanying document to the City of Newcastle's *Emergency management plan* (CoN 2019) (Newcastle EMPLAN), which sets out the responsibilities of combat agencies, including the NSW Police, City of Newcastle, NSW Ambulance Service, State Emergency Service (SES), Fire and Rescue NSW (FRNSW) and others.

Specific threshold or trigger values

The Stockton CZEAS includes a number of triggers that relate to the early warning and response phase:

- the Bureau of Meteorology (BOM) issues a 'Severe weather warning for damaging surf' or 'Severe weather warning for storm tides' or council staff identify a likely coastal erosion event
- significant erosion escarpment forms and predicted increase in storm threat
- top of erosion escarpment within 20 m of built asset with predicted increase in storm threat, or wave overtopping/coastal inundation is affecting private or public land, or predicted increase in storm threat by BOM (waves exceeding 7 m and tides exceeding 1.6 m or storm surge greater than 0.6 m)
- top of erosion escarpment within 15 m of a built asset with a predicted increase in storm threat or significant wave overtopping/coastal inundation is affecting private or public land
- a decision is made during emergency meeting to implement emergency coastal protection works.

Actions in response to the formation of a significant erosion escarpment include increased frequency of monitoring and site management to ensure public safety and engineering resources such as:

- damage assessment
- clear and re-establish roads and bridges
- demolish and shore-up buildings
- remove debris
- construct and maintain temporary levees and evacuation routes, when appropriate
- erect barricades and fences for public protection.

3.3 Inclusion in environmental planning instruments

The State Environmental Planning Policy (Resilience and Hazards) provides the policy guidance to inform:

- planning proposals, rezoning and associated development assessment provisions of local environmental plans (LEPs) prepared by councils as they relate to coastal hazards
- development in the 'coastal vulnerability area' and 'coastal zone' defined under the Coastal Management Act.

In particular, the State Environmental Planning Policy (Resilience and Hazards) prescribes that development consent must not be granted to development on land within the coastal zone unless the consent authority has taken into consideration the relevant provisions of any certified CMP that applies to the land.

LEP preparation is further guided by a suite of guidance documents prepared by the Department of Planning found on their website (see links in Section 4.1 More information). These include:

- LEP Making guideline
- LEP Making attachment A – scoping proposal template
- LEP Making guideline attachment B – interim authority and government agency planning proposal pre-lodgement referral checklist
- LEP Making guideline attachment C – supporting technical information Guide
- Planning reform action plan FAQs
- local planning directions, including *Direction 4.2 Coastal Management*
- Coastal design guidelines 2023.

This guidance reinforces that the LEP should remain a more strategic planning document that reflects the standard provisions of the State Environmental Planning Policy (Resilience and Hazards).

3.3.1 Land affected by coastal hazards

That said, there are examples where LEPs have included triggers and thresholds for coastal hazards, including the Byron Bay LEP, which sets out provisions for temporary occupation of land affected by coastal hazards subject to a defined trigger point (see Case study 10).

In addition to LEPs, triggers and thresholds approaches for coastal hazards may also be suitable for consideration in a range of other local planning documents that are relevant to the coastal zone. These include, but are not limited to, the following:

- corporate and/or strategic plans
- local area plans and strategies
- development control plans (noting the scope of these will be limited by the overarching provisions in the LEP)
- asset management and/or service management plans for public infrastructure in the coastal zone built and maintained by local government and other public agencies.

Case study 10: Byron Bay Local Environment Plan 1988

The *Scoping study for Cape Byron to South Golden Beach* coastal management program (BSC 2020), provides an overview of the planning and development controls. The scoping study refers to *Byron Local Environmental Plan 1988*, which outlines:

> 'That land use planning framework sought, amongst other things, to preclude the construction of hard engineered coastal protection works on lands zoned coastal under the Byron LEP 1988 and to require development approved in the coastal zone to be temporary and/or relocatable based on triggers pertaining to coastal hazards and the erosion escarpment, which include the imposition of conditions of consent on development approvals.'

Specific threshold or trigger values

Byron LEP 1988 clause 48A(2) 'Temporary use of land' refers to a specific number of days within a 12-month period enabling a temporary use of the land, for example, for coastal erosion protection works:

> 'Despite any other provision of this plan, development consent may be granted for development on land in any zone for a temporary use for a maximum period of 52 days (whether or not consecutive days) in any period of 12 months.'

Additionally, the definition within the Coastal Land Zone of the LEP recognises 'the need to relocate buildings in the long term'.

It is understood that the above provisions were challenged as part of an appeal in 2018 to a development application decision. The NSW Land and Environment court in relation to case 2018/00116820 Joe Davidson Town Planning v Byron Shire Council, found that in relation to coastal erosion within a 12-month period, the following is to apply:

> 'Occupation of the dwelling must cease if two consecutive [beach profile] surveys, not less than 12 months apart show that the most seaward footing of the dwelling is within 50 metres of the alignment of the mid-point between the top of the slope and the toe of the slope on the ocean side of the seaward dune face.'

This is a precedent case where once the declared trigger set in the court's decision is reached, the building would need to be relocated, or if that is not possible then occupation must cease.

3.4 Inclusion as part of Part 5 reviews of environmental factors

Part 5 of the *Environmental Planning and Assessment Act 1979* sets out the environmental assessment scheme that applies to 'activities' undertaken by or on behalf of a public authority (including local councils), or which requires the approval of such an authority. In relation to coastal protection works, these works must be clearly identified within a certified CMP to be eligible to be completed through a Part 5 pathway, or otherwise require a development application, even if undertaken by a public authority.

This scheme includes a duty in section 5.5 of the Act to:

> examine and take into account to the fullest extent possible all matters affecting or likely to affect the environment by reason of that activity

as well as duties in section 5.7 to determine whether an activity is:

> likely to significantly affect the environment.

Public authorities seeking to carry out an activity typically record their assessment for the purposes of sections 5.5 and 5.7 of the Environmental Planning and Assessment Act in a document called a review of environmental factors or REF.

Regulation 171 of the Environmental Planning and Assessment Regulation 2021 provide the considerations of an REF, which include, among other things:

> (1) When considering the likely impact of an activity on the environment, the determining authority must take into account the environmental factors specified in the environmental factors guidelines that apply to the activity
>
> (2) If there are no environmental factors guidelines in force, the determining authority must take into account the following environmental factors …
>
> (p) the impact on coastal processes and coastal hazards, including those under projected climate change conditions

Based on regulation 171, there is a clear requirement for REF assessments to consider coastal processes and coastal hazards. There is a prospective role for triggers and thresholds, set as part of CMPs, to form part of this approach and influence and guide the REF approval process.

This is critical given the range of public infrastructure that may be established in or adjacent to areas subject to coastal hazards through the Part 5 approval pathway that would not otherwise require a development approval.

However, the CMP would need to be explicit — either as part of area-based provisions or else as part of development type–based provisions as described earlier (see Section 3.1.2) — to guide what triggers and thresholds apply and what are the acceptable solutions that need to be achieved by the REF process. This would be relevant to setting associated triggers and thresholds that guide monitoring programs, which must be considered as part of the design and construction of the infrastructure and as part of its future inspection and maintenance.

3.4.1 Development approval for a public works scheme

An example of a development approval for a public works scheme for coastal protection (similar to the Part 5 approval pathway) that used a trigger and threshold approach is the case study for Maroochydore Beach (Qld) in Case study 11. A further NSW example is provided in the context of the Brooms Head revetment extension proposal within the Clarence Valley Open Coast Management Program in Case study 12.

Case study 11: Future seawall at Maroochydore Beach (Qld)

To provide certainty for long-term management of Maroochydore Beach, Sunshine Coast Council developed a strategic works scheme for an adaptive management approach to coastal hazards. Using the risk continuum framework (LGAQ 2016), the 'unacceptable impact' was defined as the loss of key land-based assets to coastal erosion, including the amenity of the beach, a nearby surf lifesaving club, a state-controlled road asset and caravan park. To mitigate these risks, beach nourishment would continue at the location, but a buried rock revetment was identified to be eventually required (at an uncertain time in the future), which would be constructed on a consistent alignment along a 1.7 km stretch of coastline.

The scheme was delivered through a 'strategic' development approval that provided for the following:

- single seawall alignment and preferred footprint across the beach unit, with clearly stated planning outcomes to be achieved
- trigger levels for 3 smaller management units, based on erosion buffer between the crest of the frontal dune and the edge of assets
- currency period of the approval up to 2050 (so as to ensure the approval does not lapse prior to the trigger potentially being exceeded)
- annual fees to be introduced only once development triggers were met
- requirement for submission of detailed design information and construction environmental management plan to the state government referral agencies for compliance assessment prior to commencement of construction.

Specific threshold or trigger values

Approval was received for the development application in 2015 with conditions that reflected the trigger-based approach.

Triggers were set in the development approval based on an established erosion buffer required for asset protection, which was informed by numerical modelling of design event erosion volumes. It was determined that once assets fell within the area of 'immediate' erosion risk from a design storm event, detailed design and construction of the buried rock wall would be triggered to prevent damage to land-based assets. This buffer width is easily monitored through aerial photography and on-ground surveys undertaken at regular intervals by council, to verify when revetment detailed design and ultimately construction works are required.

While this scheme was addressed through a formal development approval, it is a similar outcome that could be achieved by local authorities through their CMP and with the Part 5 process in New South Wales for public works.

Case study 12: Extension of Brooms Head Reserve Revetment, Clarence Valley Open Coast Management Program

The Clarence Valley Open Coast CMP (Clarence Valey Council 2024) identifies that due to risk to public assets from storm erosion and long-term recession a significant priority project is to extend the existing wall to the Ocean Road bridge and install a rock bag end control structure once external funding is secured (See Figure 15).

Specific threshold or trigger values

The CMP outlines the key elements of the management program for the protection of Brooms Head Beach at this location involving the following steps:

- review and update the design and environment assessment for the Brooms Head Reserve revetment extension
- obtain the necessary approvals and licences
- secure funding for revetment
- construct extension of Broom Head Revetment (to be constructed within 12 months of confirmed funding)

The CMP also makes provision for managing erosion and recession risks should the design and approvals not yet be in place, but an interim strategy is needed to management any immediate risks that may arise. The includes the following triggers:

- commence design and approvals (includes development of triggers for placement) for temporary coastal protection works, when the active erosion scarp is within 5 m of the Brooms Head Holiday Park reserve access road
- acquire materials and equipment to install temporary protection works
- install temporary protection works when placement triggers are reached
- commence the finalisation of the planning and design of extension of the Brooms Head revetment, if this hasn't already commenced or has not been completed.

As both the revetment extension and temporary measures are clearly identified within the CMP the works would not require development consent, but would be an activity pursuant to the provisions of Part 5 of the Environmental Planning and Assessment Act, thereby assessed and implemented by the preparation of a review of environmental factors.

The CMP also provides clear prescription for the decommissioning of any temporary measures (see CMP action BH1-3d) linked to appropriate triggers, including recovery of the beach and foreshore, the extension of the revetment being completed, failure of the works, or the development of an alternate management strategy where protection works are no longer required.

Figure 15 **Proposed revetment extension and temporary (stage 1) works to be implemented as part of the Brooms Head coastal erosion mitigation strategy**

3.5 Inclusion in development assessment

The State Environmental Planning Policy (Resilience and Hazards) includes the coastal planning provisions that were previously found in the *Coastal Management State Environment Planning Policy*.

Chapter 2 (Coastal Management) of the State Environmental Planning Policy (Resilience and Hazards) implements the objectives of the Coastal Management Act from a land-use planning perspective. It specifies approvals pathways and how development proposals are to be assessed if they fall within the coastal zone and coastal vulnerability area.

Section 2.9 of the State Environmental Planning Policy (Resilience and Hazards) sets out requirements for 'Development on land within the coastal vulnerability area':

> Development consent must not be granted to development on land that is within the area identified as "coastal vulnerability area" on the Coastal Vulnerability Area Map unless the consent authority is satisfied that—
>
> (a) if the proposed development comprises the erection of a building or works—the building or works are engineered to withstand current and projected coastal hazards for the design life of the building or works, and
>
> (b) the proposed development—
>
> (i) is not likely to alter coastal processes to the detriment of the natural environment or other land, and
>
> (ii) is not likely to reduce the public amenity, access to and use of any beach, foreshore, rock platform or headland adjacent to the proposed development, and
>
> (iii) incorporates appropriate measures to manage risk to life and public safety from coastal hazards, and
>
> (c) measures are in place to ensure that there are appropriate responses to, and management of, anticipated coastal processes and current and future coastal hazards.'

Where coastal vulnerability areas have not been declared, Division 5 of the State Environmental Planning Policy (Resilience and Hazards) provides a 'catch all' for development in the coastal zone to not increase the risk of coastal hazard and to ensure consideration of any certified CMP:

> 2.12 Development in coastal zone generally—development not to increase risk of coastal hazards
>
> Development consent must not be granted to development on land within the coastal zone unless the consent authority is satisfied that the proposed development is not likely to cause increased risk of coastal hazards on that land or other land.
>
> 2.13 Development in coastal zone generally—coastal management programs to be considered
>
> Development consent must not be granted to development on land within the coastal zone unless the consent authority has taken into consideration the relevant provisions of any certified coastal management program that applies to the land.

These provisions guide development assessment pursuant to coastal hazards — both where a development application is assessed by a council or via regional planning panels or by the NSW Government under the Environmental Planning and Assessment Act.

In general, the scope for decision-makers to embed long-term triggers and thresholds into development conditions is hampered by the need for up-front certainty around the trigger and intended response to the hazard. It is also limited by the currency period for development approvals under section 4.53 of the Act, which means that any development not acted upon will lapse after 5 years.

Councils may also issue a deferred commencement consent under section 4.16 of the Act. A deferred development consent means the activity cannot operate or the development cannot commence until the applicant satisfies the consent authority on a specific outstanding matter in accordance with the regulation 76 of the Environmental Planning and Assessment Regulation. A deferred commencement consent condition must be satisfied within a specified period, for example, 12 months, and if the condition is not satisfied, the development consent lapses.

However, there are examples (both in New South Wales and further afield) where triggers and thresholds have been able to be included as part of development conditions, which reflect the intent of section 2.9(c) of the State Environmental Planning Policy (Resilience and Hazards) to seek to define 'appropriate responses to anticipated coastal processes and current and future coastal hazards'.

In using a development approval process to manage future risk through a trigger-based approach, it is important to consider 5 key elements:

1. pre-approval phases would require technical assessments to identify risk within the agreed planning horizon and appropriate trigger points, in order to establish an overall adaptation response or outcome
2. clarity and definitiveness around the trigger value, for example, the threshold that defines future action
3. there is clarity and definitiveness around the intervention that must be achieved in response to the threshold being exceeded, including timing of when the action has to be taken
4. developing or embedding a monitoring framework for the triggers and thresholds for management and compliance actions
5. ensuring the holder of the development approval (or owner of the subject land is bound if not the holder of the development approval) is responsible for implementation of the condition including ongoing regulatory agency support in managing activities to meet the approved outcome.

In this context, the types of conditions that could be needed to support an approach of embedding a triggers or thresholds approach in development assessment could include:

- identification of the ultimate protection strategy, including the alignment and preferred footprint of any coastal defence structures, with clearly stated performance or design outcomes to be achieved
- statement of the trigger levels and clarity around the type, frequency and roles and responsibility for monitoring
- the ability to agree with the proponent(s) to set aside parts of the subject land for the future protection works as common property and ensuring suitable interim land uses over the land (that do not preclude the future protection)
- requiring a one-off financial contribution by the proponent(s) or otherwise a dollar amount per month per lot contribution toward the costs of the future protection works that is held in trust until required
- requiring submission of more detailed design information and a construction environmental management plan to regulators prior to commencement of construction
- ensuring the approval and associated trigger condition attaches to the land and binds the owner(s) and any successive owner(s) in title, including where relevant a body corporate or group title organisation.

3.5.1 Development conditions

Case studies on use of development conditions to set triggers and thresholds is provided on the Lake Macquarie (NSW) yacht club approval in Case study 13 and a development in Marcoola Beach (Qld) in Case study 14.

Case study 13: Lake Macquarie yacht club approval

An approval for the Lake Macquarie yacht club development was issued by the NSW Government under the Environmental Planning and Assessment Act in early 2010. As part of the approval, the approved plans and the construction certificate plans and specifications required to be submitted were required to include the following:

a) The ground floor level of the proposed clubhouse shall be 1.98m AHD [Australian height datum]. In the event that the water level of Lake Macquarie increases above a trigger level of 1.2m AHD at the site, the Proponent shall raise the ground floor level to 2.37m AHD. The ground floor level shall be raised no later than 6 months after the trigger level has been breached. Provision shall be made in the construction of the club house to raise the ground floor level in accordance with the Adaptable Floor Level Plan, described under condition 810.

b) Within 3 months of the date of this approval a 1.2m AHD marker shall be installed and maintained at the site to be used as the trigger point for enacting the raising of the ground floor level. In the event that the 1.2m AHD trigger level is breached prior to the construction of the proposed clubhouse, the clubhouse ground floor level shall be constructed at 2.37m AHD.'

Specific threshold or trigger values

The approach taken in the development conditions illustrate the key elements that would need to be considered in applying a trigger-based approach to conditions of a development application. These are:

- there is clarity and definitiveness around the trigger value, for example, the threshold that defines future action
- there are provisions for the subject of the trigger value to be monitored over time
- there is clarity and definitiveness around the intervention that must be achieved, including timing of when the action has to be taken
- there is clarity around the role and responsibilities of who is to undertake the monitoring and address the solution, for example, the proponent.

Case study 14: Beachside development at Marcoola Beach (Qld)

Development approval for 'The Shore' Marcoola — a private development located at Marcoola Beach on the Sunshine Coast (Qld) — included a trigger-based condition. The present-day risk from beach erosion was assessed as being low due to the protection provided by the existing vegetated dune buffer. However, this risk profile is expected to change in the future in response to sea level rise and as the shoreline gradually recedes.

To capture the changing risk profile over time, the coastal management plan embedded within the development approval condition defines 3 coastal management zones (see Figure 16) described as:

- Tier 1 – green buffer zone (period of acceptable risk)
- Tier 2 – yellow buffer zone (risk approaching unacceptability)
- Tier 3 – red buffer zone (unacceptable risk).

The coastal management plan recognises that properly implemented and coordinated soft coastal management actions over the life of the development would help to extend the green and yellow buffer zone periods. The likely sequence of activities and the trigger for implementation were defined as:

- Tier 1 – dune vegetation and rebuilding to continue while buffer is greater than 52 m
- Tier 2 – planning for beach nourishment and/or seawall to commence once buffer is between 52 m and 26 m
- Tier 3 – beach nourishment and/or seawall implementation once buffer is less than 26 m.

These actions were underpinned by knowledge of the average shoreline position, which would be identified as part of council's wider coastal monitoring program. Approval for the development application included a range of conditions that relate specifically to the trigger-based coastal management plan and a funding model to obtain financial contributions from the developer (in the form of a sinking fund) to support future coastal management activities.

Figure 16 **Coastal management zone tiers for Marcoola Beach development area**

3.6 Inclusion in planning certificates

Triggers and thresholds can also be considered as part of planning certificates under the Environmental Planning and Assessment Act. Planning certificates are a means of disclosing information about a parcel of land, including any relevant information, policies and land-use controls that apply to the land at the time of issue.

3.6.1 Purchasing planning certificates

Planning certificates may be purchased from a council by anyone, at any time and for any purpose. Councils issue them under sections 10.7(2) and 10.7(5) of the Environmental Planning and Assessment Act and Schedule 2 of the Environmental Planning and Assessment Regulation. Further information about use of planning certificates can be found in current planning system circulars (see link in Section 4.1 'More information').

Section 10.7(2) planning certificate

Items in Schedule 2 of the Environmental Planning and Assessment Regulation must be reported on, and form part of a section 10.7(2) planning certificate. A planning certificate forms part of a contract of sale for all properties in New South Wales.

Planning certificates can indicate if property is in the coastal zone (within the meaning of the State Environmental Planning Policy [Resilience and Hazards]) or in a defined area such as a coastal vulnerability area.

Including a notation on a planning certificate specifically relating to coastal hazards and risks, may currently be reported in response to Schedule 2 Item 10 which states:

> **10 Council and other public authority policies on hazard risk restrictions**
>
> (1) Whether any of the land is affected by an adopted policy that restricts the development of the land because of the likelihood of land slip, bush fire, tidal inundation, subsidence, acid sulfate soils, contamination, aircraft noise, salinity, coastal hazards, sea level rise or another risk, other than flooding.
>
> (2) In this section —
>
> **adopted policy** means a policy adopted —
>
> (a) by the council, or
>
> (b) by another public authority, if the public authority has notified the council that the policy will be included in a planning certificate issued by the council.

Planning circular – Planning certificates: coastal hazards (DPE 2021) provides suggested wording for current and future coastal hazards and the following is an excerpt from the circular:

> **Suggested wording for current hazards**
>
> If a relevant policy or development control applies to land because of a current exposure to a coastal hazard, it is suggested that councils include a notation on the planning certificate in the following form:

> This land has been identified in the [*insert name of council policy or development control*] as having a current exposure to [*insert type of hazard(s)*]. The [*insert name of council policy or development control*] is based on a study dated [*insert date adopted by council*] and reflects information available at the time. Contact council for more information.

Suggested wording for future hazards

If a relevant policy or development control applies to land because of a future exposure to a coastal hazard, it is suggested that councils include a notation on the planning certificate in the following form:

> This land has been identified in the [*insert name of council policy or development control*] as having a future exposure to [*insert type of hazard(s)*]. The [*insert name of council policy or development control*] is based on a study dated [*insert date adopted by council*] and reflects information available at the time. Contact council for more information.

Section 10.7(5) planning certificate

Under section 10.7(5) of the Environmental Planning and Assessment Act, a council may also include advice on other relevant matters affecting the land of which it may be aware in a planning certificate. Items reported as part of a section 10.7(5) planning certificate are not mandated and are not required to form part of a contract of sale for properties in New South Wales.

Councils may consider including information on specific triggers or thresholds to the extent that they apply to subject land, as a notation on a s.10.7(5) planning certification.

This could include, for example:

- Future use and development of this land is subject to a trigger or threshold set in <insert CMP or planning instrument name or section>.
- Future coastal protection work on this land from coastal hazards is subject to a trigger or thresholds set in <insert CMP or planning instrument name or section>.
- Current use and occupation of dwellings on this land is subject to a trigger or threshold set in <insert CMP or planning instrument name or section>.

Care would need to be taken to ensure the information contained in the planning certificate, under both sections 10.7(2) and 10.7(5), is updated periodically or else that the wording reflects changes over time (for example, reference to the current CMP or successive certified CMPs).

Notwithstanding, inclusion of this level of specificity in a planning certificate would be beneficial to assist landowners and prospective purchasers to understand if there are critical constraints on future development on the land or if existing use and development may be affected in future by coastal hazards when trigger levels are exceeded.

3.7 Consideration in other planning documents and frameworks

Though this guidance has considered the use of triggers and thresholds in the context of CMPs and allied documentation, it is important to note that there are a range of other strategic planning frameworks administered by other NSW agencies that operate in the coastal zone. These include, for example, marine park zoning plans as well as plans of management for coastal parks and Crown land reserves.

Under these frameworks, triggers and threshold approaches as outlined in this guidance can also be readily applied in management of coastal hazards in accordance with the management goals of these agencies for these tenures. In this context, triggers related to the protection of natural and social assets in the coastal zone may be more relevant than consideration of hazards on the built environment.

However, it is important to ensure there are complementary objectives and approaches between a CMP and these other plans, particularly as they relate to shared triggers and thresholds that have been set for management responses.

Deep Creek estuary. Photo: J Lugg/DCCEEW

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More information

NSW Coastal management guidance

- NSW Government's Coastal management framework

Key NSW Government documentation that supports this guidance include:

- NSW Coastal management manual Parts A and B (Environment and Heritage webpage)
- Coastal management toolkit (Environment and Heritage webpage)
- Guideline for preparing a coastal zone emergency action subplan (Environment and Heritage webpage)
- Strategic planning toolkit (Planning webpage)
- Local planning and zoning (Planning webpage)

Guidelines from other jurisdictions on triggers and thresholds

Copies of the guideline documents from other jurisdictions referenced in Section 2 of this guidance:

- New Zealand — Coastal hazards and climate change guidance
- Queensland — Q-Coast 2100 Minimum standards and guidance for coastal hazard adaptation strategies
- Western Australia — Coastal hazard risk management and adaptation planning guidelines

Legislation and legal instruments

- Byron Local Environmental Plan 1988
- Environmental Planning and Assessment Act 1979
- Environmental Planning and Assessment Regulation 2021
- Current planning system circulars (Planning webpage)

Other useful information

- NSW Beach Profile Database (webpage hosted by University of NSW)
- Using climate observations to identify local risks (Coast Adapt webpage)
- Make informed decisions to improve community safety (Geoscience Australia, Australian Government, webpage)
- Sharing and Enabling Environmental Data in NSW (SEED) (NSW Government data portal)
- CoastAdapt (website hosted by the National Climate Change Adaptation Research Facility)
- Australian Flood Risk Information Portal (AFRIP) (Geoscience Australia, Australian Government, webpage)

Appendix A – References in the *Coastal management manual* where triggers and thresholds are discussed

Table 9 References in the *Coastal management manual* where triggers and thresholds are discussed (OEH 2018a,b)

Manual section	Quote/Extract
1. Part A: Mandatory requirements – Matters to be dealt with in a coastal management program – Mandatory requirements – Key issues to be identified	8. A CMP must: … ix. identify a proposed monitoring, evaluation and reporting program in relation to the CMP, including by identifying key indicators, **trigger points and thresholds** relevant to the CMP
2. Part A: Mandatory requirements – Review, amendment and replacement of a coastal management program – Mandatory requirements – Monitoring and reporting on implementation of a CMP	16. When implementing a CMP, a council must: … ii. monitor key indicators, **trigger points and thresholds** identified in the MER
3. Part B: Stage 1 – Section 1.6 Review the current coastal management arrangements	When reviewing the performance of existing management responses and land use planning instruments, a council may consider whether: • any previously identified monitoring **triggers or thresholds** have been reached
4. Part B: Stage 3 – Section 3.2 Steps in Stage 3 – Step 2: Identify potential management options	Important considerations when planning the timeframes for implementing coastal management actions include the … the proposed adaptation pathway, including agreed **thresholds and triggers**
5. Part B: Stage 3 – Section 3.2 Steps in Stage 3 – Step 4: Putting it together: document the rationale	It is important to consider how the proposed coastal management actions will be implemented over time, within an adaptive pathway that includes **thresholds and triggers** for change…

Manual section	Quote/Extract
6. Part B: Stage 3 – Identify and evaluate options Section 3.4 Managing coastal wetlands and littoral rainforests areas	Alert (in section 3.4) • identifying **thresholds and triggers** for possible future intervention Section 3.5.4 Planning for change (p. 27) Recommending the relocation of assets may involve: • specifying the thresholds and triggers for changing the response from accommodation or protection to the relocation of assets… Thresholds and triggers may be linked to a specific magnitude or frequency of hazards and damages, the condition of environmental or built assets, or the effectiveness of other mitigation or emergency response measures. In determining **thresholds and triggers**, the interdependencies between service-related infrastructure and development that is reliant on it (e.g. roads, water supply and sewerage systems), may be a consideration.
• Part B: Stage 3 – Identify and evaluate options Section 3.5.4 Planning for change	Relocating private development and associated public infrastructure may be an option to consider when: • the risks to existing residential development are extreme and unacceptable • the public benefits of protection structures and mitigation measures are low • the benefits to the environment and the broader community are high • it is no longer feasible or viable to mitigate the impacts of protection works on coastal processes, environmental values, beach amenity or public access • there are significant costs associated with remaining in place • there is a high degree of uncertainty about the adverse impacts of coastal protection works • there are significant opportunities to benefit environmental, cultural and social values including continued public access to a beach. Recommending the relocation of assets may involve:

Manual section	Quote/Extract
	• specifying the thresholds and triggers for changing the response from accommodation or protection to the relocation of assets Thresholds and triggers may be linked to a specific magnitude or frequency of hazards and damages, the condition of environmental or built assets, or the effectiveness of other mitigation or emergency response measures. In determining thresholds and triggers, the interdependencies between service-related infrastructure and development that is reliant on it (e.g. roads, water supply and sewerage systems), may be a consideration.
7. Part B: Stage 3 – Identify and evaluate options Section 3.5.5 Emergency response	Emergency responses aim to: • protect human life and public safety • minimise damage to property and assets • minimise impacts on social, environmental and economic values • not create additional hazards or risks. Effective coastal emergency responses will prioritise actions that support the continued functionality of essential infrastructure during and immediately after a coastal emergency. They will also help to improve the resilience of coastal communities and reduce their future reliance on emergency responses.
8. Part B: Stage 3 – Identify and evaluate options Section 3.5.5 Emergency response	**Coastal zone emergency action subplans** Under the Coastal Management Act a CZEAS must outline: • the roles and responsibilities of all public authorities (including the local council) in response to emergencies immediately preceding or during periods of beach erosion, coastal inundation or cliff instability, where the beach erosion, coastal inundation or cliff instability occurs through storm activity or an extreme or an irregular event; and • any works to be carried out for the protection of property affected or likely to be affected by beach erosion, coastal inundation or cliff instability.

Manual section	Quote/Extract
9. Part B: Stage 3 – Identify and evaluate options Section 3.6 Managing coastal environment areas	**Alert** • identifying thresholds and triggers for possible future intervention **Active intervention** Example of an approach: • intermittently closed and open coastal lake or lagoon (ICOLL) entrance management plans and triggers for opening.
10. Part B: Stage 3 – Identify and evaluate options Section 3.9.1 Adaptive management	**Adaptive management** Effective adaptive management depends on: • clear thresholds and triggers for change
11. Part B: Stage 3 – Identify and evaluate options Section 3.9.2 Using thresholds and triggers	**Thresholds** are the point when irreversible change is likely to occur, risks become unacceptable and the current management response will no longer be effective. An ecological **threshold** may be a tipping point where irreversible change (decline) occurs to the structure, functioning and resilience of an ecosystem. A physical threshold may be a point where natural defences are no longer effective in managing the risk of coastal erosion. In a community context, a **threshold** can be the point where a building becomes uninhabitable due to safety concerns, or a village or small town is no longer viable through functional failure of essential infrastructure, or loss of employment opportunities or population. A **trigger** is an incident or occurrence that initiates other events. In the case of decision making, a trigger is used to indicate when a management response is required and/or an action should be implemented. When applying an approach that takes uncertainty into account when determining **thresholds and triggers**, it is important to identify: • what is natural variability and what is outside the normal range, based on monitoring

Manual section	Quote/Extract
	• when affected owners or the community will be notified that a change of management may be required • when to start preparing for a new management response, allowing sufficient lead time for analysis, design, consultation and allocating funding in the Resourcing Strategy and Delivery Program • when the new management response will be implemented. Generally, physical rather than time-based **triggers** are preferable as they are based on actual events rather than uncertain predictions. **Triggers** can be controversial and community members may have different views about where the **trigger** should be set, so engagement is necessary to identify an acceptable balance. Where exceeding a **threshold** is likely to have significant resourcing implications for councils, it may be important to consider their likely occurrence within the Resourcing Strategy and Delivery Program review cycle.
12. Part B: Stage 4 – Prepare, exhibit, finalise, certify and adopt a coastal management program Section 4.2.7 A coastal zone emergency action subplan	The CZEAS should include: • **triggers** for emergency response actions
13. Part B: Stage 5 – Implement, monitor, evaluate and report Section 5.3.2 Land use and development controls in the LEP and DCP	A council's DCP must be consistent with the LEP. Section 22(2)(b) of the Coastal Management Act requires councils to give effect to its CMP through the preparation of planning proposals and DCPs. A DCP may contain more detailed guidance on development for coastal management areas. Implementation of the CMP will include consideration of the CMP in undertaking land use planning functions under the Environmental Planning and Assessment Act, including preparing planning proposals and DCPs. Land use zoning and controls in the DCP should encourage development that aims to manage impacts on existing and future development and to improve community resilience consistent with the CMP. Where the CMP suggests this

Manual section	Quote/Extract
	approach, councils can consider using a broad risk management hierarchy of avoidance, minimisation and mitigation, and reduce the overall risk by: • ensuring that there is no increase in the level of risk for existing and future development • reducing the exposure and vulnerability of development and assets • steering new development towards areas of lower risk and promoting development that is compatible with the level of risk • avoiding intensification and expansion of development in coastal vulnerability areas and in or around coastal wetland and littoral rainforest areas • considering the vulnerability of differing land uses and development to varying levels of risk from coastal hazards • designing development and infrastructure to be more resilient to coastal risks • identifying triggers and thresholds for changes in land use or types of development • protecting important environmental assets and values, including beaches, foreshores, environmental features and healthy coastal waterways • enhancing opportunities for appropriate coast-dependent businesses, which support economic growth and resilient coastal communities.
14. Part B: Stage 5 – Implement, monitor, evaluate and report Section 5.6.1 CMP monitoring requirements	Key elements of a monitoring program should consider: • the implementation status of the CMP • socioeconomic and environmental parameters • triggers and thresholds • the outcomes of the CMP in meeting the objects of the CM Act.