OUTCOMES FROM THE APPLICATION OF ISO 31000:2009 RISK MANAGEMENT PRINCIPLES TO COASTAL ZONE MANAGEMENT

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Abstract

The NSW Government has advocated a risk-based approach to the preparation of Coastal Zone Management Plans. Use of a risk-based approach is a relatively new and untested concept for coastal management in NSW.

The International Standard *Risk Management Principles and Guidelines* (ISO 31000:2009) has been tried and tested across numerous industries. It is thus a reliable methodology for applying a risk based approach. A process for adapting the ISO 31000:2009 method to preparation of coastal zone management plans has been devised and examples from numerous locations in NSW are demonstrated.

The *Coastal Protection Act 1979* states that CZMPs must make provision for the management of risks arising from coastal hazards. In order to manage risks, risks arising from coastal hazards must first be identified, analysed in terms of "likelihood" and "consequence" and evaluated through a risk assessment.

Assigning "likelihood" should be constrained to describing the potential extent of occurrence of coastal hazards. Assigning of "consequence" must consider the type of impact (e.g. permanent or reversible), and the type of development or asset (e.g. commercial, residential, public open space) including the beach itself. Assigning "consequence" can also incorporate social or economic values to allow differentiation between assets of the same type.

With use of a consistent approach to assigning "likelihood" and "consequence" from coastal hazards, the risk assessment provides a robust method for determining priority areas for treatment over appropriate timeframes.

Management options must consider both existing and future development. The risk ratings provide clarity as to existing development that requires treatment at the immediate timeframe as a priority. For future development (or redevelopment of existing structures), the risk ratings can also provide a mechanism for applying development controls across different development types (e.g. residential or commercial) over the design life relevant to those developments.

The Risk Management Process Applied to Coastal Management

The Risk Management framework is a robust, internationally accepted methodology for dealing with outcomes that are uncertain or have limited data, or for impacts with uncertain timeframes. This is particularly applicable for coastal management, both in relation to existing coastal processes and future climate change. The use of a risk-based approach accords with current international best practice for natural resource management, and has recently become a requirement of the NSW Government for managing coastal hazards.

Climate change in particular presents huge challenges to local government and the wider community, and the uncertainty associated with the timing and extent of impacts aggravates this challenge. Decisions made today are likely to have ramifications for up to 100 years (depending on the development), so consideration of an extended timeframe is essential, even though risks may not manifest for several decades.

The overall level of risk is ascribed to the existing development and land use. However, management efforts will be split between addressing risks to existing assets and minimising/avoiding risks to future development. For existing development, the approach taken should involve setting of triggers to determine when and to what extent action will be taken. Determining when to act ensures there is adequate planning and funding for action, but avoids burdening the community with costly action until impacts are clearly measured to be imminent.

For future development, a number of approaches to setting and applying development controls within coastal risk zones are available. The approaches have advantages and disadvantages, and in many cases, the use of any one approach will be strongly dependent upon the tolerance to risk of the council itself.

One particular approach to future development is to use the risk ratings in combination with consideration of the likely lifespan or timeframe of a development to set the level of control for different types of development. In this case, the type of development (and so, the consequence should it be impacted), and not just the timeframe of likely hazard impact, is used to manage future landuse planning within the coastal zone.

The basic steps involved in a risk assessment, which have been applied to coastal management, are:

- Establish the context
- Identify the risks
- Analyse the risks
- Evaluate the risks
- Treat the risks
- Implement Management Strategies (Risk Treatments)
- Monitoring and Review

Presented in Figure 1 are the steps involved in a risk assessment from ISO 31000:2009 *Risk Management Principles and Guidelines* adapted to the preparation of coastal zone management plans (CZMPs) for the open coast (i.e. excluding estuaries). This method has been applied to the preparation of a number of coastal hazards definition studies and CZMPs in NSW. Key considerations in applying Risk Management Principles to coastal hazards management are outlined below.

Context and Risk Identification

The requirements of a CZMP are set by the NSW *Coastal Protection Act 1979* and accompanying *Guidelines for Preparing Coastal Zone Management Plans* (DECCW, 2010). These documents provide the context for the risk assessment, which for the open coast focuses upon identifying and managing coastal hazards over the present to 2100 timeframe. The NSW Coastal Policy 1997 provides guidance on holistic management objectives (i.e. aspects of the coast beyond physical coastal hazards). The context, objectives and performance indicators / targets should then be tailored to the specific area in consultation with the local council, stakeholders and community.

The risks arise from the coastal hazards, as defined in the *Guidelines for Preparing Coastal Zone Management Plans* (DECCW, 2010) and the *Coastline Management Manual* (NSW Government, 1990). The major coastal hazards to which the risk assessment applies includes:
- beach erosion and recession,
- coastal inundation, and
- cliff and slope instability.

Minor hazards such as sand drift, erosion at stormwater outlets, and coastal entrance instabilities can be managed through the above major hazards or specific assessment, as required. These coastal risks impact upon coastal values, which include ecological, cultural, recreational and economic values.

Analysing the Likelihood and Consequence of Coastal Hazards

Risk is defined as *likelihood X consequence* (ISO 31000:2009). In the context of coastal hazards, the likelihood relates to the extent of hazard impact, now and in the future. In NSW, this should be identified when preparing a coastal zone hazards definition study.

The consequence of coastal hazards relates to the type or duration of impact and the value of land and assets affected. The land and assets affected will include any built assets as well as community and environmental amenity, the most important being the beach itself. Consequences may be social (aesthetic, recreational, cultural, service based), environmental, and / or economic.

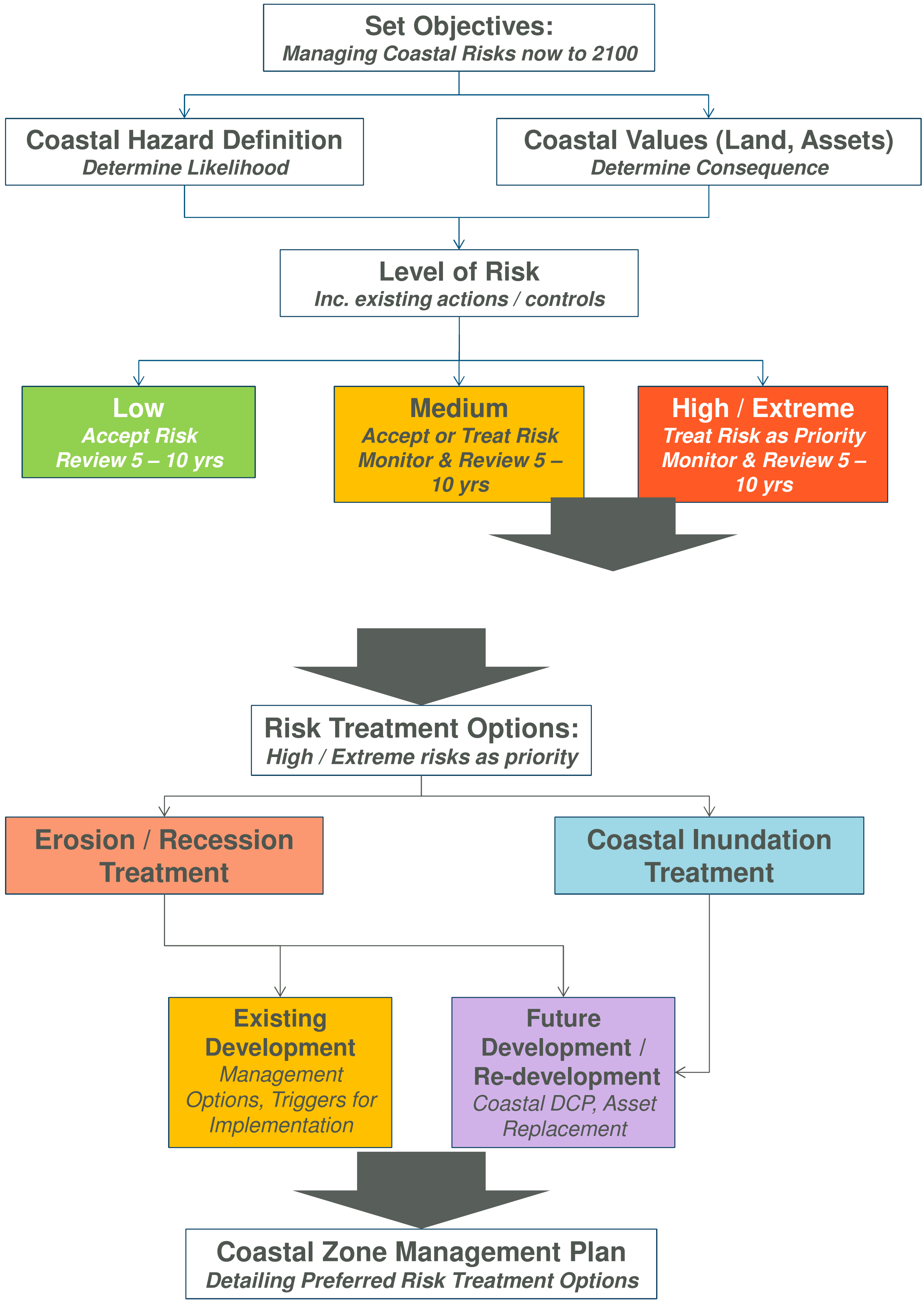

Figure 1 Risk Management Framework Applied to Preparing a Coastal Zone Management Plan

Analysing Likelihood

Ascribing likelihood to the hazard estimates provides transparency regarding the uncertainties, limitations and assumptions used to assess hazards. In addition, ascribing likelihood can educate coastal planners and the wider community that hazard lines are estimates only and not precise predictions of future shoreline response.

A qualitative likelihood scale for assessing coastal hazards has been developed, as given in Table 1. Compared with other risk assessment frameworks (e.g. council organisational risk frameworks) the likelihood scale considers considerably longer timeframes. This is necessary to encompass the likely occurrence of coastal hazards over standard planning horizons.

The likelihood scale ranges allows areas/zones to be established from 'almost certain' to 'rare', with progressively increasing distance from the coastline. The likelihood approach to coastal hazards also provides an opportunity to incorporate and qualify sensitivity testing outcomes and additional variables that may affect the extent of coastal hazards. Impacts greater than expected or "worst case scenarios" can be considered, but also qualified (e.g. as a rare likelihood).

Erosion extents may be far greater than a single best estimate, subject to the influences of various contributing factors. Uncertainty within these factors can be transparently considered using the "likelihood" rationale.

Table 1 Risk Likelihood / Probability, Coastal Hazards

Probability	Description
Almost Certain	There is a high possibility the event will occur as there is a history of frequent occurrence. The event is expected to occur in most circumstances.
Likely	It is likely the event will occur as there is a history of casual occurrence. The event has occurred several times or more in the past.
Possible	The event has occurred at least once in the past and may occur again.
Unlikely	There is a low possibility that the event will occur, however, there is a history of infrequent and isolated occurrence.
Rare	It is highly unlikely that the event will occur, except in extreme / exceptional circumstances, which have not been recorded historically.

Sea Level Rise

The likelihoods applied to coastal hazards are not related to the certainty of sea level rise itself, but rather, the likely extent of recession or inundation including other physical aspects (i.e. storm erosion and storm inundation respectively).

There is very good evidence that sea level rise is occurring. Furthermore, the NSW Government's *Sea Level Rise Policy Statement 2009* provides clarity as to the sea level rise benchmarks that must form part of coastal hazards assessment. However, uncertainties in estimating coastal hazards relate to the timeframes over which sea level rise may occur and the likely shoreline response. For example, there is still uncertainty as to whether the benchmark levels will be reached before or after 2100. Regardless, sea level rise is not expected to cease once these benchmarks are reached.

Certainly, shorelines will move upward and landward in response to sea level rise. However, the shoreline is complicated by headlands, reefs, man-made breakwaters and many other structural features. As sea level rises, the structural features of the coast will interact with waves and therefore sediment transport into and along embayments. Thus, the extent of recession along and between embayments in response to sea level rise will vary.

Tools to investigate shoreline response that account for three dimensional effects have only recently been developed. The historically applied Bruun Rule (1962) cannot account for structural features of the shoreline that will impact upon sediment transport and therefore recession as sea levels rise. The assessment technique applied in determining hazard areas thus also affects the uncertainty regarding shoreline response to sea level rise.

Erosion Events

In terms of future planning, the key consideration is determining where development can be sited in order to avoid detrimental impact. However, there are many aspects that may add to observed erosion, for example, rip currents, "beach rotation", longshore transport differentials associated with headland bypassing, consecutive storms and wave climate variability.

Thus, for planning it is important to consider the potential extent of erosion and the likely recurrence of such extents. Historical information on beach behaviour provides the best information as to the envelope of beach change over time (ie, erosion and accretion cycles). In this case, the most landward position of the beach in the past, even if the individual coastal processes or variables cannot be separated, provides a good indication of the likely future response, without climate change.

This approach is limited by the existing coastal survey data, however, the risk approach can be used to consider greater extents of erosion beyond measured values, and qualify the likelihood of such events. Where modelling must be employed due to a lack of available data, the likelihood approach can incorporate and qualify the outcomes of sensitivity testing to provide a range of likely estimates for beach erosion. This is particularly important given the complexity of coastal processes that cannot always be included in models.

Table 2 Likelihood Methodology for Erosion and Recession Extents

Probability	Immediate	2050	2100
Almost Certain	'average' beach erosion [1]	Immediate 'average' beach erosion + breakwater impacts + all structural protection	Immediate 'average' beach erosion + breakwater impacts + all structural protection
Likely	NM[2]	*Immediate 'average' beach erosion + 0.4 m SLR recession + breakwater impacts + formal structural protection only*	*Immediate 'average' beach erosion + 0.9 m SLR recession + breakwater impacts + formal structural protection only*
Possible	NM	NM	NM
Unlikely	'maximum' beach erosion at any position along the beach [1]	Immediate 'maximum' beach erosion + 0.4 m SLR recession + breakwater impacts + formal structural protection only	Immediate 'maximum' beach erosion + 0.9 m SLR recession + breakwater impacts + formal structural protection only
Rare	'extreme' beach erosion[3] + seawalls removed	**Worst Case of either**: Breakwater impacts + seawalls removed **AND** Immediate 'maximum' beach erosion + 0.7 m SLR recession **OR** Immediate 'extreme' beach erosion + 0.4 m SLR recession **OR** Immediate 'maximum' beach erosion + 0.4 m SLR + 5 ° more easterly wave climate	**Worst Case of either**: Breakwater impacts + seawalls removed **AND** Immediate 'maximum' beach erosion + 1.4 m SLR recession **OR** Immediate 'extreme' beach erosion + 0.9 m SLR recession **OR** Immediate 'maximum' beach erosion + 0.9 m SLR + 5 ° more easterly wave climate

[1] *as measured over the past 4 decades.*
[2] *NM = Not Mapped due to inadequate data to differentiate likelihoods between 'almost certain' and 'unlikely'.*
[3] *Assumed to be 'maximum' erosion plus 'average' beach erosion.*

Man-made Structures

Breakwaters, training walls or other groyne like features, artificial reefs and seawalls introduced into the coastal zone will impact upon the coastal system. In assessing the likelihood of erosion, the impact of long term recession / accretion due to man-made structural features can be clearly accounted for, with and without sea level rise, as in Table 2.

For example, river entrance training walls that occur commonly along the NSW shoreline have resulted in accretion on updrift shorelines and erosion of downdrift shorelines until the coastal system reaches equilibrium with the feature (typically ~ 100 years). Depending upon the timing of construction (0 – 150 years ago), impacts may be continuing, such as at Coffs Harbour. In severe cases, such as the Newcastle Harbour Breakwaters (Hunter River), the coastal sediment supply to the downdrift coast will not be restored without further human intervention.

The likelihood approach can also capture the protective capacity of existing seawalls. For example in Newcastle, various seawalls including both properly engineered structures and basic vertical walled promenades exist along the shoreline. The likelihood approach utilised accounted for the different levels of protection provided by the walls such that: 1) informal walls can be assumed to withstand smaller events, but fail over the long term; 2) properly engineered walls can be assumed unlikely to fail; and 3) the impact of failure of properly engineered walls can be investigated as a worst case or ‘rare’ scenario.

Assigning Consequence

The consequence scale has been expanded to provide a triple bottom line assessment, that is, to consider social, environmental and economic impacts from hazards, in Table 3. While ascribing “consequence” is much more subjective than ascribing “likelihood”, this subjectivity may be an advantage for coastal managers. The consequence levels ascribed will be different for different locations (and local government areas), and can reflect local priorities, differentiate assets of the same type, and reflect local tolerance for risk consequence.

In developing a scale to assess consequence of coastal hazards, the 100 year planning horizon is again an important consideration. The scale must also be set to provide clear differentiation between “catastrophic” down to “insignificant” impacts.

Key to the assessment of consequence is the type of impact, for example, permanent loss of land through erosion compared with periodic, short term inundation. On coastlines constrained by bedrock, the consequence may not be on back beach development, but on the beach itself, as sand is more frequently removed to expose bedrock, or the beach is permanently inundated over time.

The consequence of coastal hazards then depends on the type of development and assets (i.e. land use) and their values in the coastal zone. Consequence can be assigned to land and assets spatially. This includes utilising vegetation and other spatial data to map areas of high conservation value, recreational, aesthetic and cultural value, in addition to built assets and critical infrastructure. The beach itself is also a key asset, particularly in highly developed coastal areas or iconic beach localities.

Table 3 Consequence Scale for Coastal Hazards

Consequence	Society / Community	Environment	Economy
Catastrophic	Widespread permanent impact to community's services, wellbeing, or culture (eg, > 50 % of community affected), or national loss, or no suitable alternative sites exist	Widespread, devastating / permanent impact (e.g. entire habitat destruction), or loss of all local representation of nationally important species (e.g. endangered species). Recovery unlikely.	Damage to property, infrastructure, or local economy > $20 million*
Major	Major permanent or widespread medium term (somewhat reversible) disruption to community's services, wellbeing, or culture (eg up to 50 % of community affected), or regional loss, or Only a few suitable alternative sites exist	Widespread semi-permanent impact, or widespread pest / weed species proliferation, or semi-permanent loss of entire regionally important habitat. Recovery may take many years.	Damage to property, infrastructure, or local economy >$5 million - $20 million
Moderate	Minor long term or major short term (mostly reversible) disruption to services, wellbeing, or culture of the community (eg, up to 25 % of community affected), or sub-regional loss, or Some suitable alternative sites exist	Significant environmental changes isolated to a localised area, or loss of regionally important habitat in one localised area. Recovery may take several years.	Damage to property, infrastructure, or local economy >$500,000** - $5 million
Minor	Small to medium short term (reversible) disruption to services, wellbeing, finances, or culture of the community (eg, up to 10 % of community affected), or local loss, or many alternative sites exist	Environmental damage of a magnitude consistent with seasonal variability. Recovery may take one year.	Damage to property, infrastructure, or local economy >$50,000 - $500,000
Insignificant	Very small short term disruption to services, wellbeing, finances, or culture of the community (eg, up to 5 % of community affected), or neighbourhood loss, or numerous alternative sites exist	Minimal short term impact, recovery may take less than 6 months, or habitat affected with many alternative sites available.	Damage to property, infrastructure, or local economy >$50,000

Evaluate the Risks

As the level of risk is the combination of likelihood and consequence, spatial mapping of consequence can be combined with hazard maps, to produce a "risk" map (at relevant planning timeframes). Risk mapping enables identification of the risk to critical built assets, beach amenity, and other aspects of community, ecological and economic value in the coastal zone, allowing for clear prioritisation of management efforts towards those assets or areas at greatest risk.

The level of risk assigned shall also incorporate any existing management actions that already treat coastal risks, partially or fully.

Areas or assets affected by coastal risks are prioritised for treatment based on the level of risk that is deemed acceptable, tolerable and intolerable. Typically, ‘extreme’ and ‘high’ risks are considered intolerable, ‘medium’ risks are tolerable and ‘low’ risks are considered acceptable (with a view to monitoring over time).

Treat the Risks

The process of developing coastal management options is directly related to reducing or eliminating intolerable risks. Different approaches to existing development and future development will be required, and management actions will also be appropriate to the type of hazard impact (See Figure 1). The typical management approach to existing and future development is shown in Figure 2. That is, for existing development, management approaches over the last 20 years fall into the category of “protect”, “accommodate” or “retreat”. For future development, decisions essentially amount to “avoid”, “accommodate” or “accept” the risk, and such decisions may depend on tolerance to risk at a local government scale.

Existing Development

Existing development at extreme or high risk over the current timeframe will require treatment as a priority. However, it is still appropriate to define a trigger at which action should be implemented, as the timeframe for coastal hazards are be uncertain, regardless of climate change. Triggers should reflect the type of hazard (e.g. erosion or inundation) and must ensure enough time to implement action prior to the occurrence of an unacceptable hazard impact (Fisk and Kay, 2010).

For existing development at extreme or high risk over the 2050 or 2100 timeframe, the intent for management action can be selected and should be signalled to the community. However, there is no immediate need for action. For existing assets at risk over the longer term, the trigger for action should also include re-development, such that relocation or redesign of the asset is adopted when the asset requires replacement or refurbishment.

Future Development

Future development controls should cover both greenfield and infill development, and thus, existing development at future high risk may also be managed through future development controls. The level of control will reflect the local tolerance for risk and capacity for risk management. However, NSW Coastal Planning Guidelines stress intensification of the value of land or assets at risk over time should be avoided.

Approaches to applying future development controls have been determined to include:

- Selecting one set of hazard likelihood lines at one timeframe, and adopting "avoid", "accommodate" and "accept" in accordance with likelihood
- Utilising the spatial risk maps and expected design life (or timeframe) of development to specify controls across high, medium and low risks
- Preparing local area plans at specific locations deemed at high risk.

In selecting one timeframe and one set of hazard lines, e.g. the 2050 'almost certain', 'unlikely' and 'rare' erosion hazard estimate, the government authority may then decide to 'avoid' development seaward of the 'almost certain' line; 'accommodate' or 'avoid' development between the 'almost certain' and 'unlikely' line; and 'accommodate' or 'accept' development between the 'unlikely' and 'rare' hazard line. The advantage of this approach is to simplify the selection of hazard lines. However, development may be excluded from a zone that would otherwise be suitable, for example a community facility with a 20 year lifespan. Conversely, developments may be accepted in inappropriate areas, for example, critical infrastructure of 100 year lifespan within a 50 year hazard zone.

The use of spatial risk maps in combination with the likely timeframe for development offers a number of advantages. The approach is summarised in Table 4, and involves using the lifespan of the development to select the appropriate timeframe (immediate, 2050 or 2100) over which to ascribe the level of risk. Development controls are then applied to the level of risk (high, medium, low) as appropriate to the type of development.

For example, for critical infrastructure with a 100 year timeframe, the risk level assigned to land at the 2100 timeframe is applied when siting or rebuilding the development. High risk areas at the 2100 timeframe are then avoided. Likewise, this approach may allow a community facility to be developed in an area at low risk at the current timeframe. As the facility will no longer be present by 2100, the risk level at 2100 is not relevant.

There are a number of advantages to this approach, in particular, ensuring appropriate placement of developments over appropriate timeframes. The approach also avoids scrutiny over the 'exactness' of hazard lines, by including the consequence of coastal hazards (land use) into decision making.

The use of local area plans offers a solution where a known area of high risk requires treatment immediately. It also allows for one area to form a case study prior to employing a management approach more broadly across a local government or larger area. However, there may be disadvantages to this approach, for example a decision is still required over which hazard likelihood line should apply. Further, while resources and controls are being applied to one area, other areas will become increasingly at risk over time.

The approach to future development controls will vary between local government areas, and this is likely to reflect the tolerance to risk from coastal hazards at each location.

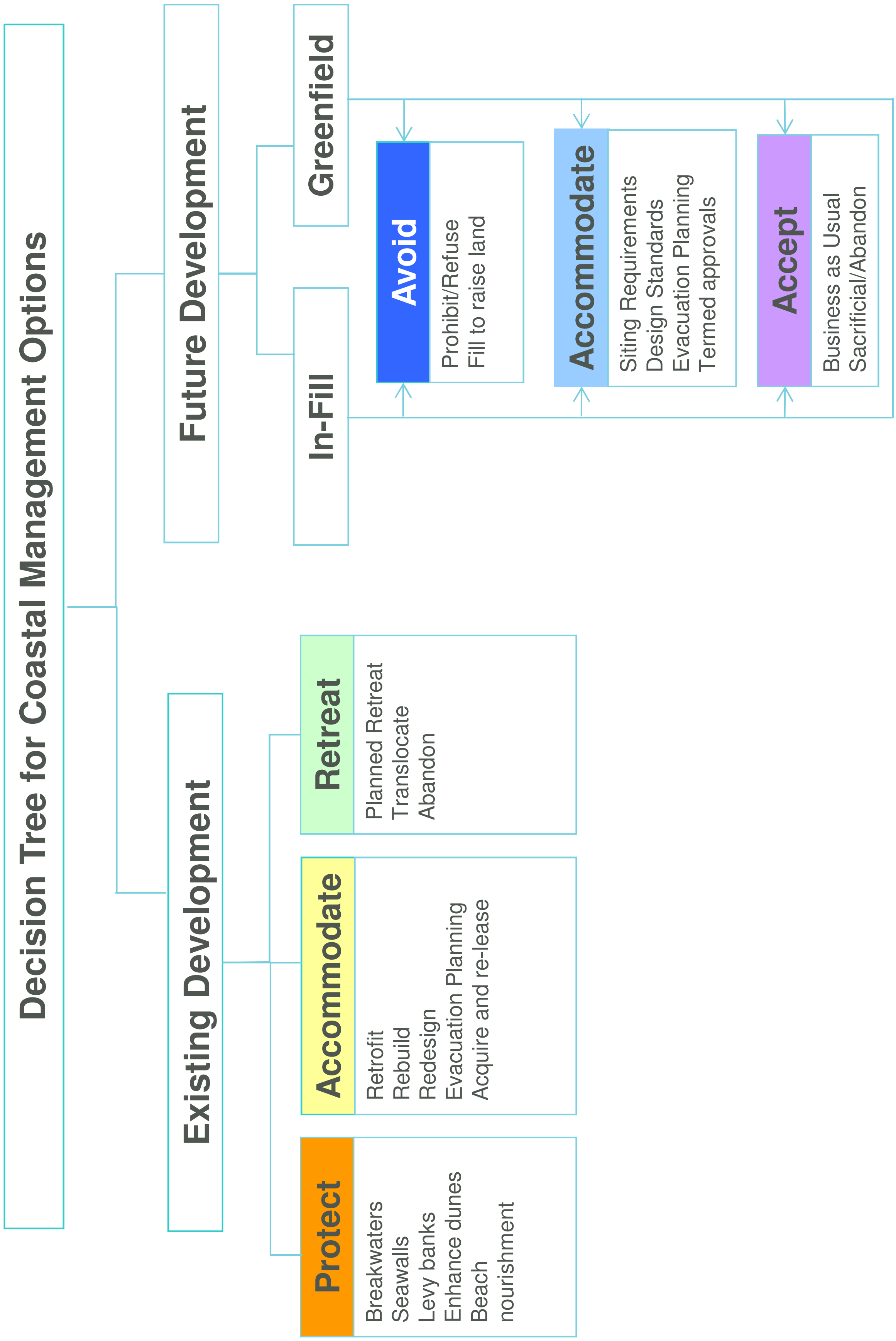

Figure 2 Coastal Management Options: Existing and Future Development

Table 4 Spatial Risk Maps and Design Life Approach to Future Development

Land Use Categories**	Anticipated **Design Life (yrs)**	Risk Level*	High Risk Areas	Medium Risk Areas	Low Risk Areas
Critical Utilities	75 -100	2100 Risk Levels	Development Not Permitted	Permissible with use of strict design criteria	Permissible with use of lesser design criteria
Residential	75 - 100	2100 Risk Levels	Development Not Permitted	Permissible with use of strict design criteria	Permissible with use of lesser design criteria
Public recreational facilities / buildings	25	2011 Risk Levels	Permissible with use of lesser design criteria	Permissible	Permissible
Commercial & Industrial	50	2050 Risk Levels	Permissible with use of strict design criteria	Permissible with use of lesser design criteria	Permissible
Tourist Related Development	25	2011 Risk Levels	Permissible (provided liability etc accounted for)	Permissible	Permissible
Recreation & Non-Urban	25	2011 Risk Levels	Permissible (provided liability etc accounted for)	Permissible	Permissible
Essential Community Facilities	75 -100	2100 Risk Levels	Development Not Permitted	Permissible with use of strict design criteria	Permissible with use of lesser design criteria
Subdivision	100	2100 Risk Levels	Development Not Permitted	Permissible with use of strict design criteria	Permissible with use of lesser design criteria

Monitoring and Review

A key component of the risk management process is monitoring and review. This involves re-assessment of risk levels over time including review of the effectiveness of management actions and new risks that may have arisen since the original risk assessment.

Risk management is an iterative process. This is particularly relevant for coastal management and climate change. Risk levels are updated as new information regarding climate change and coastline response is developed. Further, management responses can likewise be adjusted to reflect new circumstances.

Conclusions

The ISO 31000:2009 Risk Management Principles and Guidelines can be readily adapted to the preparation of coastal zone management plans for open coast hazards. The Risk Management Framework is a suitable methodology for incorporating the uncertainties associated with existing coastal processes and future climate change, particularly sea level rise.

Analysing the level of risk from coastal hazards involves consideration of both likelihood and consequence. Analysing the likelihood of coastal hazards relates to the potential extent of a hazard and provides transparency and qualification of variables that may affect the extent of coastal hazards, including sensitivity testing outcomes. Impacts greater than expected or “worst case scenarios” can be considered, but also qualified (e.g. as a rare likelihood).

Consequence of coastal hazards relates to the type of impact (e.g. permanent loss of land, or short term inundation), as well as the built and natural assets affected. Local values can also be incorporated into the assessment, enabling local priorities or risk tolerance to be captured and differentiation between similar assets.

Management approaches need to address both existing and future development. For existing development, setting a trigger for action ensures costly action can be planned, but implemented only as required. Triggers must allow time to implement action prior to the occurrence of an unacceptable hazard impact.

For future development, the decision to “avoid”, “accommodate” or “accept” development may be tied to the risk from coastal hazards over the lifespan of the development. However, future development decisions may depend on tolerance to risk at a local government scale.

Whilst this paper has outlined a sound approach for applying the ISO Risk Standard to coastal management, there remains a lack of effective technical guidelines that would enable a consistent approach to be adopted for coastal risk assessments. Such guidelines could be targeted at broadscale strategic landuse planning, such as that required by Councils under the NSW Government's Coastal Management Program, or individual and asset landowners (including Federal, State and Local Governments) who require 'due diligence' on risks to existing land and assets, and guidance on the scope and potential restrictions for future land and asset improvements.

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