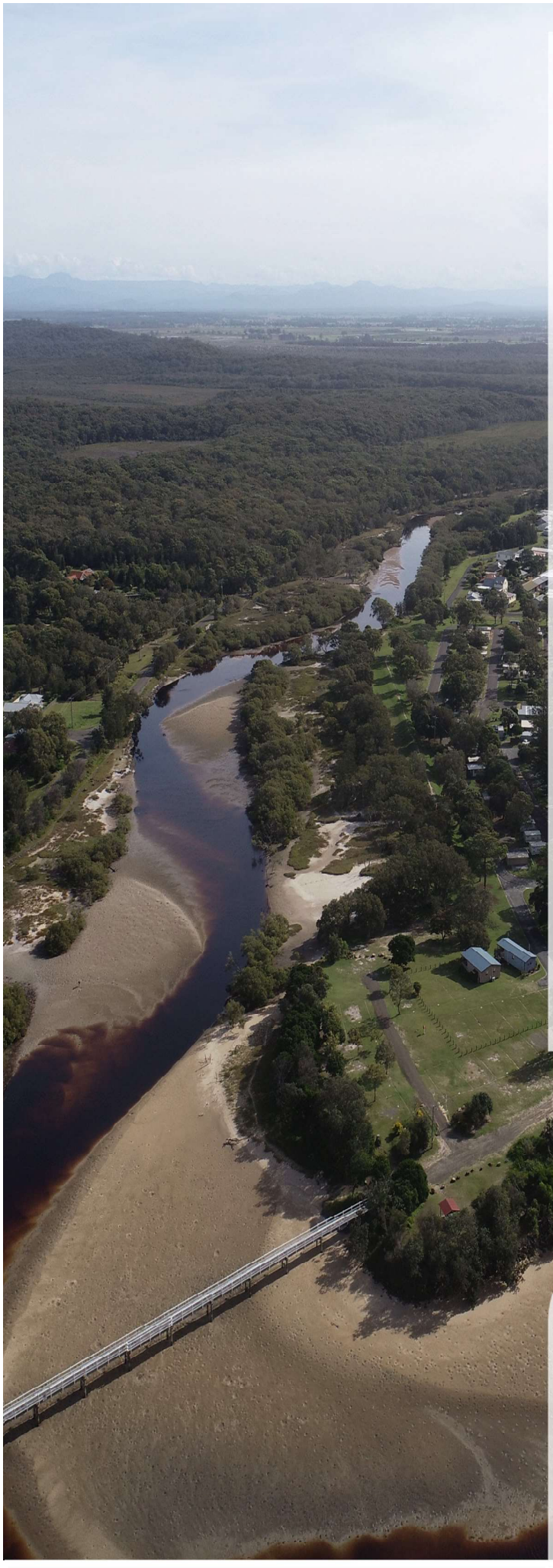

JBP
scientists
and engineers

Coastal vulnerability maps and associated

Coastal Hazards Mapping Risk Assessment

Final Report

January 2021

KEMPSEY
Shire Council

JBP Project Manager

Daniel Rodger
Jeremy Benn Pacific
Suite T46, 477 Boundary Street
Spring Hill, QLD 4000
Australia

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Contract

This report describes work commissioned by Ron Kemsley, on behalf of Kempsey Shire Council. Ellie Vahidi, Barney Bedford, Michael Thomson and Daniel Rodger of JBP carried out this work.

Prepared by ..... William Prentice BEng, MIEAust, CPEng, NER, FMA
Technical Director

Reviewed by ..... Dr Ellie Vahidi PhD, MEng, BEng
Hydraulic Engineer

Reviewed by ..... Daniel Rodger BSc MEng CEng CMarEng MIEAust
Director

Approved by ..... Daniel Rodger BSc MEng CEng CMarEng MIEAust
Director

Purpose

This document has been prepared as a Final Report for Kempsey Shire Council. JBP accepts no responsibility or liability for any use that is made of this document other than by the Client for the purposes for which it was originally commissioned and prepared.

JBP has no liability regarding the use of this report except to Kempsey Shire Council.

Acknowledgements

Kempsey Shire Council has prepared this document with financial assistance from NSW Government through the Department Planning, Industry & Environment. This document does not necessarily represent the opinions of the NSW Government or the Department Planning, Industry & Environment.

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Trading as Jeremy Benn Pacific and JBP Scientists and Engineers

ABN: 56 610 411 508

ACN: 610 411 508

Executive Summary

JBPacific were commissioned by Kempsey Shire Council to develop a Coastal Vulnerability Area (CVA) map for the Kempsey Local Government Area (LGA). The CVA map is a key output of Stage 2 of the Coastal Management Program (CMP), in compliance with the *Coastal Management Act 2016* and the *State Environmental Planning Policy (Coastal Management)* 2018 (the Coastal Management SEPP).

This report describes the development of mapping of the coastal vulnerability areas (CVA), which identifies land subject to coastal hazards. The development of the CVA map has included consideration of seven coastal hazard mapping components;

- Hazard 1: beach erosion
- Hazard 2: shoreline recession
- Hazard 3: coastal lake or watercourse entrance instability
- Hazard 4: coastal inundation
- Hazard 5: coastal cliff or slope instability
- Hazard 6: tidal inundation
- Hazard 7: erosion and inundation under tides, waves, and catchment floodwaters.

The development of the CVA maps has been undertaken in close consultation with council stakeholders, who have worked with the Department of Planning, Industry and the Environment (DPIE) Environment, Energy and Science group and the Department's regional planning team.

Coastal hazard modelling and mapping has been undertaken by reviewing existing coastal zone mapping and where necessary updating or completing specialist coastal hazard modelling and assessment at a local scale.

It was noted that information related to hazard 7 is currently not available for the Saltwater Creek catchment and updating the existing study to provide that information was outside the scope of the Technical Studies project. It is recommended that funding, including via available grant programs, be obtain for the necessary flood study updates in the Saltwater Creek catchment as a matter of priority. The updated flood study should also aim to provide information related to Hazard 7, so that comprehensive data is available to support the adoption of Coastal Vulnerability Area mapping across the local government area.

It is recommended that the outcomes of Stage 2 of the Coastal Management Program be progressed to Stage 3, subject to formal Council endorsement.

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Abbreviations

AHD ..... Australian Height Datum

CMP ..... Coastal Management Program

CVA..... Coastal Vulnerability Area

HAT..... Highest Astronomical Tide

IRSD ..... Index of Relative Socio-economic Disadvantage

JBP ..... Jeremy Benn Pacific or JBPacific

KCPHDS..... Kempsey Coastal Processes and Hazard Definition Study

KSC..... Kempsey Shire Council

LGA..... Local Government Area

MHL ..... Manly Hydraulic Laboratory

NSW..... New South Wales

RDM..... Resource Design Management

SEPP ..... State Environmental Planning Policy (Coastal Management) 2018

Definitions

Where possible, definitions used in this document are based on the NSW Coastal Management Manual and NSW Coastal Management Glossary. The seven hazards are defined as:

- Hazard 1: Beach erosion: the 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.
- Hazard 2: Shoreline recession: the 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.
- Hazard 3: Coastal lake or watercourse entrance instability: 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.
- Hazard 4: Coastal inundation: 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.
- Hazard 5: Coastal cliff or slope instability: No definition of this hazard is provided in the NSW Coastal Management Manual, however the NSW Coastal Management Manual relates instability to risk to life and property, e.g. from "catastrophic failure of cliffs and headlands and hazards associated with rock platforms".
- Hazard 6: Tidal inundation: 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.
- Hazard 7: Erosion and inundation of foreshores under tides, waves, and catchment floodwaters: This hazard does not have a formal definition within the NSW Coastal Management Glossary.

1 Introduction

JBPacific were commissioned by Kempsey Shire Council (KSC) to develop a Coastal Vulnerability Area (CVA) map for the Kempsey Local Government Area (LGA). This has been developed in accordance with the *Coastal Management Act 2016* (the Act) and *State Environmental Planning Policy (Coastal Management) 2018* (the SEPP), as a part of the NSW government coastal planning reforms. The development of this CVA map has included two studies; a Stage 2 Technical Study and this Stage 2 coastal hazard risk assessment. This report should be read in conjunction with the Stage 2 Technical Study.

In developing the CVA mapping consideration was given to ensuring Council would be able to meet the objectives of the Act. The objectives of the Act are:

> *'to manage the coastal environment of New South Wales in a manner consistent with the principles of ecologically sustainable development for the social, cultural and economic well-being of the people of the State, and in particular—*
>
> *(a) to protect and enhance natural coastal processes and coastal environmental values including natural character, scenic value, biological diversity and ecosystem integrity and resilience, and*
>
> *(b) to support the social and cultural values of the coastal zone and maintain public access, amenity, use and safety, and*
>
> *(c) to acknowledge Aboriginal peoples' spiritual, social, customary and economic use of the coastal zone, and*
>
> *(d) to recognise the coastal zone as a vital economic zone and to support sustainable coastal economies, and*
>
> *(e) to facilitate ecologically sustainable development in the coastal zone and promote sustainable land use planning decision-making, and*
>
> *(f) to mitigate current and future risks from coastal hazards, taking into account the effects of climate change, and*
>
> *(g) to recognise that the local and regional scale effects of coastal processes, and the inherently ambulatory and dynamic nature of the shoreline, may result in the loss of coastal land to the sea (including estuaries and other arms of the sea), and to manage coastal use and development accordingly, and*
>
> *(h) to promote integrated and co-ordinated coastal planning, management and reporting, and*
>
> *(i) to encourage and promote plans and strategies to improve the resilience of coastal assets to the impacts of an uncertain climate future including impacts of extreme storm events, and*
>
> *(j) to ensure co-ordination of the policies and activities of government and public authorities relating to the coastal zone and to facilitate the proper integration of their management activities, and*
>
> *(k) to support public participation in coastal management and planning and greater public awareness, education and understanding of coastal processes and management actions, and*
>
> *(l) to facilitate the identification of land in the coastal zone for acquisition by public or local authorities in order to promote the protection, enhancement, maintenance and restoration of the environment of the coastal zone, and*
>
> *(m) to support the objects of the Marine Estate Management Act 2014.'*

The development of CVA maps form part of the Coastal Management framework for land use planning within the coastal zone. The overall framework includes four coastal management areas:

- Coastal wetlands and littoral rainforests
- Coastal Vulnerability Area (CVA)
- Coastal environment area
- Coastal use area.

The coastal vulnerability area (CVA) is land which is subject to current and future hazards, where development controls will aim to manage risk to human life, infrastructure and public and private property. Because development within the CVA may create a legacy issue for future generations, where appropriate, land use planning instruments should effectively manage the long-term risk associated not just with present day exposure, but should also consider future coastal processes and conditions. The development of the CVA map has included consideration of seven coastal hazards:

1. Beach erosion
2. Shoreline recession
3. Coastal lake or watercourse entrance instability
4. Coastal inundation
5. Coastal cliff or slope instability
6. Tidal inundation
7. Erosion and inundation under tides, waves, and catchment floodwaters.

In addition to this introductory chapter the report contains the following sections:

- Section 2: Summary of available mapping for coastal hazards
- Section 3: Risk assessment
- Section 4: Recommendations

2 Available hazard mapping

2.1 Hazard 1: Beach erosion

Beach erosion is defined as:

"the 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."

Beach erosion mapping has been completed within the Kempsey Coastal Processes and Hazard Definition Study (KCPHDS). This mapping has used an evidence base to understand past erosion events and their potential to occur again in the future. Through analysis of photogrammetric data spanning the 1940's to 2011, beach erosion extents have been defined based upon analysis of the most eroded profiles observed within historic records. Three beach erosion likelihoods were produced; reflecting 'almost certain', 'unlikely' and 'rare' extents. These three likelihoods are described as following:

- Almost certain: There is a high possibility the event will occur as there is a history of frequent occurrence
- Unlikely: There is a low possibility that the event will occur, however, there is a history of infrequent or isolated occurrence
- Rare: It is highly unlikely that the event will occur, except in extreme/exceptional circumstances, which have not been recorded historically

Whilst comprehensive, the analysis and modelling were completed in 2011 based on beach erosion data now a decade old. New beach profile data is available from NSW Beach Profile Database, which indicate recent erosion extents may exceed, or be very similar to, the significant erosion observed within the 1970 storms. Based on this new data, and the current practise to include an allowance for reduced foundation capacity within erosion extents, coastal erosion hazard mapping has been based on the 'rare' extents produced within the KCPHDS. This 'rare' erosion hazard map reflects an extent larger than the envelop of historic shoreline positions captured within the 1940-2011 record, which is considered suitable for the CVA map until an updated assessment is undertaken. One exception has been made at Crescent Head, where the 'unlikely' erosion hazard extents have been adopted for areas behind the rock armour revetment wall that lines the southern side of Killick Creek. Under this 'unlikely' scenario it is assumed the revetment will mitigate any erosion.

2.2 Hazard 2: Shoreline recession

Shoreline recession is defined as:

"the 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."

Shoreline recession mapping has been completed within the KCPHDS (2013) using numerical modelling. The future shoreline position was assessed using the Shoreline Evolution Model (SEM), which simulated the response of the shoreline to sea level change. The SEM model was calibrated against historic field data spanning 1940 to 2011 before being used to project future trends.

The model performance is critically linked to the historic trends within beach profile data. A degree of uncertainty exists within the shoreline recession modelling due to their lack of data since 2011.

Whilst a high-level review only was completed as part of the technical studies, the inclusion of new data is not expected to substantially change the long-term recession map. By projecting these trends forward by 80 years, the inclusion of new data may change the future 2100 shoreline position by around ±10m. Given the variability in long term coastal hazard assessments, this uncertainty has been acknowledged within the CVA mapping, and the existing maps recommended for use until a revised coastal recession assessment can be undertaken.

Given the nature of the previous assessment the Stage 2 Technical Study considers it reasonable to utilise estimates of shoreline recession mapped in conjunction with beach erosion estimates for existing and future exposure.

2.3 Hazard 3: Coastal lake or watercourse entrance instability

Coastal lake or watercourse entrance instability is described as:

" 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."

At many untrained coastal estuaries and rivers, there is inherent variability of the coastal entrance position. While some estuary channels and entrances are relatively stable through time and are held by natural geomorphic features (e.g. Korogoro Creek), others have historically broken through at various positions along the coast. Other causes for entrance instability can be artificial openings or new engineered structures being introduced into the coastal system, such as the large-scale changes made to the Macleay River.

Mapping of beach erosion and shoreline recession within the KCPHDS does not consider the dynamic position of the estuary entrances. A new entrance instability assessment was undertaken for Crescent Head (Killick Creek), Hat Head (Korogoro Creek), and South West Rocks (Saltwater Creek). This has used historic aerial imagery to map the maximum observed envelope of entrance positions. The instability area was limited to the estuary mouth. It extends around the envelope of historic shoreline positions, following logical cadastre lot boundaries. The width of the instability zone has been reduced in areas where the historic entrance position has now been formalised by an approved training structure. The outputs of this mapping is considered fit-for-purpose for inclusion in the CVA map.

2.4 Hazard 4: Coastal Inundation

Coastal inundation is described as occurring 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 flooding is a complicated process, affected by several dependent and independent variables. In order to map the coastal inundation occurring behind the shoreline, consideration has had to be given to the underlying astronomical tide, storm surge and the wave effects.

Coastal inundation was simulated using the updated hydraulic model described in the Stage 2 Technical Studies report. In addition to the tidal signature, the model was updated to include a component of storm surge and wave setup within the coastal boundaries, and new wave overtopping inputs at Hat Head. The hydrodynamic model is considered robust and fit-for-purpose of defining the likely areas affected by Coastal Inundation (Hazard 4).

2.5 Hazard 5: Tidal Inundation

Tidal inundation is defined as:

" 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."

Tidal inundation modelling and mapping has been undertaken using the updated hydraulic model described the Stage 2 Technical Studies report, using the outputs of a hydrodynamic model, which simulated a Highest Astronomical Tide throughout the Kempsey coastline and estuaries. The calibrated hydrodynamic model is considered robust and fit-for-purpose of defining the likely areas affected by Tidal Inundation (Hazard 5).

2.6 Hazard 6: Coastal cliff or slope instability:

No definition of this hazard is provided in the NSW Coastal Management Manual, however the NSW Coastal Management Manual relates instability to risk to life and property, e.g. from "catastrophic failure of cliffs and headlands and hazards associated with rock platforms".

A goal of the KCPHDS was to identify areas that may be subject to cliff instability for further investigation. No significant cliff instability areas were identified within the document, and the hazard associated with coastal cliff or slope instability is considered minor.

Consequently, no mapping has been produced for Hazard 6.

2.7 Hazard 7: Erosion and inundation of foreshores under tides, waves, and catchment floodwaters

This hazard does not have a formal definition within the NSW Coastal Management Glossary. It is understood to encapsulate all foreshore areas that could be affected by erosion or inundation from combined coastal and fluvial processes.

Mapping has been based on a combined flood and tide scenario simulated within the Lower Macleay Flood Study (2019). The design event combined a 1% Annual Exceedance Probability (AEP) (100-year return period) fluvial flood coinciding with a Higher High Water Spring (HHWS) tidal boundary. The model includes a number of flood gates, flood control structures and levees that help mitigate flooding throughout the Lower Macleay valley. The fluvial-tidal interaction is captured at the downstream extents of the modelled creeks where a tidal signature provides a realistic oscillation in flood levels. Whilst the modelled inundation extends throughout the greater floodplain, its inclusion provides consistency with other Council flood risk planning maps.

It is noted that the hydraulic model extends from the confluence of the Macleay River at the coastline upstream, to a point approximately two kilometres upstream of West Kempsey near Euroka. Given the accepted approach to mapping of this hazard, the model extents limit the mapping of hazard 7 beyond this point. Mapping of hazard seven shows the ‘limit of modelling’ at this location.

2.8 Summary of coastal hazard exposure mapping

The Stage 2 Technical Study established the appropriate coastal hazard exposure mapping based on a review of existing understanding of hazards, update of existing hazard assessments where necessary, and detailed modelling of hazards where required.

The basis of the CVA mapping is summarised in Table 2-1.

Table 2-1: Summary of Stage 2 Technical Studies recommend hazard mapping

	Coastal Hazard	Existing Studies	CVA mapping approach
1	Beach Erosion	Coastal Processes Study (BMT, 2013)	Rare mapping extent adopted for open coasts, 'Unlikely' mapping extent adopted behind Crescent Head seawall
2	Shoreline Recession	Coastal Processes Study (BMT, 2013)	Rare mapping extent adopted
3	Coastal lake or watercourse instability	Nil	New analysis undertaken.
4	Coastal Inundation	Coastal Processes Study (BMT, 2013)	Updated modelling and mapping from Stage 2 Technical Studies
5	Coastal cliff or slope instability	Not applicable	No mapping required
6	Tidal Inundation	Coastal Processes Study (BMT, 2013)	Updated modelling and mapping from Stage 2 Technical Studies
7	Erosion and inundation of foreshores caused by tidal waters and the action of waves, including the interaction of those waters with catchment floodwaters.	Adopted flood study (JACOBS, 2019)	Existing mapping adopted

3 Risk Assessment

3.1 Risk assessment philosophy

An assessment of risk has been completed in line with ISO31000: 2018 Risk Management. The risk assessment framework is shown within the risk management standard, as shown in Figure 3-1.

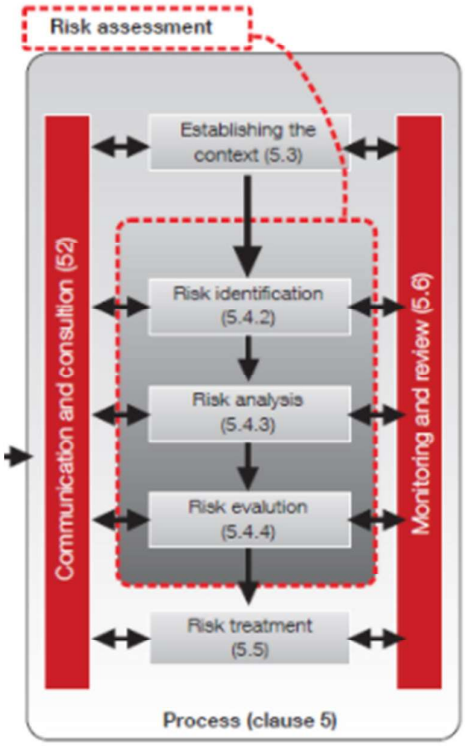


Figure 3-1: Risk Management framework (adapted from ISO31000)

In an environmental hazards context, broadly speaking, the risk assessment considers the likelihood and consequence associated with a natural hazard to determine the relative risk rating and the effectiveness of risk management measures/controls.

Given that many of the coastal hazards involve inundation of areas adjoining the coast line, specifically hazards 4, 6 and 7, it is practical to also consider national best practice flood risk guidance[1]. National guidance notes that risk mitigation may be categorised into three categories:

- Response modification
- Property modification
- Behaviour modification.

It is likely that one or a combination of these mitigation approaches will be suitable to mitigate the risk associated with coastal hazards with the Kempsey CVA. The NSW Coastal Management Manual also outlines an approach to risk assessment under the Act and Coastal Management SEPP. This considers:

- Vulnerability
- Exposure
- Sensitivity

[1] AIDR (2017) Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia. Australian Institute for Disaster Resilience

- Adaptive capacity
- Future scenarios

An analysis of each coastal hazard has been undertaken to quantify the magnitude of natural hazard across the LGA. To validate the hazard exposure, where existing hazard mapping is available, a comparison of hazard areas was also undertaken.

3.2 Vulnerability

Vulnerability in a coastal context can be determined by:

- Developing an understanding of the exposure and potential impacts of hazards and threats
- Assessing the sensitivity of communities, assets and values to potential impacts
- Assessing the capacity to respond and adapt – which is also influenced by the environmental, socio economic and planning context.

An assessment of community vulnerability has been undertaken using Australian Bureau of Statistics (ABS) census data. The ABS provides a number of relative indices at a neighbourhood scale (Statistical Area 'SA' 1) that help to understand community vulnerability as well as capacity to respond and adapt – through the ability to understand coastal hazards and contribute to adaptive behaviours. The Socio-Economic Indices for Areas (SEIFA) provides a quantitative approach to measuring vulnerability. The SEIFA database has been demonstrated to provide a valuable tool to understand risk exposure to natural hazards and the ability of a community to build resilience. In particular, the relative indices for socio-economic advantage/disadvantage, economic resources and education and occupation are beneficial proxies for community vulnerability.

3.2.1 Socio-economic indices

The socio-economic index, or Index of Relative Socio-economic Disadvantage (IRSD) summarises variables that indicate relative disadvantage. This index ranks areas on a continuum from most disadvantaged to least disadvantaged. A low score on this index indicates a high proportion of relatively disadvantaged people in an area. The ABS notes the IRSD cannot conclude that an area with a very high score has a large proportion of relatively advantaged people, as there are no variables in the index to indicate this. Instead, it can only conclude that such an area has a relatively low incidence of disadvantage.

The IRSD has been mapped throughout the Kempsey LGA, as shown in Figure 3-2. This map indicates the CVA has a broad geographic area, and relatively neutral in terms of social-economic factors. It is likely that natural mitigation measures and longer horizon adaption to coastal hazards would be more readily implemented in comparison to those measure which require significant financial contribution or rapid change.

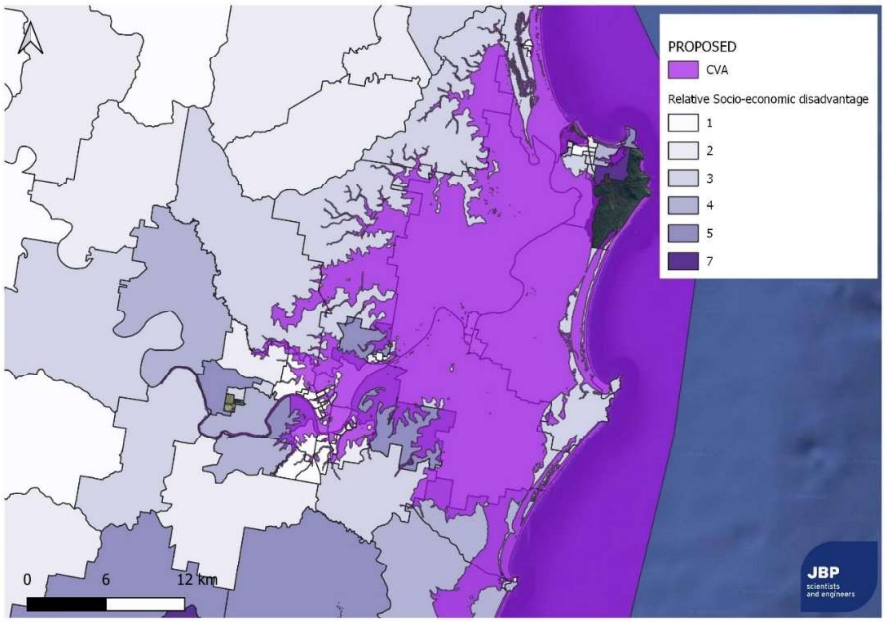


Figure 3-2: Relative Socio-economic indices

3.2.2 Economic Resources

The index of economic resources relates to the financial aspects of relative socio-economic advantage and disadvantage. These include indicators of high and low income, as well as variables that correlate with high or low wealth. Areas with higher scores have relatively greater access to economic resources than areas with lower scores.

The index of economic resources has been mapped throughout the Kempsey LGA, as shown in Figure 3-3. The CVA covers a range of relative economic indices, which is not uncommon in NSW coastal communities. The statistical areas of the Kempsey CBD have the highest economic resource as would be expected, whilst the coastal regions have a medium to high indices.

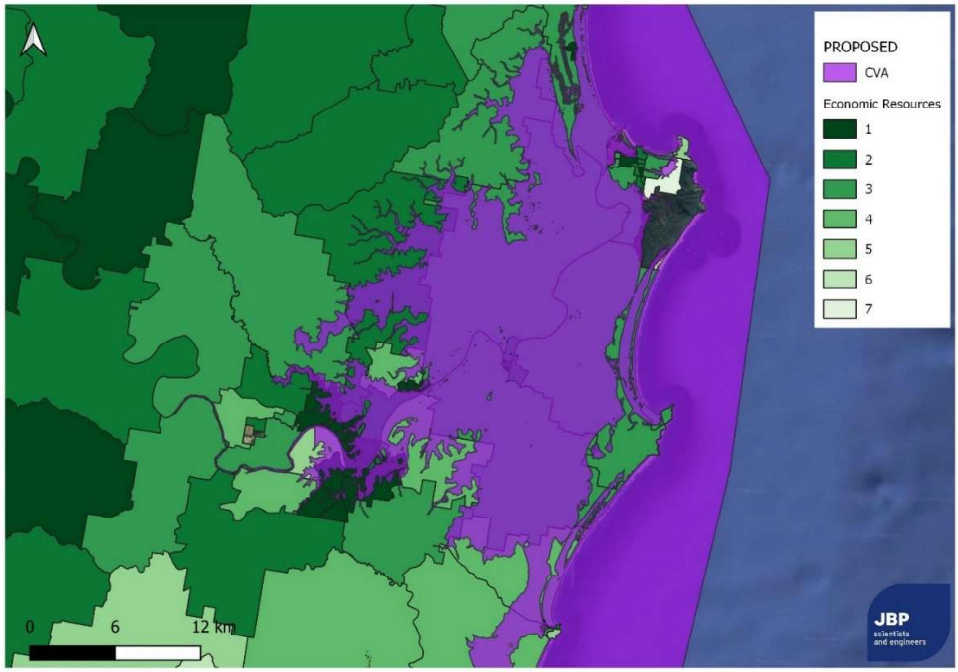


Figure 3-3: Relative economic indices

3.2.3 Education and Occupation

This index focuses on the skills of the people in an area, both formal qualifications and the skills required to perform different occupations. A low score indicates that an area has a high proportion of people without qualifications, without jobs, and/or with low skilled jobs. A high score indicates many people with high qualifications and/or highly skilled jobs.

The Education and Occupation Index has been mapped throughout the Kempsey LGA, as shown in Figure 3-4. The relative education and occupation indices is skewed towards the Kempsey region as would be expected by the employment density of the CBD; however there are some valuable insights which can be drawn from the education and occupation indices:

- Communities along the coastal areas to the north of Southwest Rocks are relatively lower than the coastal areas of Hat Head and Crescent Head which may make the northern coastal areas relatively less sensitive to coastal hazards.
- The coastal area between Hat Head and Crescent Head has a relatively higher education and employment value which may make it more sensitive to coastal hazards.

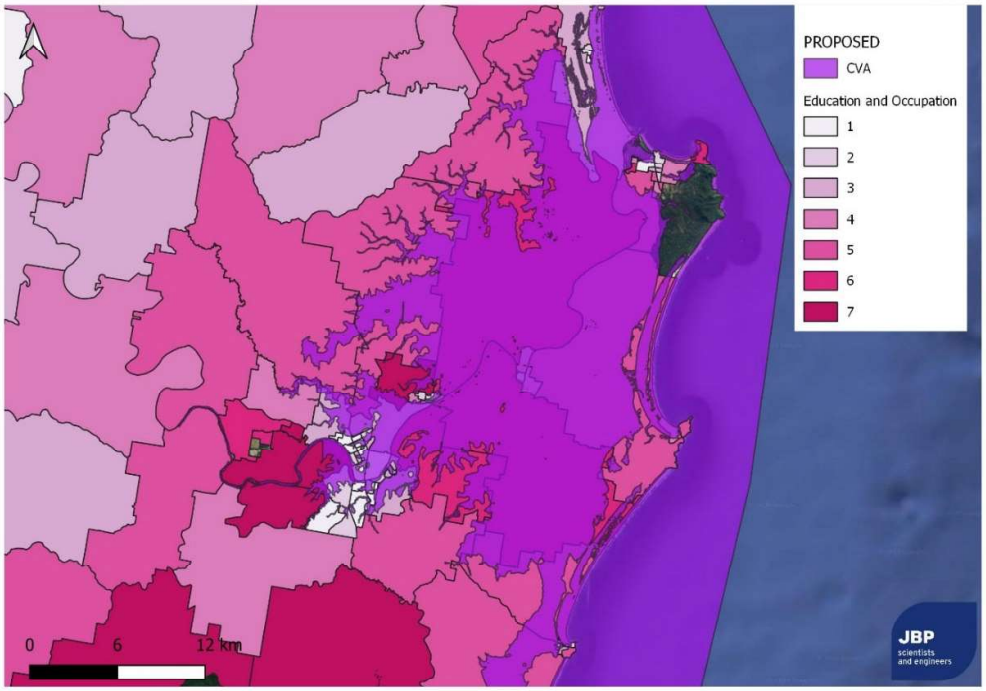


Figure 3-4: Relative education and occupation indices

3.3 Sensitivity

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

The analysis of sensitivity has been qualitative, providing a relative assessment of coastal hazards on the coastal communities, environment and infrastructure/assets within the CVA. These qualitative values are to be determined in consultation with council stakeholders following Council endorsement of the Stage 2 Technical Studies.

3.4 Exposure

An exposure assessment has been undertaken to consider the impact that defined coastal hazards may have on properties within the Kempsey local government area. For ease of comparison, the properties have been grouped into types based on zoning as follows:

- Centre: Neighbourhood Centre, Local Centre

- Commercial: Commercial Core
- Residential: General Residential, Medium Density Residential, Large Lot Residential
- Industrial: General Industrial, Light Industrial
- Infrastructure: Infrastructure
- Rural: Primary Production, Rural Landscape, Primary Production Small Lots, Village
- Tourist: Tourist
- Other: Environmental, Parks and Reserves, Rural Landscape, Forestry

Wherever a property has multiple land use zones, it will also be reported against the most sensitive land use.

3.4.1 Exposure to Beach Erosion and Shoreline Recession

The Stage 2 Technical Studies project recommended the adoption of the 'rare' likelihood beach erosion and shoreline recession hazard area, and a 'unlikely' hazard area behind the Crescent Heads seawall. The number of properties falling within this hazard map was reviewed over three planning horizons (present day, 2050 and 2100) and is shown in Table 3-1.

Table 3-1: Summary of property exposure to beach erosion and shoreline recession

	Present Day	2050	2100
Centre	0	0	0
Commercial	0	0	0
Industrial	0	0	0
Residential	0	0	1
Rural	0	37	113
Infrastructure	1	1	1
Tourist	0	0	0
Other	60	60	60
Total	61	98	175

When considering the adoption of the 'Rare' coastal erosion hazard extent, consideration has been given to the additional exposure of property that may be missed if the 'Unlikely' hazard scenario is used. This comparison is summarised in Table 3-2.

Table 3-2: Summary of comparative property exposure between previous 'unlikely' scenario and proposed 'rare' scenario

	Previous Coastal Processes Study (BMT, 2013) (Unlikely)	Adopted scenario within CVA Mapping (Rare)
Existing (Present Day)	43	61
Future (2050)	61	98
Future (2100)	133	175

3.4.2 Exposure to Coastal lake or watercourse entrance instability

The Stage 2 Technical Studies project recommended the adoption of a coastal lake or watercourse instability hazard area. This did not have a likelihood return period associated with the hazard area, instead based on the maximum observed envelope of historic entrance positions. A summary of the number of properties included in the hazard area is provided in Table 3-3.

Table 3-3: Summary of property exposure to coastal lake and watercourse entrance instability

	Properties flagged within Coastal Hazard 3
Centre	0
Commercial	0
Industrial	0
Residential	2
Rural	2
Infrastructure	1
Tourist	0
Other	9
Total	14

The identified residential lots are located in Crescent Head and South West Rocks (one in each locality) and both rural land uses are located in Hat Head.

Crescent Head

In Crescent Head, the residential zoning is the balance of a large allotment located to the south of the inlet and north of Pacific Street. As shown in Figure 3-5, there are currently no dwellings located with the extent of Hazard 3 on the the medium density residential land in Crescent Head.

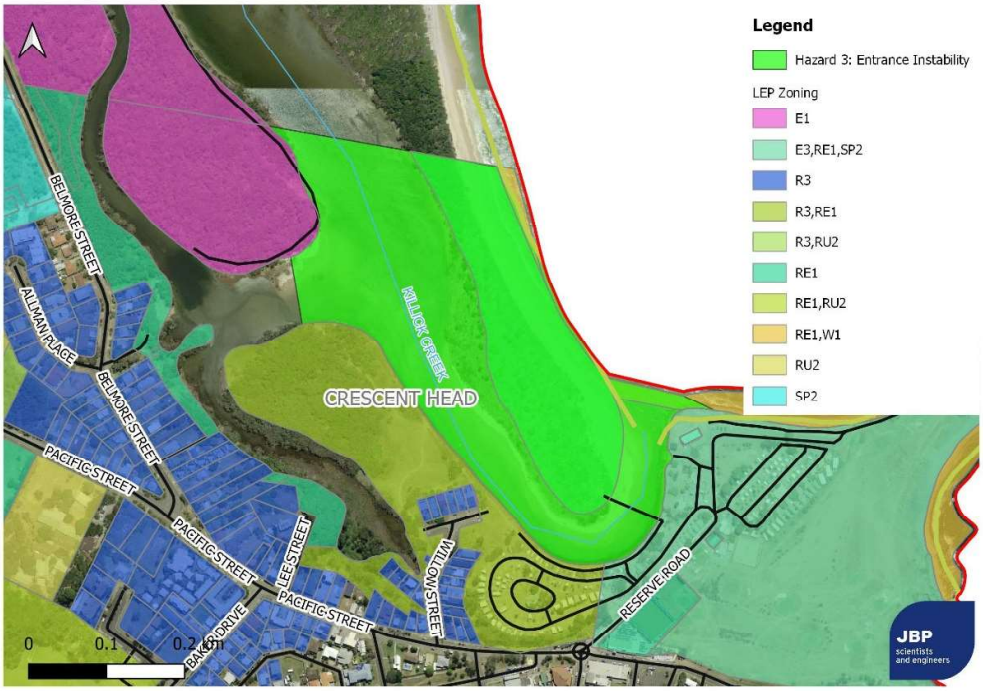


Figure 3-5: Location and zoning of residential (R3,RE1) land at Crescent Head

South West Rocks

In South West Rocks, the residential zoning is the balance of a large allotment located to the south of the inlet and north of Paragon Avenue Street. As shown in Figure 3-6, there are currently no dwellings located with the extent of Hazard 3 on the medium density residential land in South West Rocks.

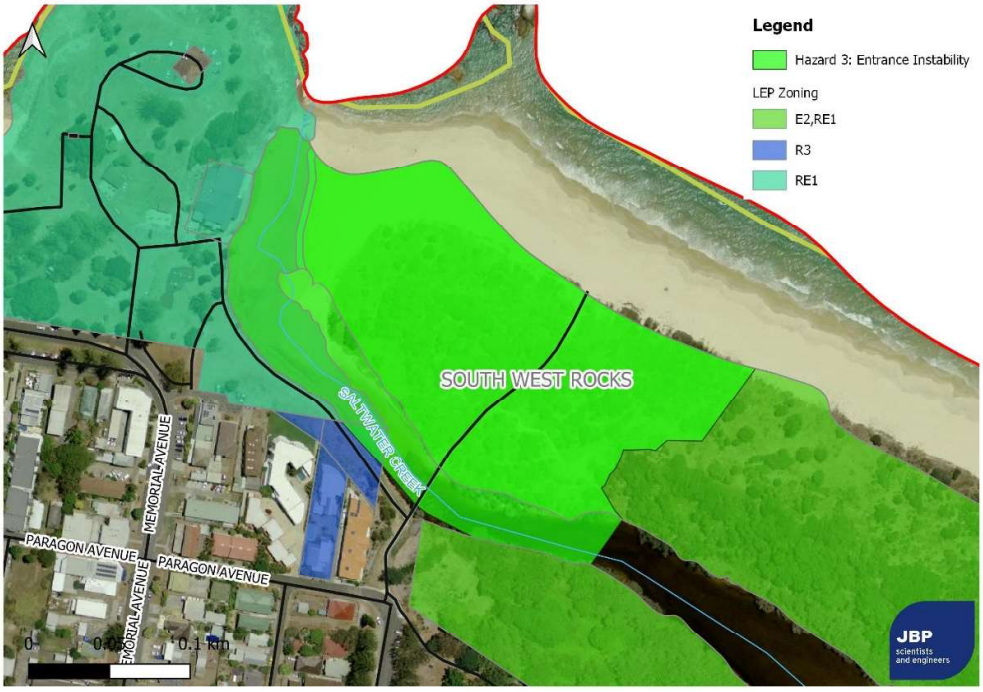


Figure 3-6: Location and zoning of residential (R3) land at South West Rocks

Hat Head

In Hat Head, the rural zoning is the balance of a large allotment located to the west of the inlet and of the inlet and along the foreshore. As shown in Figure 3-7, there are currently no dwellings located with the extent of Hazard 3 on the Village land in Hat Head.

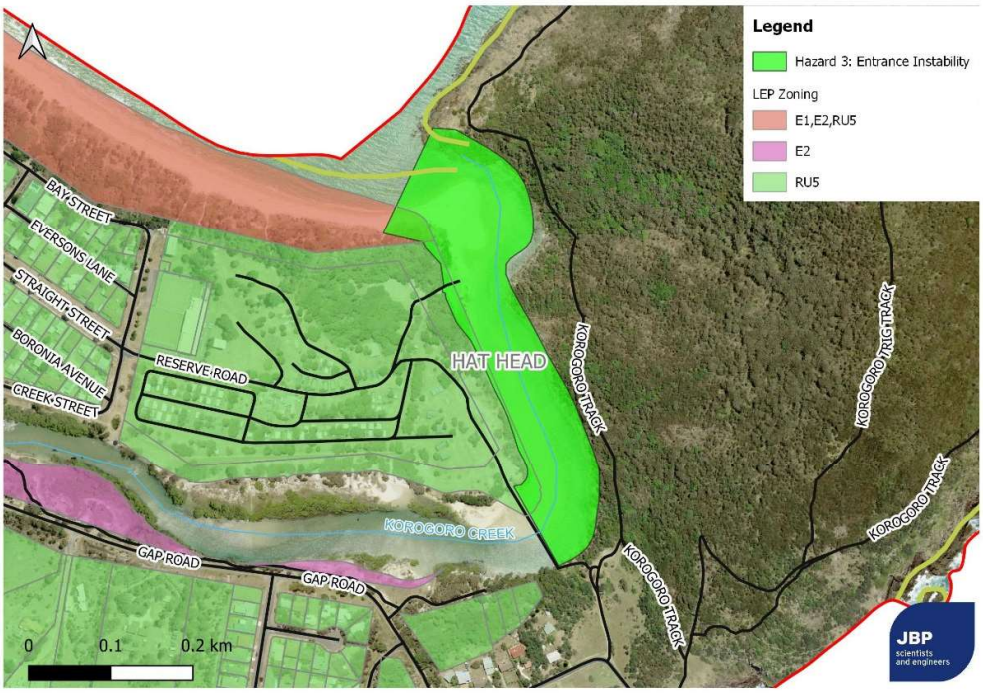


Figure 3-7: Location and zoning of residential (RU5) land at Hat Head

3.4.3 Exposure to Coastal Inundation

The Stage 2 Technical Studies recommended the adoption of a coastal inundation hazard zone based on new numerical modelling. This likelihood was proposed at three planning horizons, present day, 2050 and 2100, and has adopted a 1% Annual Exceedance Probability (AEP) coastal event. A summary of the number of properties included in the hazard area is provided in Table 3-4.

Table 3-4: Summary of property exposure to coastal inundation

	Present Day	2050	2100
Centre	0	0	0
Commercial	12	16	17
Industrial	5	5	5
Residential	170	249	282
Rural	834	1030	1322
Infrastructure	3	14	22
Tourist	0	0	0
Other	332	291	331
Total	1356	1606	1971

The new modelling undertaken for the CVA mapping project is based on current best-practise guidance. It moves away from existing mapping undertaken within the KCPHDS, which has been based on a 'bath-tub level' approach. A comparison of properties contained within the bath-tub and new CVA coastal inundation mapping is shown in Table 3-5.

Table 3-5: Summary of comparative property exposure between previous 'bath-tub' mapping and new hydrodynamic modelling of coastal inundation

	Previous Coastal Processes Study (BMT, 2013) (Bath-tub mapping)	Adopted scenario within CVA Mapping (hydrodynamic modelling)
Existing (Present Day)	3,124	1,356
Future (2050)	3,498	1,606
Future (2100)	4,080	1,606

3.4.4 Exposure to Tidal Inundation

The Stage 2 Technical Studies recommended the adoption of a Tidal Inundation hazard area derived from hydrodynamic modelling. Similar to Hazard 4: Coastal Inundation, this has been undertaken to advance the 'bath-tub' mapping approach used within the existing coastal processes study. The number of properties included in the new tidal inundation hazard maps is shown in Table 3-6.

Table 3-6: Summary of property exposure to tidal inundation

	Present Day	2050	2100
Centre	0	0	0
Commercial	11	13	16
Industrial	5	5	5
Residential	159	196	222
Rural	437	479	631
Infrastructure	7	6	10
Tourist	0	0	0
Other	217	236	236
Total	836	935	935

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

The Stage 2 Technical Studies recommended the adoption of a combined flood and tide scenario simulated within the Lower Macleay Flood Study (Jacobs 2019). This was based on a fluvial flood event from the catchment return period of 1-in-100 years (1% AEP) interacting with a MHHW ocean level.

The Lower Macleay Flood Study included the appropriate data for the Kempsey LGA, except in the Saltwater Creek catchment, which was outside the scope of the study. The flood study for Saltwater Creek was adopted in 2006 and whilst appropriate to define fluvial or catchment flood risk the modelled simulations did not include a scenario equivalent to the present day or future exposure to erosion and inundation of foreshores caused by tidal waters and the action of waves, including the interaction of those waters with catchment floodwaters (hazard) adopted across the rest of the LGA. Due to budget constraints, it was not possible to update information in this catchment as part of this study. It is recommend that a future project be commissioned (subject to available funding) to update the flood study including the necessary coastal hazard information required for assessment of Hazard 7.

A summary of the number of properties included in the hazard area is provided in the Table 3-7; however, given the lack of available information in the Saltwater Creek catchment, the property exposure analysis does not include potential risk in this catchment.

Table 3-7: Summary of property exposure to erosion and inundation of foreshores caused by tidal waters and the action of waves, including the interaction of those waters with catchment floodwaters

	Present Day	2050	2100
Centre	1	1	1
Commercial	232	256	275
Industrial	107	123	125
Residential	1111	1223	1374
Rural	3551	3612	3699
Infrastructure	162	164	164
Tourist	0	0	0
Other	961	957	950
Total	6125	6336	6589

3.4.6 Summary of exposure

A comparison of each hazard was undertaken to gain an understanding of the exposure under current and future planning horizons. This comparison is summarised in Table 3-8 below, and shown graphically in Figure 3-8.

Table 3-8: Summary of exposure to coastal hazards

	Present Day	2050	2100
Beach erosion and shoreline recession	61	98	175
Coastal lake and watercourse inlet instability	39		
Coastal Inundation	1356	1,606	1971
Coastal cliff instability	Not Applicable in the Kempsey LGA		
Tidal Inundation	836	935	1,137
Joint probability hazard	6,125	6,336	6,589
Total	8,417	9,014	9,546

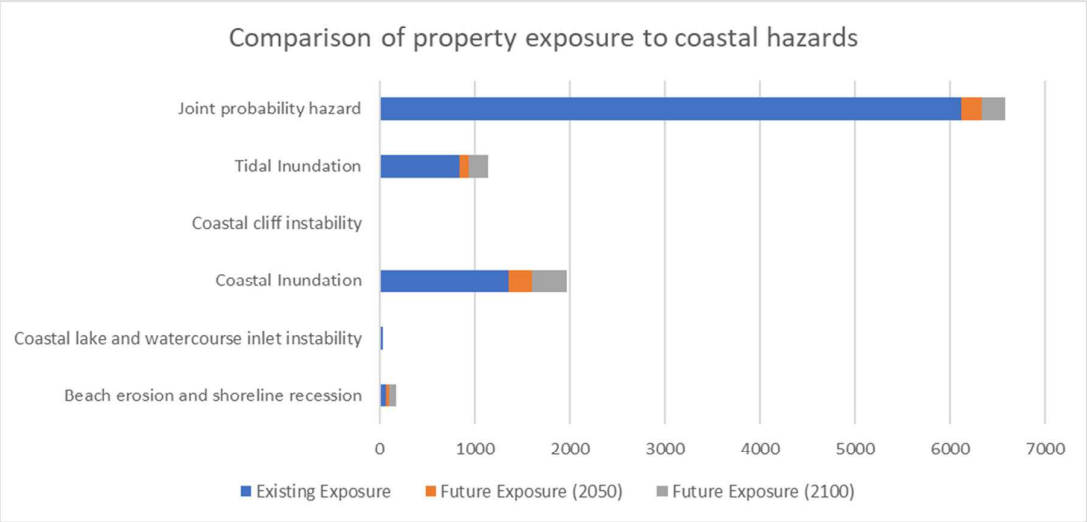


Figure 3-8: Comparison of property exposure to coastal hazards

The comparison of property exposure demonstrates that the coastal hazard with the greatest spatial coverage is Hazard 7 - erosion and inundation of foreshores caused by tidal waters and the action of waves, including the interaction of those waters with catchment floodwaters. This is generally in-line with the expected exposure, given it is significantly influenced by catchment flooding, where property exposure is higher than those areas along the coastal shoreline. This hazard is understood to generally cover the same inundation areas as the flood planning area within the Lower Macleay flood study, so whilst the number of properties is significantly larger, this is not anticipated to require development controls on properties not already subject to floodplain risk management planning controls.

Coastal Inundation is the second next most significant hazard for exposed property. This hazard may be subject to coastal management provisions. There is an 18% increase in property exposure by 2050 over the existing coastal hazard exposure, increasing to 27% greater property numbers by 2100 in comparison to the existing exposure.

Tidal inundation is the third highest ranking, in terms of exposure of property. Whilst having a smaller area, tidal inundation is expected to occur more frequently than the extreme coastal inundation or joint probability inundation mapped within the CVA, which may influence planning decisions. Property exposure increases incrementally by 12% over each modelled planning horizon, with an increase of 12% and 24% respectively to future exposure horizons in 2050 and 2100.

The long-term risk exposure to beach erosion and shoreline recession is lower than other hazards in terms of property numbers, representing around 1-2% of total properties within the CVA. However, these exposed areas are often widely used public areas, containing important assets and infrastructure, with a high recreational and historical value. It will be important to understand the growing exposure of these areas, which the exposure analysis indicates will increases by approximately 60% to 2050 and will almost triple by 2100 (to 175 properties).

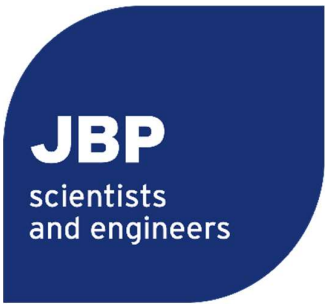
4 Recommendations

It is recommended that following Council's endorsement of the outputs of the Stage 2 Technical Studies, that community and/or key stakeholder consultation be undertaken to finalise the CVA mapping, as part of the broader Coastal Management Program. The Coastal Management Manual suggests that community and stakeholder engagement can assist in:

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

Community and stakeholder engagement would improve the inputs to a detailed risk assessment and enable the finalisation of the CVA Mapping risk assessment, which will help to form the scope of the Stage 3 Coastal Management Program and would provide a basis for future economic analysis of coastal management.

It is also recommended that funding, including via available grant programs, be obtain for the necessary flood study updates in the Saltwater Creek catchment as a matter of priority. The updated flood study should also aim to provide information related to Hazard 7, so that comprehensive data is available to support the adoption of Coastal Vulnerability Area mapping across the local government area.



Offices in
Australia
Cambodia
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Romania
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UK
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Registered Office
477 Boundary Street,
Spring Hill QLD 4000
Australia

t: +61 (0)7 3085 7470
e:info@jbpacific.com.au

ABN: 56 610 411 508
ACN: 610 411 508

Visit our website
www.jbpacific.com.au