Coastal hazards under sea-level rise

Estuarine Inundation Snapshot

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Acknowledgement of Country

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About this snapshot

This snapshot summarises projected changes in estuarine inundation across the 184 recognised estuaries in New South Wales, based on latest sea-level rise trajectories.

Future changes in estuarine inundation extent and associated asset exposure were assessed using tide gauge data to model water level surfaces within estuaries, and projections of sea-level rise. This provides a consistent, state-wide assessment of estuarine inundation hazards for coastal New South Wales (NSW). Projected impacts of estuarine inundation are represented through an exposure assessment of built assets and cultural heritage sites along NSW estuaries.

Information from all 184 estuaries potentially exposed to inundation hazards is included. In this snapshot, the exposure of buildings to estuarine inundation is presented for the baseline year 2020 and the future time horizons of 2050, 2100, and 2150, under projected sea-level rise scenarios aligned with the Shared Socioeconomic Pathways (SSPs).

This snapshot provides a high-level overview, with more detailed findings available in a technical report (NSW Coastal Erosion and Inundation Hazards and Exposure Assessment – Technical Report, 2025[i]) and through the Future Climate and Adaptation Hub on the SEED Data Portal. This assessment provides the foundation for coordinated, strategic action, helping to prioritise investment, plan infrastructure resilience, or protect cultural heritage and communities at risk. It supports councils, agencies, and planners in identifying vulnerable assets, assessing future exposure, and designing targeted climate adaptation and disaster risk responses.

Estuarine inundation information from across all 184 estuaries in NSW.

Understanding estuarine inundation

Estuarine inundation occurs when low-lying foreshore areas surrounding estuaries are periodically covered by rising water levels and subsequently exposed as water levels fall (Figure 1). This assessment focuses on regular estuarine inundation, examining water levels at different frequencies. Rainfall-driven catchment inflows and fluvial flooding were excluded from the analysis for all estuaries.

The extent and duration of estuarine inundation are influenced by several factors, including tidal range, estuary type, seasonal variations, and projected sea-level rise. Estuary types in NSW are sometimes classified according to entrance condition and geomorphology and display broadly consistent regional patterns. The northern third of the NSW coast is dominated by large tidal rivers and coastal floodplains, the central region by extensive tidal lakes and drowned river valleys, and the southern region by Intermittently Closed and Open Lakes and Lagoons (ICOLLs).

Drowned river valleys, such as the Hawkesbury River, are typically characterised by an amplified tidal range within the estuary relative to the adjacent open coast. Tidal rivers, such as the Tweed River, generally exhibit a modest reduction in tidal range, while tidal lakes, such as Lake Macquarie, show a significant reduction in tidal range beginning close to the entrance (Figure 2). Water levels in some tidal lakes can exceed adjacent sea levels due to tidal pumping, where tidal inflows exceed outflows.

ICOLLs, such as Lake Wollumboola, experience small tidal ranges when open to the ocean but are unaffected by tides when closed, with inundation primarily resulting from rainfall and catchment inflows (Figure 2).

Estuarine inundation of foreshores may occur during only a few of the largest high-water events in a year or, in more low-lying areas, as frequently as monthly or fortnightly during spring high tides.

Estuarine inundation occurs when low-lying foreshore areas surrounding estuaries are inundated by tides as they rise and then exposed again when tides fall.

Recent observations indicate that estuarine inundation increasingly manifests through tidal water ingress into stormwater systems, resulting in short-term inundation of low-lying streets and urban areas. While such events are typically minor and short-lived, their frequency is increasing and they are expected to become more widespread with continuing sea-level rise[ii].

Figure 1: *Examples of estuarine inundation (otherwise known as sunny day or nuisance flooding) in urban streets of Marks Point, 13 May 2015 (left), and Tea Gardens, 4 January 2018 (right).*

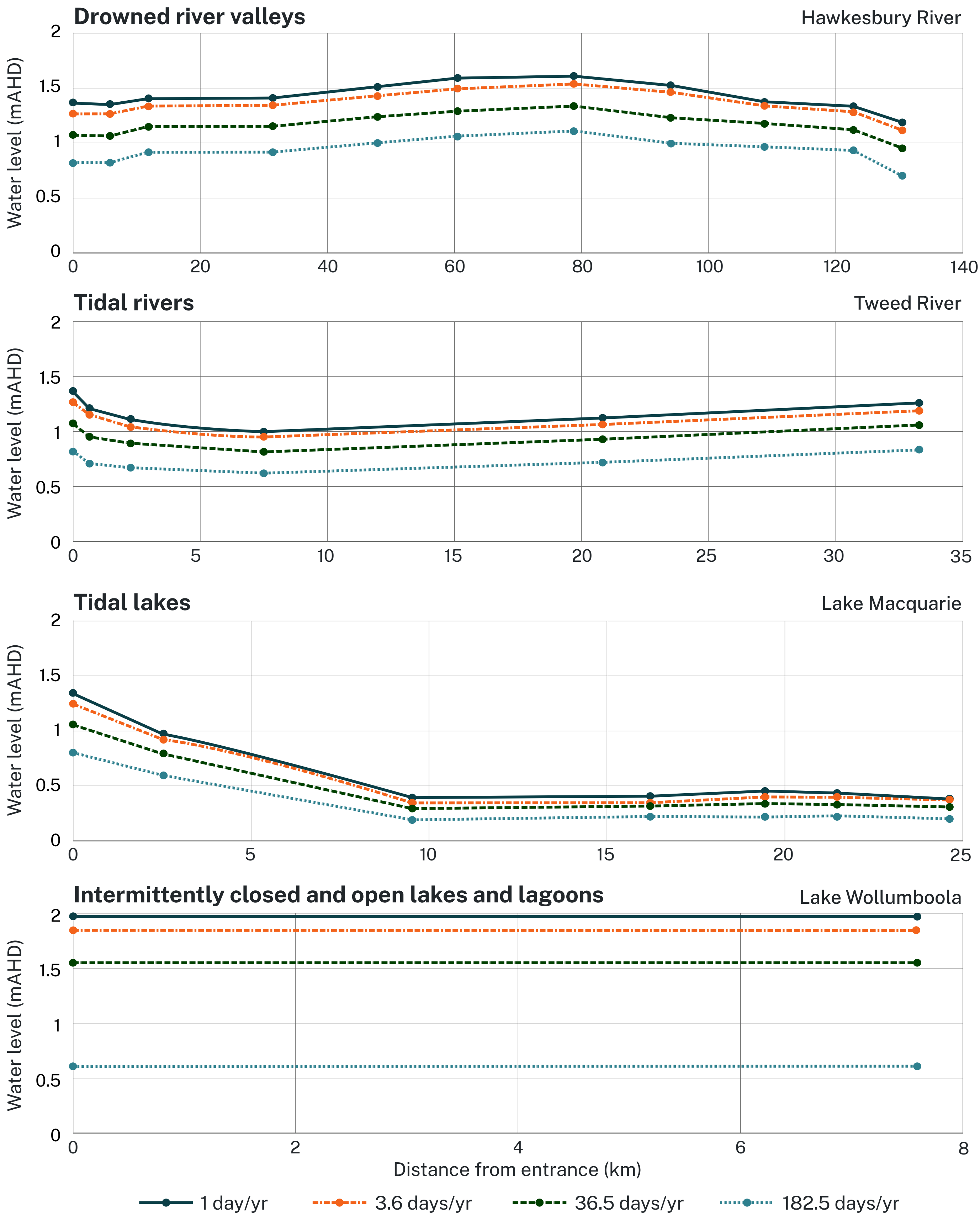

Figure 2: *Examples of water levels and how tide behaviour can vary with distance from estuary entrance and in different estuary types.*

Shared Socioeconomic Pathways

The estuarine inundation modelling in this snapshot is based on the latest emissions and SSP scenarios adopted in the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (2021).

The SSPs describe plausible future trajectories of greenhouse gas emissions and associated socioeconomic factors such as population growth, economic development, education, urbanisation, and land use change.

Low-emissions future

SSP 1-2.6

SSP1-2.6 describes a **low-emissions future** with a global transition towards sustainable and equitable development and increased international cooperation on climate action.

Medium-emissions future

SSP 2-4.5

SSP2-4.5 describes a **medium-emissions future** with uneven economic growth, slow sustainability progress, ongoing environmental degradation and persistent social and environmental challenges.

High-emissions future

SSP 3-7.0

SSP3-7.0 describes a **high-emissions future** of regional conflict and development where countries do not collaborate on tackling climate change and do not focus on sustainable and equitable development.

Very high-emissions future

SSP 5-8.5

SSP5-8.5 describes a **very high-emissions future** with rapid economic growth and intensive fossil fuel exploitation and dependence. Technological advancement is prioritised over environmental protection, with limited mitigation of climate impacts.

Sea-level rise

Sea levels are rising and are projected to have a major impact on coastal communities in NSW over coming decades. At the State's baseline sea level monitoring station at Port Kembla[iii], average sea level has been rising at a rate of approximately 3.7 mm/year, with approximately 12 cm of sea-level rise since 1991[iv]. Regardless of future emissions trajectories, sea-level rise will continue for centuries to millennia due to the long-term response of the deep ocean and ice sheets to past and ongoing warming[v,vi].

Sea level along the NSW coastline is projected to continue rising under all emissions scenarios, with only minor spatial variation. Slightly higher rates of rise are projected toward the north.

This assessment presents modelled projections under low-, medium-, and high-emissions scenarios, with an additional very high-emissions scenario (SSP5-8.5) included to capture high-consequence futures.

Further information on emissions scenarios is available on AdaptNSW.

Port Kembla is projected to experience increases in sea level of 0.23–0.56 m under SSP1-2.6, 0.37–0.73 m under SSP2-4.5, 0.50–0.91 m under SSP3-7.0, and 0.59–1.04 m under SSP5-8.5 by 2100, relative to the 1995–2014 baseline period (Figure 3).

The 'likely' range of sea-level rise projected for Port Kembla relative to a 1995-2014 baseline (Table 1 and Figure 3) is presented for context to the coastal hazard modelling. The IPCC defines the 'likely' range as the 17th to 83rd percentile of modelled outcomes, representing a 66% confidence interval – meaning there is a two thirds chance that sea-level rise will fall within this range, based on current knowledge.

Table 1: *Projected increase in sea-level rise at Port Kembla (in cm) as per NASA Sea Level Projection Tool*[vii].

Year	SSP1-2.6	SSP2-4.5	SSP3-7.0	SSP5-8.5
2050	**17** (11–24)	**19** (13–26)	**21** (16–28)	**23** (17–30)
2100	**37** (23–56)	**52** (37–73)	**67** (50–91)	**77** (59–104)
2150	**58** (33–93)	**87** (58–129)	**118** (83–165)	**134** (94–192)

The bold number is the median. Underneath the median is the 'likely' (17th-83rd percentile) range of sea-level rise

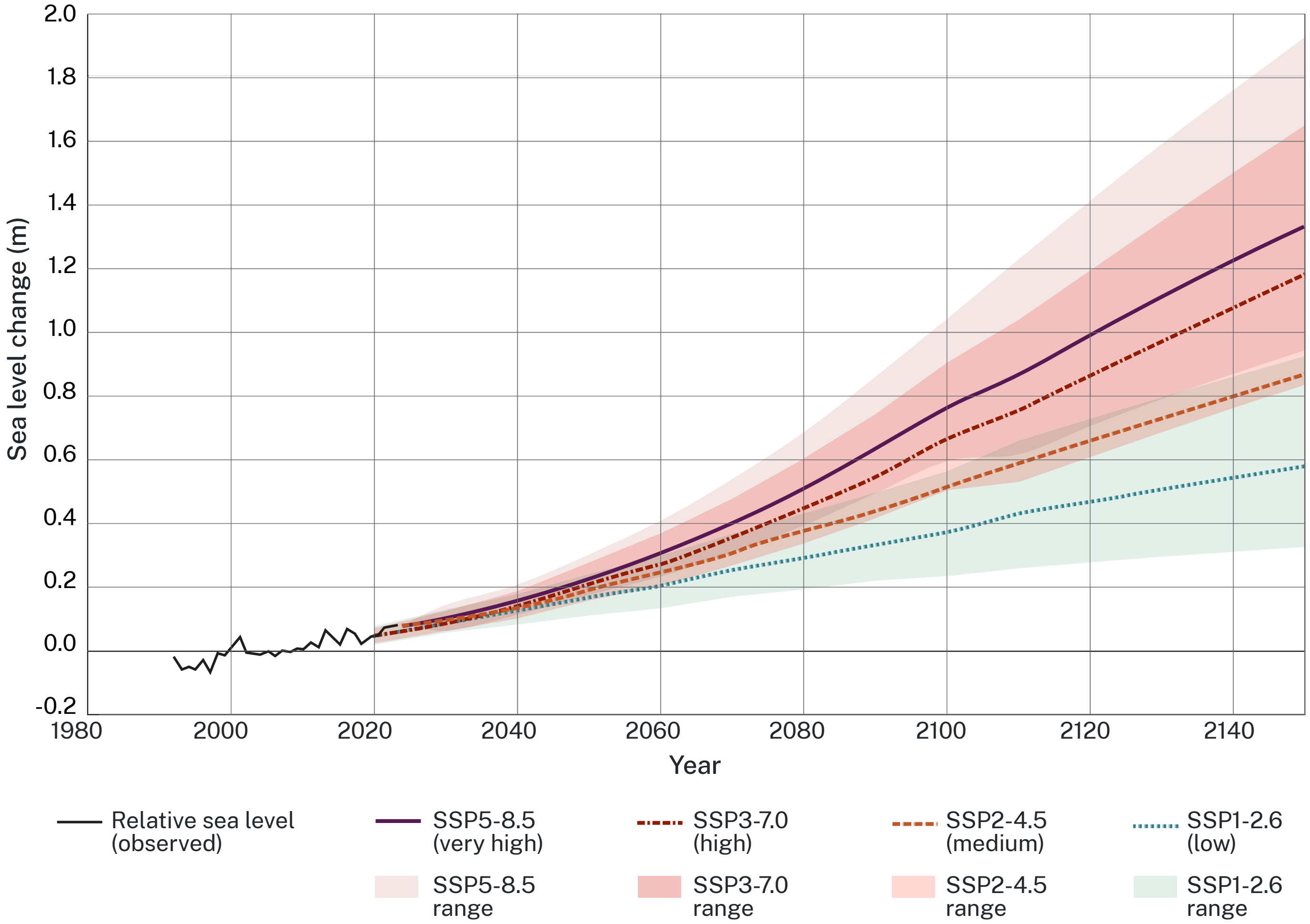

Figure 3: *Median sea-level rise trajectories for Port Kembla out to 2150 (solid lines) and their associated likely ranges (shading) representing the 17th-83rd percentile for the low-emissions scenario SSP1-2.6, medium-emissions scenario SSP2-4.5, high-emissions scenario SSP3-7.0, and very high-emissions scenario SSP5-8.5. Projected increases are relative to a 1995-2014 baseline*[vii].

Modelling estuarine inundation

Estuarine inundation extents were estimated using a surface-fitting method that integrates water level data from tidal gauges located across 96 estuaries to develop a model of the water surface across estuaries (Figure 4). In cases where gauges were unavailable, data from nearby, similar estuaries were used to fill the gaps. For ICOLLs, a generalised tidal pattern and an averaged exceedance distribution was applied, scaled according to measured elevation of the sandy beach barriers at ICOLL entrances (referred to as berms).

Compared to simplistic 'bathtub' models used in previous assessments, this approach offers improved accuracy while remaining less complex than full hydrodynamic modelling for each estuary.

To project future estuarine inundation, sea-level rise projections were added to current water levels. These projections were mapped at decadal intervals from 2020 to 2150. The year 2020 was chosen as the reference baseline to optimise the use of the extensive measured water level and beach morphology data available in NSW and to align with the IPCC's Sixth Assessment Report sea-level rise data.

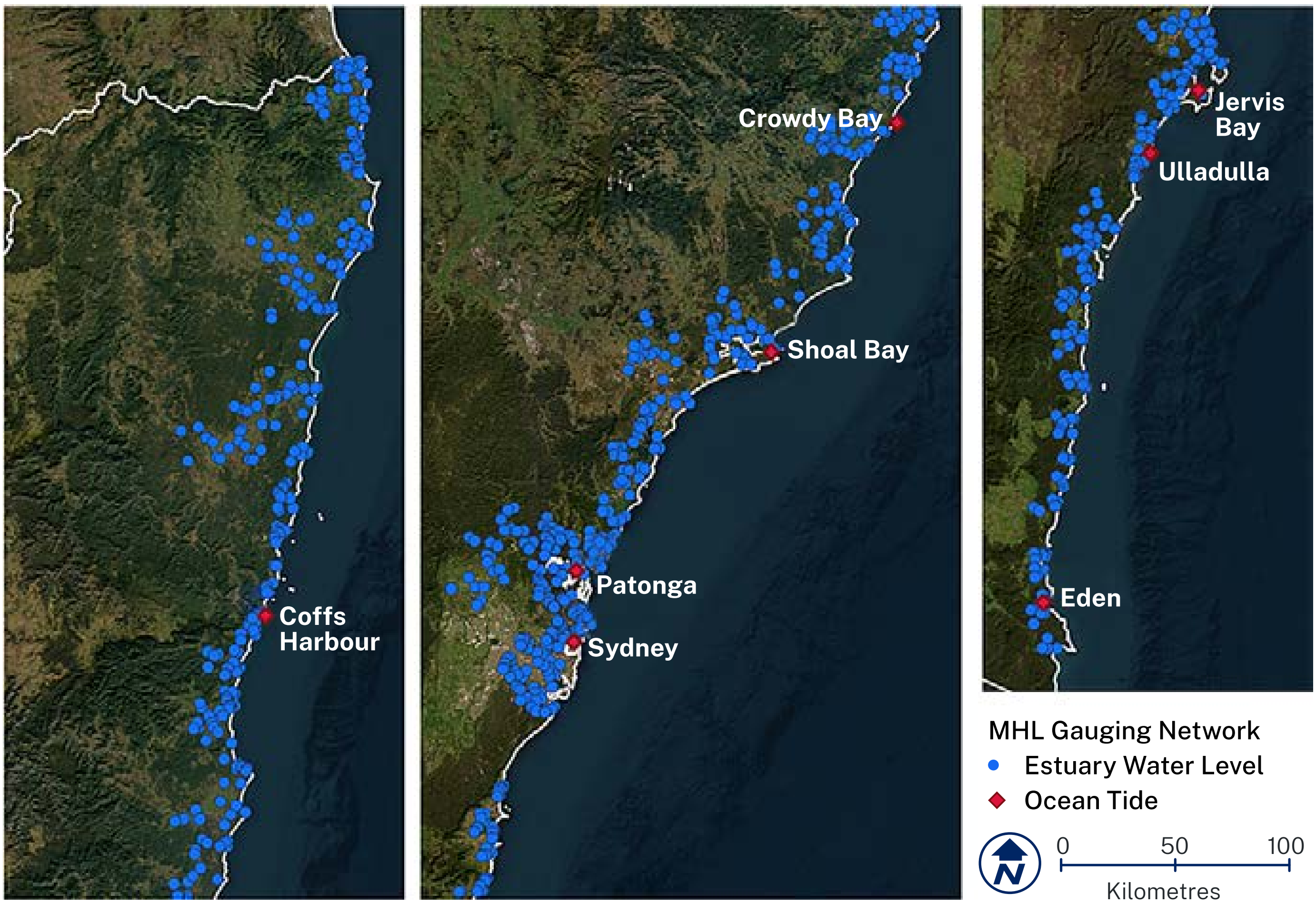

Figure 4: *Map showing location of NSW Manly Hydraulics Laboratory (MHL) tide and water level gauging network.*

What inundation frequencies were considered?

To help address uncertainties in future sea-level rise, a probabilistic approach was applied. The probability distribution of future sea-level rise was randomly sampled and added to current estuarine water levels to generate density functions estimating the extent of estuarine inundation projected to occur at different frequencies in the future.

The data presented in this snapshot are primarily based on the inundation extent corresponding to a frequency of 3.6 days per year, analogous to a 1% exceedance probability. Projections for other exceedance frequencies (1 day/year (0.27% frequency), 36.5 days/year (10% frequency), and 182.5 days/year (50% frequency)) are also available and may be more appropriate depending on the application or acceptable level of risk (Figure 5).

These additional projections can be explored through the Future Climate and Adaptation Hub on the SEED Data Portal and the technical report[i] to support tailored decision-making aligned with specific risk tolerances and planning needs.

There are inherent uncertainties in modelling estuarine inundation hazards associated with sea-level rise. These include uncertainty in the sea-level rise trajectory that will eventuate, connectivity through natural or built pathways at different water levels, limitations in current understanding and modelling of estuarine responses, and the unpredictability of future land use and infrastructure development. The probabilistic approach used here helps enable exploration of these uncertainties and ensures that the full range of plausible outcomes for estuarine inundation hazard exposure is considered in risk assessment and adaptation planning.

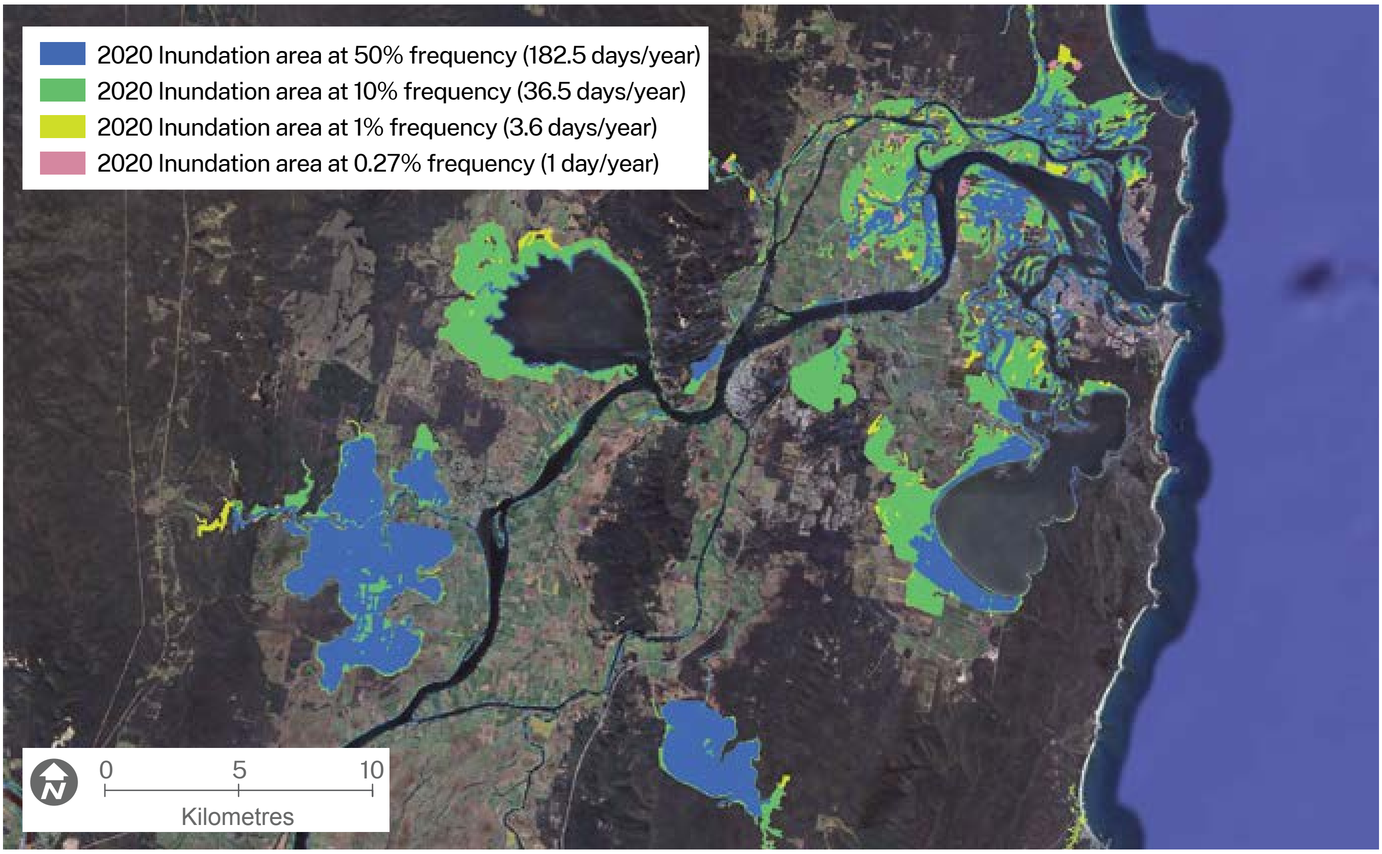

Figure 5: *Map showing estuarine inundation at different frequencies in the Clarence River.*

Assessing asset exposure

Exposure statistics are based on the spatial extent of projected estuarine inundation intersecting with the existing distribution of built assets and recorded Aboriginal cultural heritage sites along the NSW coast. The exposure assessment does not account for potential future development, current or future adaptation measures to protect assets, or changes to land use.

Exposure statistics are grouped by coastal regions following the Australian Sediment Compartments framework[viii], which delineates nine distinct compartments characterised by regionally linked coastal processes and geomorphology: North Coast, Northern Rivers, Mid-North Coast, Port Stephens, Central Coast, Sydney, Illawarra, Shoalhaven, and South Coast. These compartments are separated by major geomorphic features such as headlands, rivers, or significant changes in coastline orientation.

Regarding buildings exposure, structures without an assigned address were excluded to reduce false positives, although secondary structures (e.g., sheds, water tanks, and carports) at locations with an assigned address remain in the dataset. Several building categories (e.g., residential, commercial) were considered; therefore, the building exposure results presented herein do not represent a single building class only.

Exposure statistics for buildings are presented in this snapshot. Additional information on the exposure of roads, critical infrastructure (such as hospitals, schools, emergency services and judicial facilities), paths, railways, Aboriginal cultural heritage sites, electricity transmission lines, airports, and runway lengths can be explored through the technical report[i].

Estuarine inundation extent

Estuarine inundation is projected to increase

The extent of estuarine inundation around foreshores is projected to increase over time, with higher emissions scenarios and associated sea-level rise resulting in greater impacts. Currently, approximately 688 km^2 of land along the NSW coast is affected by estuarine inundation at 3.6 days/year frequency. By 2100, this area is projected to increase to around 1,688 km^2 under a low-emissions scenario (SSP1-2.6), 1,877 km^2 under a medium-emissions scenario (SSP2-4.5), 2,135 km^2 under a high-emissions scenario (SSP3-7.0), and 2,268 km^2 under a very high-emissions scenario (SSP5-8.5) (Table 2, Figure 6).

As sea levels continue to rise, estuarine inundation will increasingly occur under astronomical tide conditions alone. Over time, such events are expected to become both higher and more frequent, with longer durations. Ultimately, persistent inundation is anticipated to lead to the permanent submergence of some low-lying areas.

Table 2: *Projected estuarine inundation extent (km^2) along the NSW coast at 3.6 days/y frequency. The numbers are rounded up.*

Year	SSP1-2.6	SSP2-4.5	SSP3-7.0	SSP5-8.5
2050	993	1015	1042	1074
2100	1688	1877	2135	2268
2150	2536	2926	3259	3476

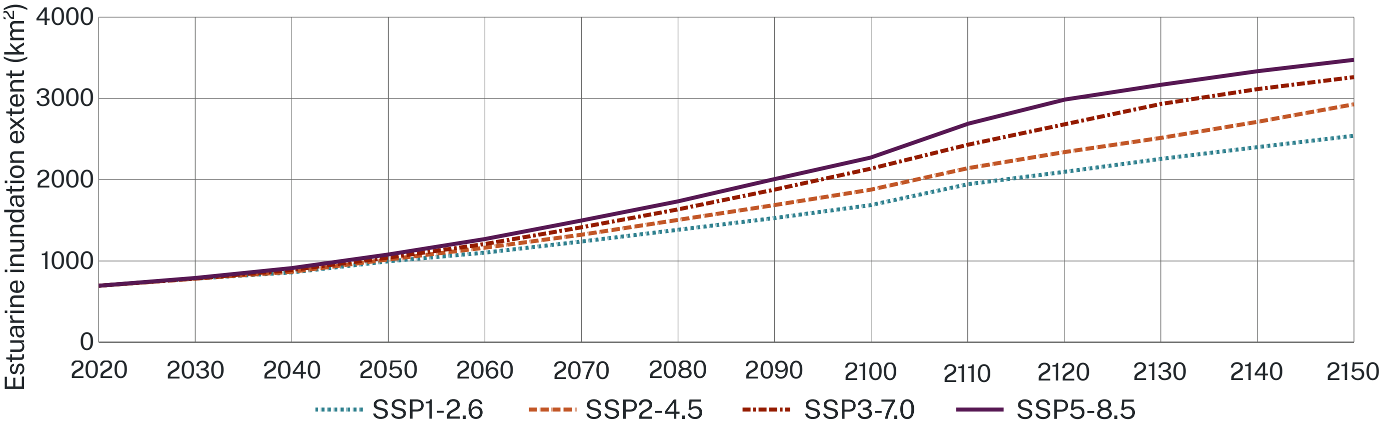

Figure 6: *State-wide estuarine inundation extent for a 3.6 days/year frequency to 2150 under different emissions scenarios.*

Exposure to estuarine inundation

Exposure of buildings to estuarine inundation will increase over time, with higher emissions scenarios and sea-level rise resulting in greater impacts. Currently, around 2,720 buildings are impacted by estuarine inundation at a 3.6 days/year frequency. By 2100, this is projected to increase to 34,692 buildings under a low-emissions scenario, to 49,019 buildings under a medium-emissions scenario, to 71,241 buildings under a high-emissions scenario, and to 85,655 buildings under a very high-emissions scenario. By 2150, this is projected to increase to 110,122 buildings under a low-emissions scenario, to 146,066 buildings under a medium-emissions scenario, to 184,175 buildings under a high-emissions scenario, and to 211,340 buildings under a very high-emissions scenario (Table 3 and Figure 7).

Table 3: *Exposure of buildings (shown as number of buildings) to estuarine inundation at 3.6 days/year frequency.*

Year	SSP1-2.6	SSP2-4.5	SSP3-7.0	SSP5-8.5
2050	5,325	5,663	6,265	6,654
2100	34,692	49,019	71,241	85,655
2150	110,122	146,066	184,175	211,340

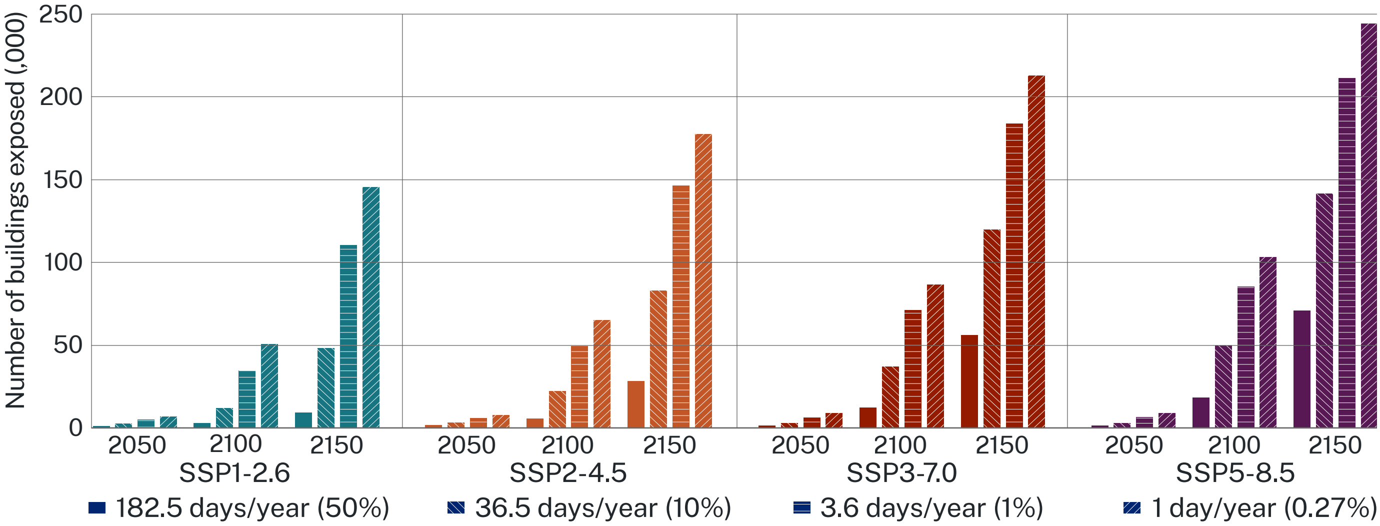

Figure 7: *State-wide building counts exposed to estuarine inundation at different exceedance frequencies and under different SSPs. NOTE: Several building categories (e.g., residential, commercial) were considered; therefore, the building exposure results presented herein do not represent a single building class only (e.g., major residential)*

Regional breakdown of building exposure

Regional statistics for estuarine inundation are grouped under the Australian Sediment Compartments framework[viii], which delineates nine distinct compartments characterised by regionally linked coastal processes and geomorphology. These compartments are the North Coast, Northern Rivers, Mid-North Coast, Port Stephens, Central Coast, Sydney, Illawarra, Shoalhaven, and South Coast.

Currently, buildings in the central regions of NSW are the most exposed to estuarine inundation. For example, at 3.6 days/year frequency, the combined number of exposed buildings in the Port Stephens, Central Coast, and Sydney regions is approximately 1,952 (Figure 8). In contrast, the northern regions (North Coast, Northern Rivers, and Mid-North Coast) have a total of about 679 exposed buildings, while the southern regions (Illawarra, Shoalhaven, and South Coast) have approximately 89.

The differences in projected exposure reflect regional variation in estuary types and historical development patterns. The large coastal lakes common in central NSW have extensive low-lying foreshores and historically high levels of residential development. Many of these systems have permanently open entrances, contributing to higher projected exposure in these areas. Similarly, large tidal rivers in the northern regions together with their expansive, low-lying floodplains are projected to experience substantial increases in inundation extent.

In contrast, the smaller Intermittently Closed and Open Lakes and Lagoons (ICOLLs) that dominate the southern regions are frequently closed and have historically experienced less development along their foreshores, resulting in relatively lower projected exposure compared to northern and central regions.

Significant lengths of roads, railways, and other infrastructure are also projected to be at risk of estuarine inundation. Further information on the exposure of these asset types is available through the Future Climate and Adaptation Hub on the SEED Data Portal and the detailed technical report[i].

While estuarine inundation hazard is projected to increase over time, proactive adaptation is needed to reduce future impacts and enhance coastal resilience. Coastal communities can implement a range of adaptation measures, including dune recovery, habitat restoration, and the design of resilient infrastructure to accommodate changing conditions. The NSW Coastal Management Framework provides the primary mechanism for managing these hazards, with local councils playing a key role in preparing coastal management programs that identify local issues and outline targeted actions for mitigation and adaptation.

Figure 8: *Map showing the nine primary sediment compartment regions along the NSW coast and the number of buildings exposed to estuarine inundation at 3.6 days/year frequency, under a high-emissions scenario (SSP3-7.0) at 2050 and 2100. NOTE: Multiple building categories were included in the analysis; therefore, the building exposure results presented here do not represent a single building class.*

Climate action and information

Climate action

This estuarine inundation hazard snapshot highlights both current hazard-exposure levels and the projected changes under various sea-level rise scenarios. The stark differences between emissions scenarios highlight the need for global action to reduce greenhouse gas emissions, and specifically for NSW to meet its legislated Net Zero emissions reduction target by 2050. Avoiding the more severe outcomes associated with high-emissions scenarios depends on timely and sustained mitigation action.

Equally important is the prioritisation of adaptation strategies to manage both existing and future estuarine inundation risks. Highly developed and vulnerable areas identified as at risk should be prioritised for early adaptation planning and investment. As hazard exposure is projected to accelerate over time, proactive adaptation now provides an opportunity to strengthen resilience and ensure that communities can adapt effectively and equitably.

Detailed guidance (including options) on managing coastal hazards is included in the Coastal Management Manual, which recognises that coastal risk management decisions need to consider local circumstances, including the vulnerability of development and local social, economic and environmental factors.

Information

Coastal hazard-exposure projections are delivered with support from the NSW Reconstruction Authority and the Commonwealth Government through the Disaster Risk Reduction Fund. Detailed information on the methods and applications of the hazard projections can be found in the technical report[i]. The projection dataset for estuarine inundation is available on the SEED Data Portal. This comprehensive range of future scenarios ensures that decision-makers can plan for likely outcomes while also preparing for less probable, high consequence events.

This snapshot summarises key headline findings for projected estuarine inundation, as part of the NSW Coastal Erosion and Inundation Assessment 2025. The assessment forms part of the NSW Government's commitment to 'publish regularly updated and improved local level climate change projections' under Action 3 of the NSW Climate Change Adaptation Strategy.

References

i. DCCEEW, 2025. *NSW coastal erosion and inundation hazards and exposure assessment: technical report 2025,* Department of Climate Change, Energy, the Environment and Water, Parramatta, NSW

ii. Hanslow, D.J., Fitzhenry, M.G., Hughes, M.G. et al. 2023. Sea level rise and the increasing frequency of inundation in Australia's most exposed estuary. *Reg Environ Change* 23, 146. doi.org/10.1007/s10113-023-02138-8

iii. www.bom.gov.au/oceanography/projects/abslmp/abslmp.shtml

iv. BOM 2023. Monthly Data Report – December 2023 Australian Baseline Sea Level Monitoring Array. Published by the Australian Bureau of Meteorology.

v. The Special Report on the Oceans and Cryosphere (SROCC) in 2019 (IPCC, 2019) and Sixth Assessment Report by Working Group 1 (AR6) in 2021 (IPCC, 2021).

vi. IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)].

vii. NASA Sea Level Projection Tool (https://sealevel.nasa.gov/ipcc-ar6-sea-level-projection-tool)

viii. Thom, B.G., Eliot, I., Eliot, M., Harvey, N., Rissik, D., Sharples, C., Short, A.D. and Woodroffe, C.D., 2018. National sediment compartment framework for Australian coastal management. Ocean & coastal management, 154, pp.103-120.