Cooks River Catchment Coastal Management Program: Stage 2

Coastal Hazards Assessment

Cooks River Alliance | Report | March 2024

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1 Introduction

1.1 Overview

The Cooks River Alliance (CRA) is developing the Cooks River Catchment Coastal Management Program (CMP) on behalf of the six catchment Councils and Sydney Water. The Cooks River Catchment CMP aims to develop a shared understanding and program of works required to address key management issues and knowledge gaps. Several key management issues were identified in the Scoping Study including tidal and coastal inundation as priority coastal hazards (BMT, 2020).

This study addresses an identified knowledge gap related to these priority coastal hazards, facilitating an increased understanding of exposure and risk for Councils now and into the future with consideration of sea level rise (SLR).

This report consists of the following sections:

- *Section 1 Introduction* – describes the context and objectives of the study.
- *Section 2 Study Area* – defines the geographic scope of the study and the broad impacts of coastal and tidal inundation.
- *Section 3 Coastal and Tidal Inundation Mapping Methodology*– describes the rationale behind the SLR scenarios considered in the study and the methodology used to model and map coastal and tidal inundation.
- *Section 4 Results* – reports the water levels at various locations in the study area for the selected SLR scenarios.
- *Section 5 Tidal and Coastal Inundation Impacts* – summarises the impacts of tidal and coastal inundation on public and private assets, identifies areas potentially affected by backwater flooding and overbank flooding, and demonstrates the potential impact of SLR on estuarine ecosystems in the Cooks River.
- *Section 6 Conclusions* - Identifies potential management options for further consideration in Stage 3 of the Cooks River Catchment CMP development and describes the next steps in the process.

1.2 CMP Context

Local councils and public authorities are required to manage their coastal areas and activities in accordance with relevant state legislation, policies and plans. The framework (**Figure 1-1**) for managing the NSW coast includes:

- *Coastal Management Act 2016* (CM Act)
- State Environment Planning Policy (Resilience and Hazards) 2021 (Resilience and Hazards SEPP)
- CMPs prepared in accordance with the NSW Coastal Management Manual (2018).
- Inter-related legislation and strategies, such as the *Environmental Planning & Assessment Act 1979*, *Marine Estate Management Act 2014* and the Marine Estate Management Strategy.

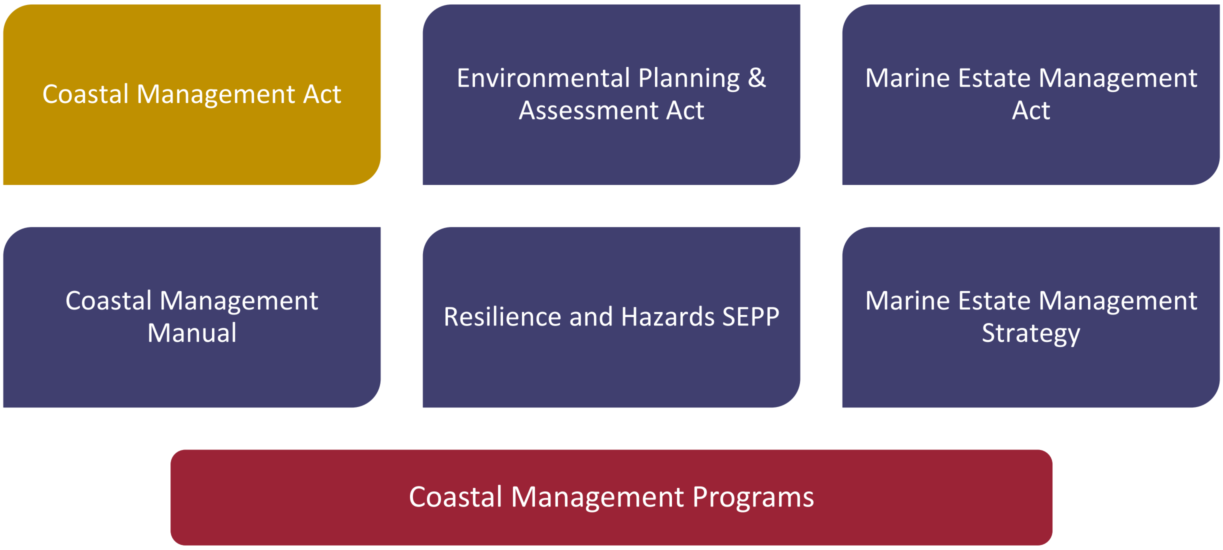

Figure 1-1 NSW coastal management framework

The NSW Coastal Management Manual (the Manual) specifies five stages of preparing a CMP (**Figure 1-2**). This study is part of Stage 2 of the Cooks River Catchment CMP.

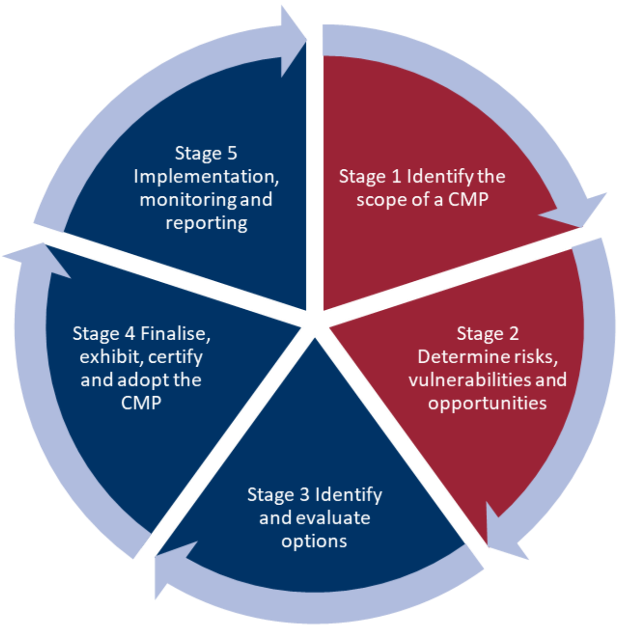

Figure 1-2 The five stages of a CMP (Adapted from OEH, 2018a)

1.3 Recommendations of the Scoping Study

The Stage 1 Scoping Study (Scoping Study) for the Cooks River Catchment CMP was completed in January 2020 (BMT) and was a collaborative project led by the Cooks River Alliance. The Scoping Study identified that tidal and coastal inundation are considered high priority management issues within the CMP study area and are expected to be exacerbated by sea level rise. The Scoping Study recommended as part of the forward plan that the following related studies be undertaken during Stage 2 of the CMP:

- Critically review (in detail) existing data, particularly historical tidal behaviour information, wave and ocean water level data, topography (LIDAR), bathymetry (riverine / marine LIDAR), etc.
- Determine coastal hazard model input parameters (starting with state-wide parameters set by The Department of Planning and Environment -EES[1]) and assumptions to be applied in the study area. This shall include confirming the timeframes for outputs (e.g. 2020, 2050, 2100 etc) and the sea level rise scenarios to be applied. Consideration should be given for a Botany Bay / sediment compartment wide study.
- Determine hazard assessment and mapping outputs needed to inform coastal management going forward. This may include:
    - hazard mapping suitable for preparing a planning proposal to update the Coastal Vulnerability Area maps in the Resilience and Hazards SEPP; and
    - hazard mapping outputs enabling assessment of immediate and future coastal vulnerabilities.

1.4 Purpose of this Study

This study seeks to address the recommendations of the Scoping Study. Specifically, the key objectives of the current scope of work are to:

- Identify key locations of current and future coastal hazards.
- Identify current and future risks for coastal and tidal inundation coastal hazards in the Cooks River Catchment CMP study area; and
- Assess exposure of assets and critical infrastructure affected to these coastal hazards.

1.5 Stakeholder Engagement

This study is underpinned by engagement and consultation with the member Councils and other stakeholders. This was accomplished through two collaborative workshops at key points during the project. An overview of these workshops is provided in **Table 1-1**.

Table 1-1 Overview of engagement activities

Purpose of workshop	
Workshop #1 (29 August 2023)	• Provide context of the project • Discuss and confirm inundation assessment approach • Discuss and confirm sea level rise scenarios and planning horizons
Workshop #2 (22 November 2023)	• Review coastal and tidal inundation mapping • Discuss risk to Councils and other stakeholders • Identify potential management options

[1] Note that as of 1 January 2024, The Department of Planning and Environment has been restructured into the Department of Climate Change, Energy, the Environment and Water (DCCEEW), with coastal management under the Environment and Heritage office.

2 Study Area

2.1 Geographic Area

The geographic scope of the Cooks River Catchment CMP covers coastal areas along the estuary and in the suburb of Botany. The Cooks River flows for 23 km through the heart of highly urbanised and industrialised area of Sydney from Yagoona in the southwest to Botany Bay. The inclusion of the suburb of Botany recognises the original river entrance and connection to Botany wetlands. An overview of the study area is provided in **Figure 2-1**.

The Scoping Study identified many of the highest threats to the health of coastal areas arising from transboundary and catchment wide management issues including habitat loss, contamination, stormwater inputs and urban development. For this reason, the river's catchment, freshwater tributaries and upper streams are included in the CMP study area.

The Cooks River Catchment CMP will focus on all four coastal management areas (CMAs), as listed in the CM Act and mapped in the Resilience and Hazards SEPP. Coastal Vulnerability Area mapping is not currently available and has not been prepared for this study area. This current coastal hazards study can be used by the partner Councils to inform their decision making about Coastal Vulnerability Area application.

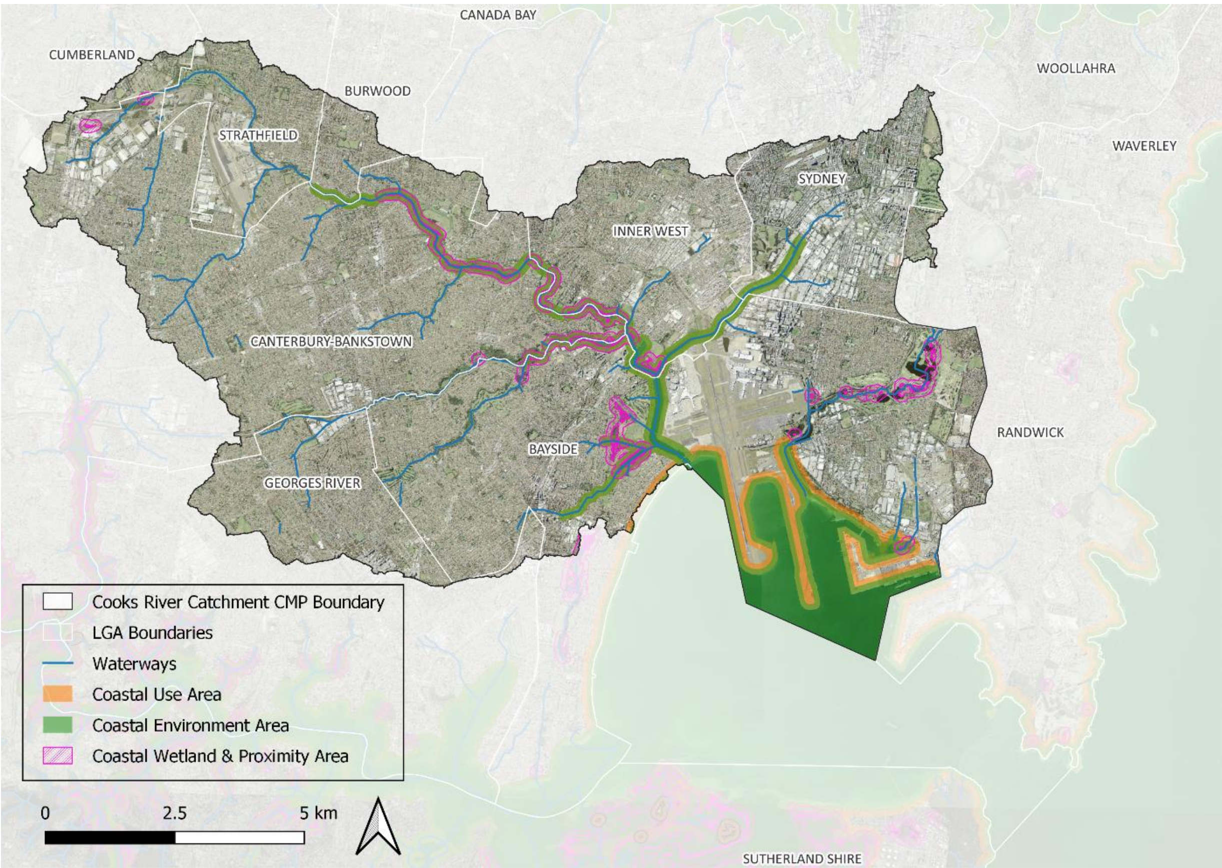

Figure 2-1 Cooks River Catchment CMP study area

2.2 Coastal Hazards Affecting the Study Area

The CM Act defines seven coastal hazards. The Scoping Study (BMT, 2020) identified which of these hazards are present in the Cooks River CMP study area. Coastal and tidal inundation are identified as the priority hazards in the study area. These are summarised in **Table 2-1**.

Table 2-1 Coastal Hazards in the Cooks River Catchment Coastal Management Program study area (BMT, 2020)

Type of coastal hazard (from the CM Act)	Present in Cooks River Catchment and Botany Bay
(a) beach erosion	N/A. Foreshore Beach is already managed with groynes. Plane Spotting beach is too small.
(b) shoreline recession	N/A
(c) coastal lake or watercourse entrance instability	N/A - Trained entrance
(d) coastal cliff or slope instability	N/A
(e) coastal inundation	Yes, present in study area
(f) tidal inundation	Yes, present in study area
(g) erosion and inundation of foreshores caused by tidal waters and the action of waves, including the interaction of those waters with catchment floodwaters	Being completed through the Cooks River Catchment Flood Study

Tidal inundation is defined in the OEH (2018) Coastal Management Glossary 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. Some locations in the study area are already impacted by tidal inundation (**Figure 2-2**).

Coastal inundation occurs when a combination of marine and atmospheric processes raises the water level at the coast above normal elevations, causing land that is usually ‘dry’ to become inundated by sea water. Alternatively, the elevated water level may result in wave run-up and overtopping of natural or built shoreline structures (e.g. dunes, seawalls) (OEH, 2018).

Coastal inundation is primarily caused by severe weather events such as east coast lows and other low pressure storm systems. Unlike tidal inundation, which is a regular occurrence, coastal inundation is often associated with extreme weather events and can result in more significant, although temporary, flooding.

The frequency and magnitude of both hazards are expected to increase as sea level rises in response to climate change.

Figure 2-2 Tidal inundation in Botany (Photo taken 1 February 2018 by Martin Fitzhenry, DPE)

2.3 Other Considerations

Beyond the impacts of coastal and tidal inundation as a coastal hazard, these phenomena will have widespread impacts on low-lying and adjacent areas. Many of these areas are currently used for public recreation associated with the scenic amenity provided by the Cooks River. Other urban areas are at risk from backwater flooding which occurs when tides surge up through the stormwater system.

2.3.1 Diminished Stormwater Drainage Capacity

The invert (bottom) and obvert (top) levels of the stormwater outlets determines the drainage window available for water to flow in or out of the stormwater system. If the high tide reaches above obvert, then there is potential for backwater flooding to flow up the pipes and into low-lying areas adjacent to the drains. Devices such as floodgates, or one-way flow valves can prevent the inflow of tidal waters, but they require regular maintenance to maintain their ability to prevent tidal ingress, and frequent clearing to maintain their ability to convey stormwater.

Additionally, if the low tide level is above the invert, then the drainage capacity of the stormwater outlet is diminished. This concept is illustrated in **Figure 2-3**. Importantly, as sea level rises, the drainage window for low level stormwater outlets will increasingly diminish over time.

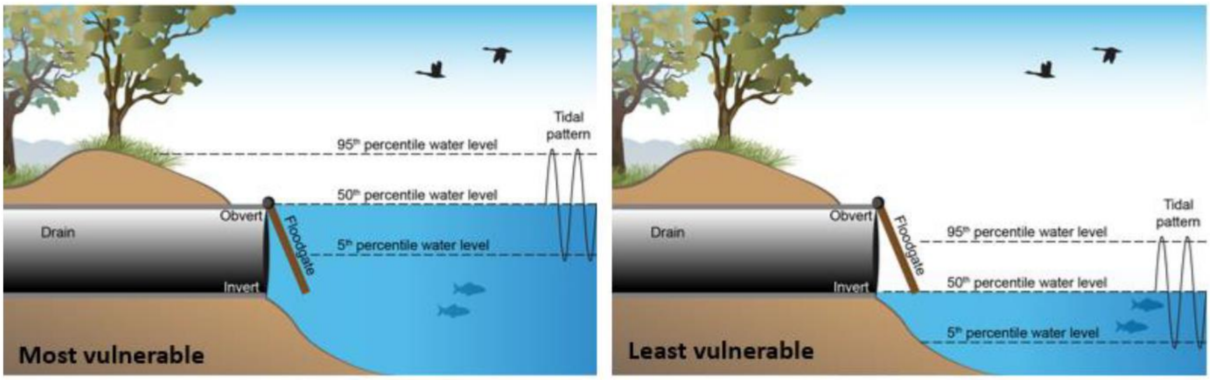

Figure 2-3 Concept drawing of the impacts of tide levels on stormwater drains (D S Rayner et. al., 2023)

At first, tidal inundation through the stormwater system can be managed at the pipes using tide gates. But over time as sea level rise continues, the water levels may eventually overtop the bank. This would require more extensive landform changes or asset redesign to address impacts. This progression is illustrated in **Figure 2-4**.

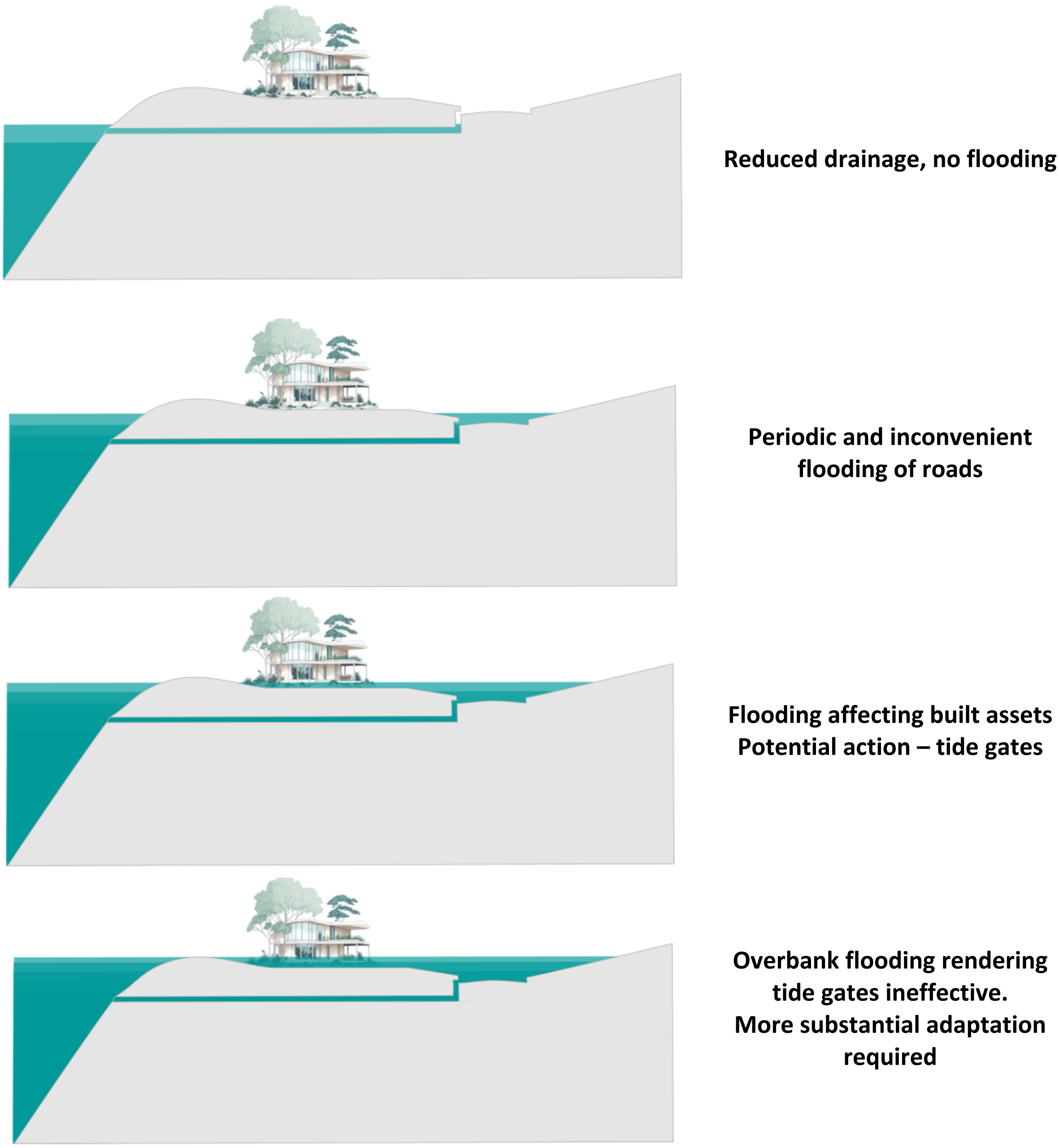

Figure 2-4 Progressing of backwater flooding with sea level rise (Hanslow, 2023)

2.3.2 Increased Frequency of Inundation

As sea level rises, inundation that currently only occurs rarely will become more frequent. Manly Hydraulics Laboratory has developed a Future Inundation Projections tool that provides information on how frequently certain inundation thresholds are expected to be reached throughout NSW (MHL, 2024). The tool leverages the extensive network of tide gauges in NSW and enables users to investigate the potential implications of sea level rise using water level exceedance data from their local tide gauge.

The tool visualises projected future changes to the frequency of inundation above a user defined threshold. Doing this enables users to understand how frequently inundation above the threshold level is occurring now, including the extent of interannual variability based on observed variability in annual water level exceedance distributions.

Additionally, it considers sea level rise projections, at decadal intervals, of future increases to inundation frequency associated with each of the sea level rise scenario's undertaken for the UN Intergovernmental Climate Change Sixth Assessment Report (AR6) (IPCC, 2021). An example output illustrating the projected flooding days at the Tempe Bridge tide gauge, with a selected threshold of 1.30 m AHD, for three climate change scenarios is shown in **Figure 2-5**.

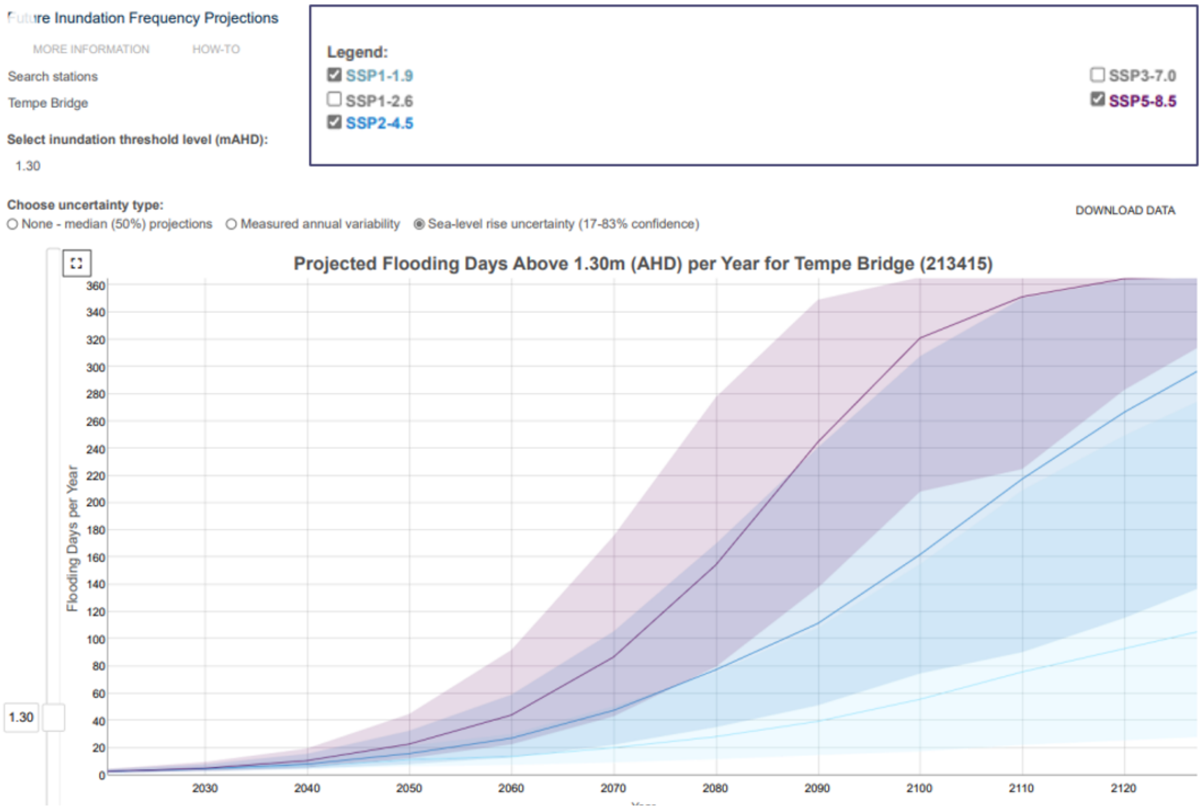

Figure 2-5 Example output from the MHL Future Inundation Projections tool showing the projected number of days where flooding will exceed the 1.30m (AHD) threshold. Three climate change scenarios adopted from IPCC AR6 (IPCC, 2021) are shown along with associated uncertainty tolerance of 17-83% confidence.

Quantifying the increasing frequency of inundation at certain thresholds provides information that can be used to guide adaptation. Different assets and areas have different risk tolerance. Risk tolerance is informed by asset owners and managers, as well as the community. An understanding of risk tolerance can help to determine appropriate triggers for adaptation action such as the installation of tide gates, small levees, or land use change. It is also important to continuously monitor both actual inundation frequency and stakeholders' risk tolerance, which may change over time.

2.3.3 Ecological Impacts

Tidal inundation with sea level rise will have widespread impacts on estuarine ecosystems such as mangroves and saltmarsh, ranging from species specific sub-lethal or lethal impacts to changes in reproductive processes/success. Healthy, resilient and protected ecosystems are best placed to naturally adapt to a changing climate, as long as the conditions that support their health are maintained into the future. These habitats will be subject to 'coastal squeeze', where ecosystems are unable to gradually migrate landward in response to sea level rise due to natural or artificial barriers. Barriers such as drainage infrastructure, roads, and seawalls can prohibit landward migration and therefore the survival of these ecosystems into the future. This process is illustrated in **Figure 2-6**.

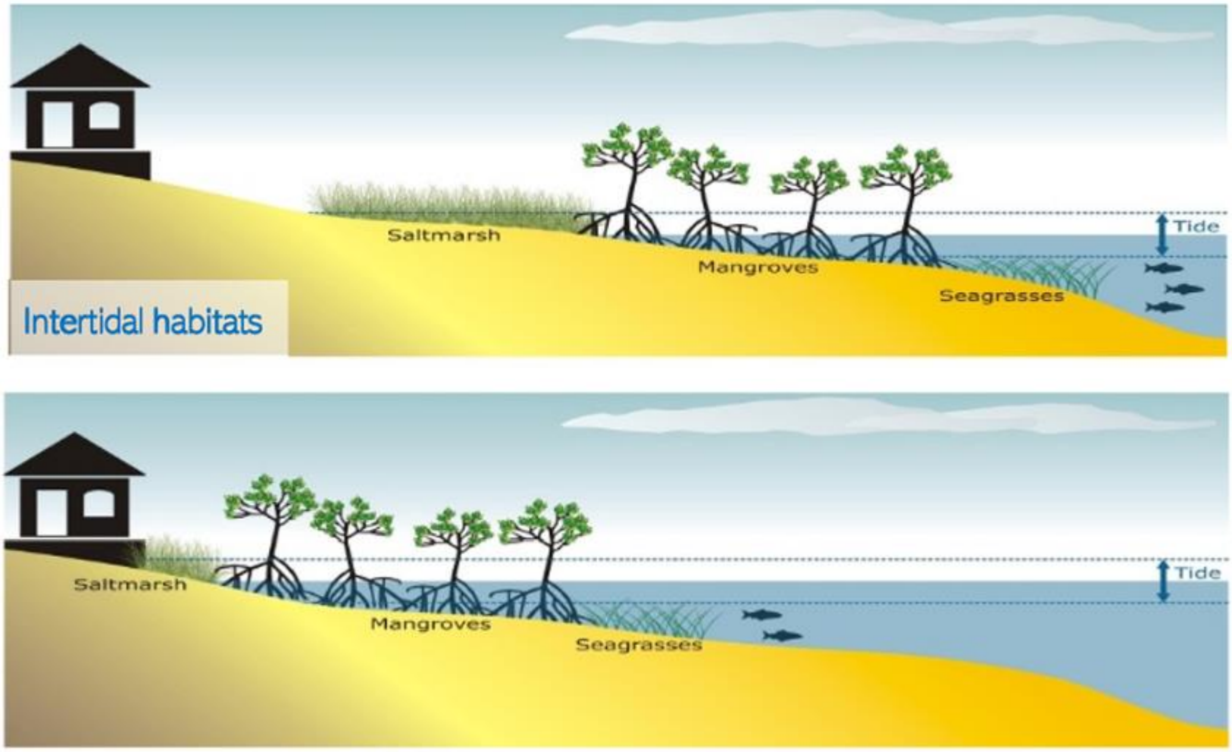

Figure 2-6 Effects of sea level rise on estuarine intertidal habitats undergoing coastal squeeze (UNSW WRL, 2023)

This study considers these factors and provides detailed information relating to the Cooks River Catchment CMP study area so that appropriate management actions can be identified and implemented through Stages 3 to 5 the CMP.

3 Coastal and Tidal Inundation Mapping Methodology

The methodology used to map coastal and tidal inundation for this study is summarised below. A more detailed technical description of the mapping methodology is provided in **Appendix A**.

3.1 Data Review

A range of existing datasets have been reviewed to inform the coastal inundation and tidal inundation mapping methodology. This includes available water level data from three tide gauge stations operated by Manly Hydraulics Laboratory (MHL) on the Cooks River; namely, Tempe Bridge (Station ID: 213415), Illawarra Road Bridge (Station ID: 213420) and Canterbury Road (Station ID: 213411).

These were compared to water level data from the Fort Denison Primary Tide water level gauge operated by the Port Authority of NSW (both predicted and measured water level). Due to their relative proximity and similar estuarine characteristics, water levels at Fort Denison closely match those at Botany Bay with very minor lag (Bureau of Meteorology, 2023).

Snapshots from these comparisons are provided in **Figure 3-1**, showing a tidally dominant period (top), a period of elevated coastal water levels (middle) and a period where catchment flows are notable (bottom) for comparison.

From this analysis, the following observations can be made:

- Water levels at the three gauges along the Cooks River closely match the measured water levels from Fort Denison, indicating minor tidal amplification (~0.05m) along the river.
- The same is observed during periods of elevated coastal water levels (identified from the residual tide at Fort Denison), with the potential for local setup processes within Botany Bay to increase the water level at the Cooks River Entrance above the Fort Denison gauge.
- Peak residuals within the Cooks River resulting from catchment flows reduce along the river closer to Botany Bay.

Water level data was obtained from the Port Authority of NSW (Port Botany measurements) to enhance the analysis of extreme coastal water levels and inform the estimates of local processes within Botany Bay, such as wind set up. The water level comparisons were also supported by available offshore wave data (from Botany Bay) and daily rainfall totals (from Canterbury Racecourse AWS) to identify periods where coastal water levels are dominant along Cooks River.

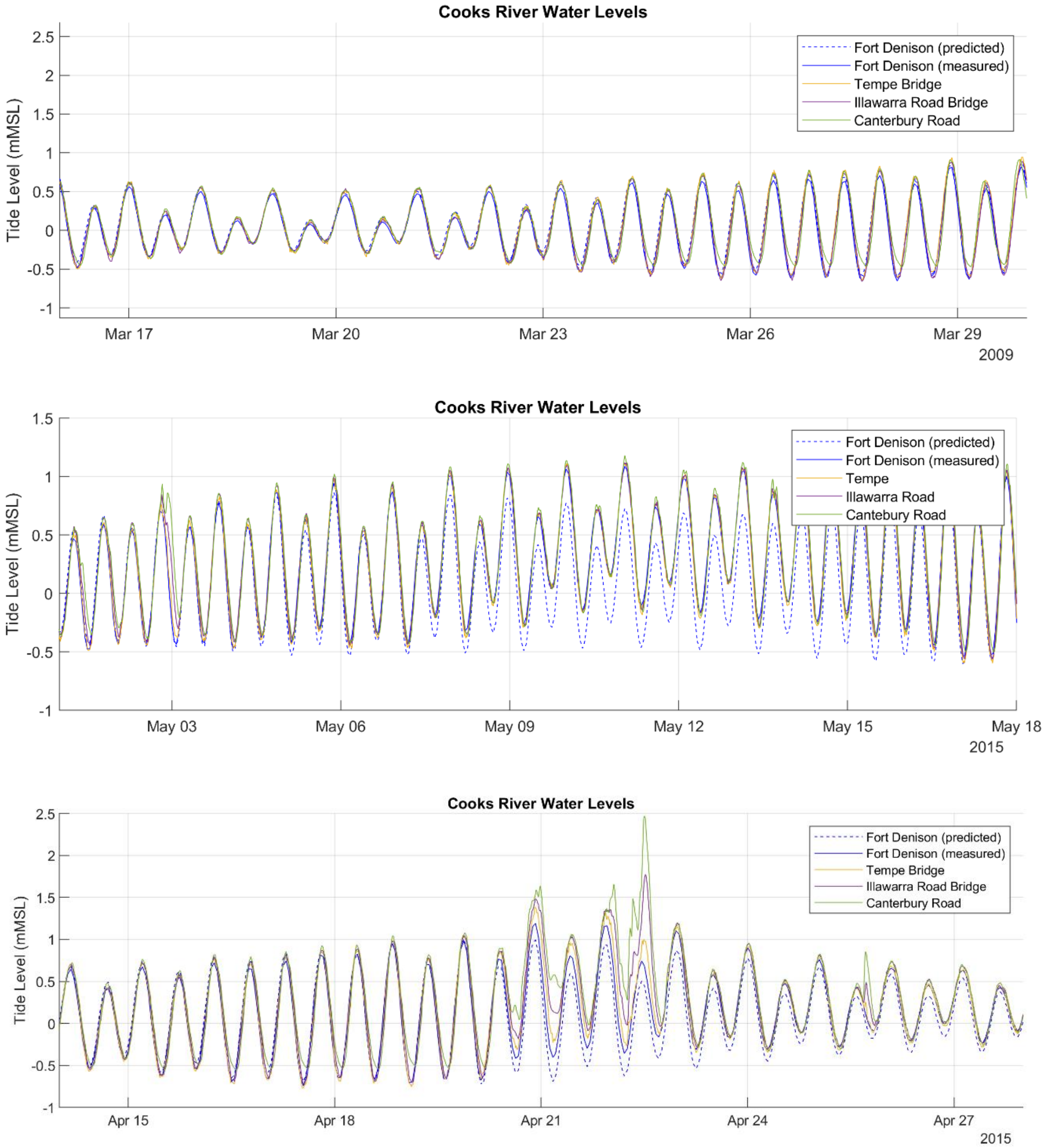

Figure 3-1 Measured water levels along the Cooks River compared against water levels at Fort Denison for a tidally dominant period (top), a period of elevated coastal water levels (middle) and a period where catchment flows are notable (bottom)

3.2 Sea Level Rise Scenarios for Future Risk Assessment

Determining appropriate sea level rise scenarios for future inundation risk is critical to understanding potential impacts on the Cooks River catchment and Botany coastal areas. Aligning with the CM Act objectives and the Manual, sea level rise has been considered across multiple planning horizons, namely present day, 20 years, 50 years, 100 years and beyond. This provides short, medium, and long-term perspectives on the potential hazards.

The selection of sea level rise projections for various planning horizons for the purpose of the current hazard assessment leverages existing projections set by national and international bodies. Given the inherent uncertainties in predicting future sea levels, it is beneficial to consider multiple scenarios with varying assumptions to determine the range of potential risks.

The Intergovernmental Panel on Climate Change (IPCC) and the US National Aeronautics and Space Administration (NASA) provide global estimates of sea level rise under different emission scenarios and for planning horizons in line with the requirements of the NSW Coastal Management Manual (OEH, 2018).

The IPCC Sixth Assessment Report (IPCC, 2021) provides regional scale sea level change projections for a number of emissions scenarios for planning horizons to 2150. A data visualization tool is available at Sea Level Projection Tool – NASA Sea Level Change Portal (NASA, 2022).

Sea level change for emissions scenarios projections with at least medium confidence is provided. Two low-confidence scenarios, indicating the potential effect of low-likelihood, high-impact ice sheet processes that cannot be ruled out, are also provided. Projections for medium confidence processes for Sydney are presented in **Figure 3-2.** Sea level rise scenarios considered for this study (see **Table 3-1** below) are highlighted, showing the range of years when they could be reached. The grey shaded areas indicate planning horizons noted in the Manual.

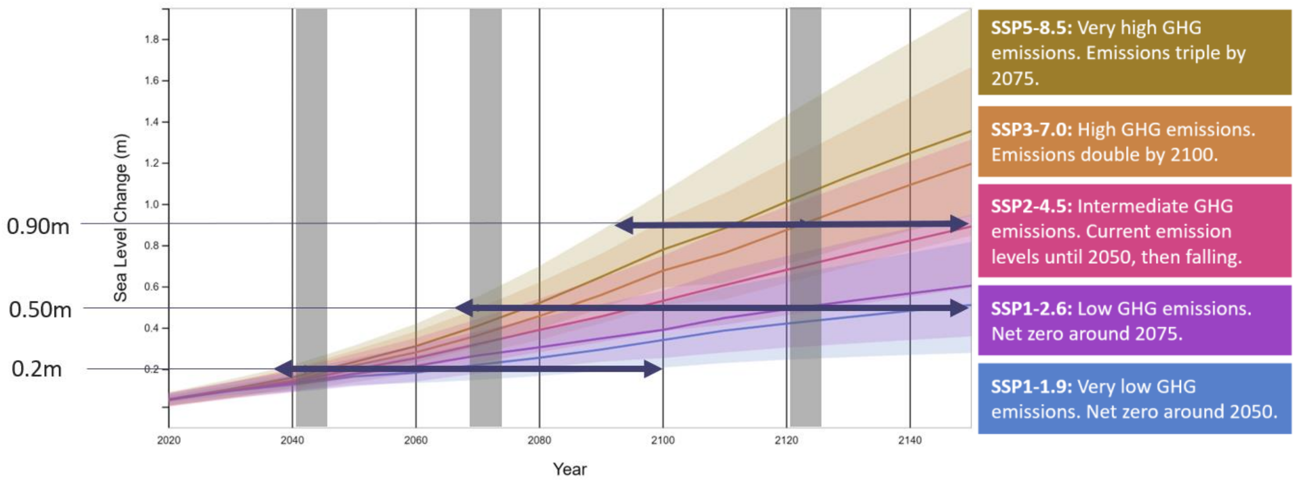

Figure 3-2 Sea level change projections for Sydney (NASA, 2022).

Fit for purpose sea level rise scenarios based on these projections have been identified for this assessment and are provided in **Table 3-1**.

It is important to note that regardless of future greenhouse gas emissions outcomes, global mean sea level is expected to increase well into the future, and beyond the planning horizons considered in the CMP (IPCC, 2021). Therefore, although conservative scenarios have been selected for each planning horizon, it is virtually certain that mean sea level will reach these heights at some point.

Table 3-1 Fit for purpose sea level rise scenarios

Planning Horizon	Sea Level Rise (above present day)
Approximately 20 years (Short Term)	0.2 m
Approximately 50 years (Medium Term)	0.5 m
Approximately 100 years (Long Term)	0.9 m

The sea level rise values agreed upon for the purposes of the CMP were determined through a workshop with Councils on 29 August 2023 (see **Table 1-1**).

The agreed upon short-term scenario of 0.2 m SLR is the 83rd percentile projected value to be reached under the Intermediate Emissions Scenario, SSP2 – 4.5 by 2041. This amount of sea level rise could be reached as soon as 2039 (83rd percentile of modelled projections for the Very High Emissions Scenario, SSP5 – 8.5), and as late as 2094 (17th percentile of modelled projections for the Very Low Emissions Scenario, SSP1 – 1.9).

A more conservative projection has been selected for the medium- and long-term planning horizons, an appropriate approach considering the highly urbanised (i.e. high risk) nature of the low-lying areas of the study area. The agreed upon medium-term scenario of 0.5 m SLR is the 83rd percentile projected value to be reached under the High Emissions Scenario, SSP3 – 7.0, by 2073. This amount of sea level rise could be reached as soon as 2067 (83rd percentile of modelled projections for the Very High Emissions Scenario, SSP5 – 8.5), and as late as 2150 (50th percentile of modelled projections for the Very Low Emissions Scenario, SSP1 – 1.9).

The agreed upon long-term scenario of 0.9 m SLR is the median projected value to be reached under the High Emissions Scenario, SSP3 – 7.0, by 2123. This amount of sea level rise could be reached as soon as 2091 (83rd percentile of modelled projections for the Very High Emissions Scenario, SSP5 – 8.5), and beyond 2150 (modelled projections for the Very Low Emissions Scenario, SSP1 – 1.9).

Key reasons why these scenarios have been selected include:

- *Alignment with IPCC AR6 projections and the CM framework* – these values are expected to be reached under various emissions pathways within a timeframe that aligns with Councils' planning horizons, asset and development design life, and the requirements of the CMP.
- *Balance between conservative and overestimation* – A more conservative approach is appropriate when planning for SLR in a highly urbanised area such as Cooks River, however it is important to not overestimate the risk and begin unwarranted planning for very unlikely outcomes. The scenarios that have been selected are associated with High Emissions Scenarios. Current pledges from the global community would result in the Medium Emissions Scenarios, and the intent of increasingly ambitious nationally determined contributions under the Paris Agreement is to ratchet up to achieve lower emissions pathways. However there remains significant uncertainty

in both model projections and future emissions pathways, so understanding and planning for higher sea levels sooner is prudently being achieved with the selected scenarios.

- *Ability to adapt* – The longer-term perspectives of this study allow for future adaptation and adjustment as more information becomes available over time. The scenarios selected provide good information for present day planning and adaptation, while also embedding knowledge for future decisionmakers.
- *Supported by existing policies* – Information from various organisations current policies on SLR, climate change, adaptation and planning has been provided and considered when selecting these scenarios. Due to the number of councils and agencies involved in this study, it was impossible to align with all parties. However, these scenarios were selected deliberately to align with these policies, providing supporting technical information that can be readily considered and adopted across the board.
- *Supported by previous studies* – Numerous flood studies and inundation mapping studies have been developed for the Cooks River. The relevance of these studies is dependent on how recently they were completed. It is important that this study does not duplicate previous effort, but rather builds on existing knowledge and improves it by incorporating the most recent data and best practice. The most recent tidal inundation study for the area is the NSW Estuary Tidal Inundation Exposure Assessment (OEH, 2018) which modelled 0m, 0.5m, 1.0m and 1.5m SLR for estuaries across the State using existing tide gauge data. This information provides additional, more conservative, scenarios for consideration allowing this study to fine tune lower SLR scenarios which will be reached earlier. The crossover of the 0.5m SLR scenarios with the State-wide study and this more locally focused one provide a chance to compare results and understand the nuance of the study area.

3.3 Approach to Hazard Assessment

Based on the water level data observations (**Section 3.1**), which are supported by the NSW tidal plane analysis (MHL, 2023), a data driven methodology has been developed to undertake an inundation coastal hazard assessment for both coastal and tidal inundation. Theses hazards were then mapped throughout the study area for multiple SLR scenarios and event likelihoods.

3.3.1 Tidal Inundation

Building on the *NSW Estuary Tidal Inundation Exposure Assessment* (OEH, 2018), a harmonic analysis of available tide gauge data along the Cooks River, and within Botany Bay has been completed and used to update the tidal plane information reported in MHL (2023). This includes both High High Water Spring Solstice (HHWSS) and Mean Low Water Spring (MLWS) tidal planes.

Tidal plane values have been interpolated along Cooks River up to the tidal extent and has formed the basis of mapping tidal inundation along the Cook River. SLR has been applied by adding the corresponding increase to the tidal planes.

The following tidal planes and SLR scenarios have been assessed:

- HHWSS
  - 0 m SLR
  - +0.2 m SLR
  - +0.5 m SLR

    - +0.9 m SLR
- MLWS
    - 0 m SLR
    - +0.2 m SLR
    - +0.5 m SLR
    - +0.9 m SLR

3.3.2 Coastal Inundation

Extreme value estimates of design coastal water levels are available from the long-term water level record at Fort Denison. To derive equivalent extreme water level estimates for Botany Bay, concurrent water level data from both Fort Denison and Port Botany has been assessed with the coastal residuals correlated.

In addition, the potential contribution for local wind setup at the coastal entrance to the Cooks River, generated over the enclosed waters of Botany Bay, has been assessed using a coarse resolution hydrodynamic model of Botany Bay with consideration of wind conditions during coastal storms. Wave setup at the entrance was not considered given the fact it is a relatively deep trained river entrance where wave setup would be negligible.

The local contribution of setup has been added to the design coastal water levels for mapping of coastal inundation along the Cooks River and considers the effects of sea level rise on the setup potential.

Similar to the tidal inundation, review of the available tide gauge data during periods of elevated coastal water levels indicates that only minor amplification along the Cooks River occurs. The gradient of this amplification has been defined and applied to the estimates of extreme coastal water levels at the Cooks River entrance such that coastal inundation extents can be defined along the Cooks River and tributary lengths.

Coastal inundation scenarios assessed include:

- Present day 5 year ARI
- Present day 10 year ARI
- Present day 100 year ARI
- +0.2 m SLR 100 year ARI
- +0.5 m SLR 100 year ARI
- +0.9 m SLR 100 year ARI

3.3.3 Inundation Mapping

The tidal and coastal inundation assessments described above were used to map the extent and depth of inundation for the various scenarios. Bathymetric data provided by the Cooks River Alliance and 1m resolution topographic data obtained from Elvis (Sydney 2013-04-11 2kmx2km 1 metre Resolution Digital Elevation Model) were used to establish a digital elevation model of the study area. An interpolated water level surface was created for each inundation scenario using nodes at locations throughout the waterway. These locations were selected based on the location of water level gauges and known tidal limits of the Cooks River and main tributaries, noting that there is a reltaively small gradient in water levels across the waterway. Locations where water levels were determined are shown in **Figure 3-3.**

Inundation mapping has been undertaken by overlaying the interpolated water level surfaces onto the ground surface based on Lidar to determine which areas are lower in elevation than the water level. A hydro-connectivity routine was adopted to determine inundation extents in areas that are hydraulically connected to the Cooks River. Stormwater infrastructure, and their influence on hydro-connectivity, has been considered to identify areas of 'backwater flooding'. This was undertaken using stormwater pipe and pit spatial data to determine potential flow pathways to low-lying areas with an elevation lower than the interpolated tidal plane. This approach does not consider the pipe diameter, nor invert and obvert levels, but treats all pipes and pits as potential conveyance pathways for inundation from the seaward direction. This assessment should be used as a first pass gauge of stormwater connectivity for backwater flooding, and more detailed investigation would consider the specifications of the stormwater assets and incorporate this information.

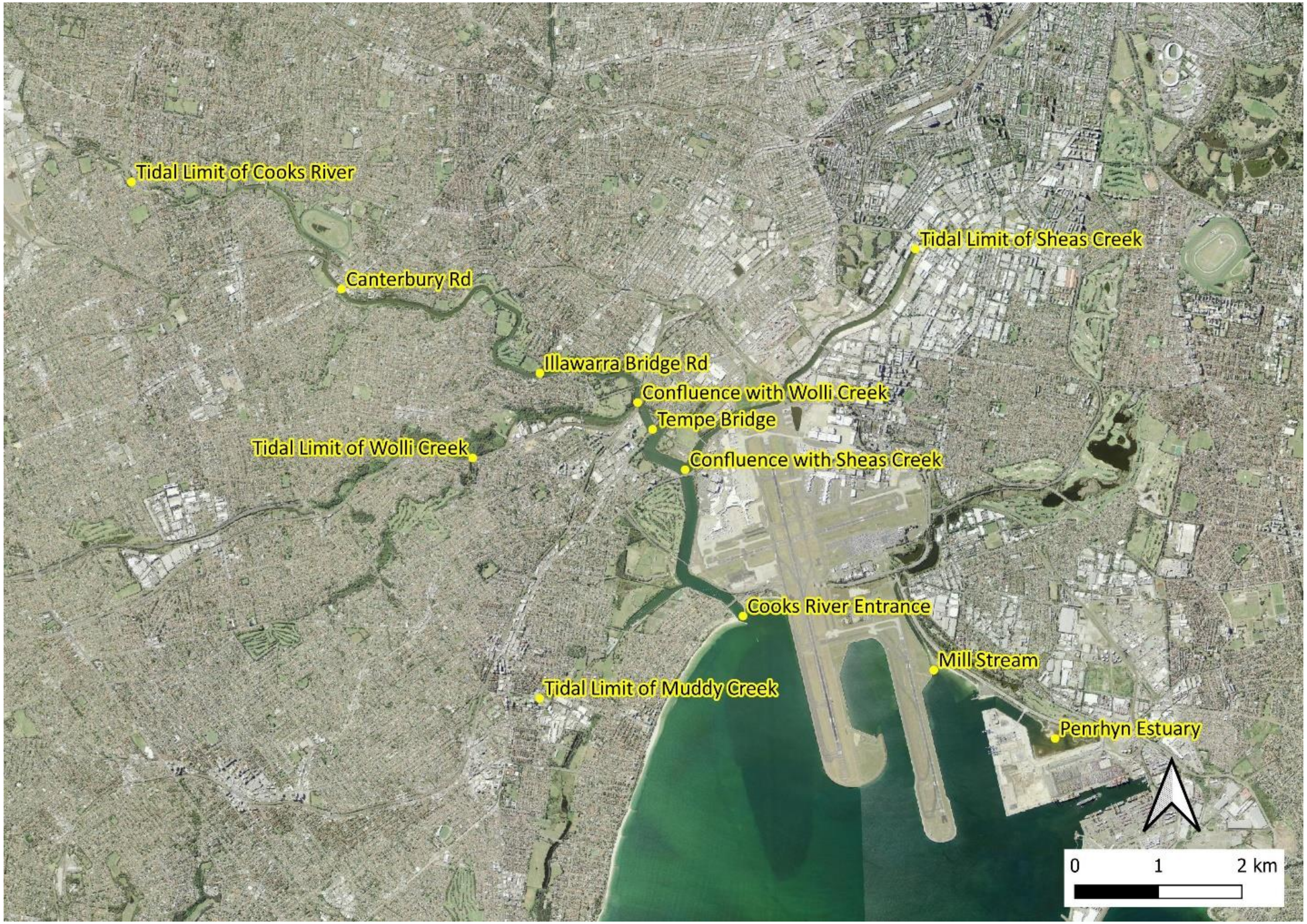

Figure 3-3 Locations used to interpolate tidal datum and report water levels

4 Results

In **Sections 4.1** and **4.2**, water levels for the various inundation scenarios are reported for the locations shown in **Figure 3-3**. Each inundation scenario is mapped in **Appendix B.**

4.1 Tidal Inundation

Tidal inundation is defined in **Section 2.2** and the approach to derive tidal levels for mapping is described in **Section 3.3.1** and **Appendix A**.

Tidal water levels were derived at the locations reported in **Table 4-1**. Mapping of inundation extents was prepared based on these levels. The extent of tidal inundation for the scenarios noted in **Table 4-1** is shown in maps **RG_01_01** through **RG_01_07** in **Appendix B**.

Table 4-1 Tidal planes water levels

Location	Tidal Levels (mAHD)							
	HHWSS				MLWS			
	No SLR	SLR= 0.2m	SLR= 0.5m	SLR= 0.9m	No SLR	SLR= 0.2m	SLR= 0.5m	SLR= 0.9m
Penrhyn Estuary	1.03	1.23	1.53	1.93	-0.57	-0.37	-0.07	0.33
Cooks River Entrance	1.03	1.23	1.53	1.93	-0.57	-0.37	-0.07	0.33
Tidal Limit of Muddy Creek	1.03	1.23	1.53	1.93	-0.57	-0.37	-0.07	0.33
Mill Stream	1.03	1.23	1.53	1.93	-0.57	-0.37	-0.07	0.33
Confluence with Sheas Creek	1.06	1.26	1.56	1.96	-0.55	-0.35	-0.05	0.35
Illawarra Bridge Rd	1.06	1.26	1.56	1.96	-0.55	-0.35	-0.05	0.35
Canterbury Rd	1.06	1.26	1.56	1.96	-0.52	-0.32	-0.02	0.38
Tidal Limit of Cooks River	1.06	1.26	1.56	1.96	-0.52	-0.32	-0.02	0.38
Tidal Limit of Sheas Creek	1.06	1.26	1.56	1.96	-0.55	-0.35	-0.05	0.35
Tidal Limit of Wolli Creek	1.06	1.26	1.56	1.96	-0.54	-0.34	-0.04	0.36
Tempe Bridge	1.07	1.27	1.57	1.97	-0.55	-0.35	-0.05	0.35
Confluence with Wolli Creek	1.07	1.27	1.57	1.97	-0.55	-0.35	-0.05	0.35

4.2 Coastal Inundation

Coastal inundation is defined in **Section 2.2** and the approach to derive tidal levels for mapping is described in **Section 3.3.2** and **Appendix A**.

Coastal inundation water levels were derived at the locations reported in **Table 4-2**. Mapping of inundation extents was prepared based on these levels. The extent of coastal inundation for the present day scenarios is shown in maps **RG_02_01** through **RG_02_07** in **Appendix B**. The extent of coastal inundation for the 100 yr ARI with sea level rise is shown in maps **RG_03_01** through **RG_03_07.**

Table 4-2 Coastal inundation water levels

Locations	Water Levels (mAHD)					
	10 year ARI	5 year ARI	100 year ARI			
	No SLR		No SLR	SLR=0.2m	SLR=0.5m	SLR=0.9m
Penrhyn Estuary	1.43	1.40	1.52	1.72	2.02	2.42
Cooks River Entrance	1.48	1.43	1.62	1.82	2.12	2.52
Tidal Limit of Muddy Creek	1.48	1.43	1.62	1.82	2.12	2.52
Mill Stream	1.48	1.45	1.57	1.77	2.07	2.47
Tidal Limit of Sheas Creek	1.50	1.45	1.64	1.84	2.14	2.54
Confluence with Sheas Creek	1.50	1.45	1.64	1.84	2.14	2.54
Tempe Bridge	1.51	1.46	1.65	1.85	2.15	2.55
Confluence with Wolli Creek	1.51	1.46	1.65	1.85	2.15	2.55
Illawarra Bridge Rd	1.53	1.48	1.67	1.87	2.17	2.57
Tidal Limit of Wolli Creek	1.53	1.48	1.67	1.87	2.17	2.57
Canterbury Rd	1.54	1.49	1.68	1.88	2.18	2.58
Tidal Limit of Cooks River	1.55	1.5	1.69	1.89	2.19	2.59

5 Tidal and Coastal Inundation Impacts

As demonstrated by the hazard assessment, tidal and coastal inundation exposure will gradually increase throughout low lying locations in the study area. As this occurs, more area and assets will be at greater risk of inundation impacts.

The impacts of inundation differ for tidal and coastal inundation. Driven by astronomical forces, tidal inundation is more frequent and independent of weather. Astronomical tides can be predicted well in advance, providing time to prepare and implement adaptation actions. However, tidal inundation will occur more frequently, and whilst some areas may only be inundated 2-4 times a year under current sea levels, with sea level rise this may increase to once or twice a month (see **Section 2.3.2** for further discussion).. Areas and assets not designed for regular saltwater exposure will need to be removed or replaced, unless mitigation measures can effectively prevent inundation. As discussed in **Section 2.3**, there are different mitigation approaches required for overbank flooding compared with backwater flooding.

Coastal inundation is driven by episodic meteorological events that temporarily increase water level. Additionally, these events bring rainfall that may exacerbate coastal inundation levels. Therefore, while the exposure footprint is greater, the inundation is short-lived, generally on the order of a few hours. Coastal inundation occurs with less forewarning than tidal inundation. Adaptation for coastal inundation needs to consider catchment rainfall and is therefore focused on preparation, response, and recovery.

Based on the differences between tidal and coastal inundation hazards, there are likely to be differences in tolerable risk as well. For example, an area or asset that gets wet during extreme events would be considered a more tolerable risk than an area more frequently inundated by tidal inundation.

5.1 Inundation Risk to Public and Private Assets

The inundation extents were used to map assets and areas that are exposed under the various inundation scenarios. The following have been included in this exposure assessment:

- Roads and paths
- Buildings
- Public open space / recreation area
- Land zoning
- Priority Growth Areas.

Results of this assessment are reported for each LGA, and for each inundation scenario. Full results in tabular format are provided in **Appendix C**. Information on how the results are reported is provided in **Table 5-1**. Maps showing roads and buildings exposed to tidal inundation are provided in maps **RG-04-01_exp** through **RG-04-07_exp** in **Appendix B**.

Table 5-1 Exposure assessment results provided for each asset type.

Asset type	Results provided
Buildings	• Count of footprints exposed (overbank and backwater)
Roads and paths	• Length exposed of road and path types (overbank and backwater)
Public open space / recreation area	• Area exposed of each space (overbank and backwater)

Asset type	Results provided
	• Percentage exposed of each space
Land Zoning	• Total area of each zone classification exposed
Priority Growth Areas	• Area exposed of each space (overbank and backwater) • Percentage exposed of each space

5.2 Overbank and Backwater Inundation Impacts

Hydraulic connectivity of low-lying land was classified as either overbank or backwater. Overbank inundation is when flooded land is directly hydraulically connected to the main Cooks River waterway. Backwater inundation is when land is hydraulically connected via the subterranean stormwater system. Without intervention, areas subject to backwater flooding will expand with sea level rise. In some cases, these areas will eventually become hydraulically connected to the main Cooks River waterway, becoming overbank inundated areas.

Viable adaptation responses differ for backwater and overbank flooding. To prevent backwater flooding, measures such as one-way valves or tide gates can be installed to prevent water ingress. Overbank flooding require more significant landform changes such as infill land raising or levees.

Backwater hydraulic connectivity was assessed using the stormwater spatial data of pipes and pits provided by partner Councils. Where the pit and pipe network provided a linear connection between the main waterway and an area of land with an elevation below the specified inundation water level, then this area was included in the inundation extent. This approach to mapping backwater inundation should be considered a first pass, with more detailed investigation recommended for areas identified as exposed.

For some key areas, this analysis shows a general trend of increasing total exposure with rising sea levels, with a notable shift from backwater to overbank flooding. These trends are critical for planning and implementing effective adaptation strategies in response to sea level rise and changing inundation patterns.

Table 5-2 highlights the suburbs most exposed to tidal and coastal inundation in terms of area exposed and provides information about the relative proportions of backwater and overbank flooding and the trends with sea level rise.

Table 5-3 provides information for all suburbs in the study area exposed to tidal inundation, while **Table 5-4** provides information for all suburbs exposed to coastal inundation.

Table 5-5 lists the three most exposed suburbs for present day and +0.9 m SLR tidal and coastal inundation, respectively.

The extent of backwater and overbank flooding for the the HHWSS scenarios with sea level rise is shown in maps **RG_04_01** through **RG_04_07** in **Appendix B**.

Table 5-2 Summary of suburbs most exposed to tidal and coastal inundation

Suburb (LGA)	Summary of Tidal Inundation Exposure (HHWSS)	Summary of Coastal Inundation Exposure
Arncliffe (Bayside)	Starting with approximately 5,000 m^2 of exposure at 0 m SLR, Arncliffe experiences a considerable increase to approximately 337,000 m^2 at 0.9 m SLR. Initially, the inundation is entirely driven by overbank process (100%), which continues to be dominant, reducing slightly to 99% at 0.9 m SLR, with backwater inundation playing a small role in inundation.	A present day 5 year ARI event exposes approx. 23,000 m^2 entirely due to overbank flooding. The exposure remains consistently overbank but increases to 223,000 m^2 at a 100-year ARI. With a 0.9 m SLR, the area affected increases to 444,000 m^2 at a 100-year ARI, with overbank flooding still at 100%.
Banksia (Bayside)	Banksia shows no exposure at 0 m SLR. However, it begins to experience inundation at 0.2 m SLR with an exposure of approx. 53,000 m^2, escalating to approx. 94,000 m^2 at 0.9 m SLR. Overbank inundation is predominantly the key process driving inundation (with 98% of inundation being driven by overbank processes at 0.2 m SLR). Backwater inundation plays a slightly large part in inundation as sea levels rise, however, 95% of inundation is still driven by overbank processes at 0.9 m SLR).	Banksia shows no exposure at a 5-year ARI but faces 69,000 m^2 of overbank inundation at a 10-year ARI. This increases marginally to 80,000 m^2 at a 100-year ARI under current SLR conditions. In the long-term scenario with a 0.9 m SLR, the area exposed to inundation escalates to 130,000 m^2, with overbank flooding remaining the dominant process of inundation.
Botany (Bayside)	Initially exposed to approximately 4,000 m^2 at 0 m SLR, this area sees a dramatic increase to approximately 190,000 m^2 at 0.9 m SLR. Initially, backwater inundation is more prevalent (56%), but with 0.9 m SLR, overbank flooding becomes the dominant process driving inundation.	A present day 5-year ARI event exposes approximately 72,000 m^2 of inundation with an almost equal split between backwater and overbank flooding. In the 100-year ARI present scenario, the area increases modestly to 108,000 m^2, still with a similar backwater predominance. Future projections show a significant rise to 359,000 m^2 at a 100-year ARI with 0.9 m SLR, with overbank flooding becoming more prominent at 72%.
Kyeemagh (Bayside)	Kyeemagh starts with an exposure of approx. 4,000 m^2 at 0 m SLR, which significantly increases to approximately 126,000 m^2 at 0.9 m SLR. Overbank flooding is the primary process driving inundation.	A present day 5-year ARI event exposes approximately 80,000 m^2 exposed to predominantly backwater flooding (91%). This shifts dramatically to 99% overbank flooding at a 100-year ARI, with the area impacted by inundation rising to 97,000 m^2. In the long-term, the area impacted by inundation doubles to 182,000 m^2 under a 100-year ARI with 0.9 m SLR, with overbank flooding accounting for all inundation.
Mascot	Starting with approximately 51,000 m^2 of inundation exposure at 0 m SLR, Mascot	A present day 5-year ARI event exposes approximately 70,000 m^2, primarily to

Suburb (LGA)	Summary of Tidal Inundation Exposure (HHWSS)	Summary of Coastal Inundation Exposure
(Bayside)	experiences a significant rise to approx. 711,000 m^2 at 0.9 m SLR. Backwater inundation is initially dominant (73%) but overbank inundation processes dominate at 0.9 m SLR.	backwater flooding (71%). The area affected increases to 107,000 m^2 at a 100-year ARI, maintaining a backwater majority. Future scenarios predict a substantial expansion to 1,543,000 m^2 at a 100-year ARI with 0.9 m SLR, transitioning entirely to overbank flooding.
Wolli Creek (Bayside)	Exposure during HHWSS increases from approximately 8,000 m^2 at 0 m SLR to approx. 156,000 m^2 at 0.9 m SLR. Initially, backwater flooding is more significant (54%), but overbank flooding becomes predominant (84%) at 0.9 m SLR.	A present day 5-year ARI event exposes approx. 42,000 m^2, with 80% attributed to overbank flooding. At a 100-year ARI today, the exposure is more than doubled to 88,000 m^2 with a slight increase in overbank proportion. Future conditions with 0.9 m SLR reveal a significant increase in inundation area to 285,000 m^2, exclusively resulting from overbank flooding.
Earlwood (Canterbury Bankstown)	Exposure increases from approximately 24,000 m^2 at 0 m SLR to approximately 193,000 m^2 at 0.9 m SLR. Overbank flooding is almost the sole process of inundation under existing and sea level rise scenarios.	A present day 5-year ARI event exposes approximately 59,000 m^2 to inundation, mainly as a result of overbank flooding (80%). The area at risk increases significantly in the present-day 100-year ARI scenario to 100,000 m^2. Long-term projections indicate a significant increase to 379,000 m^2 at a 100-year ARI with 0.9 m SLR, with inundation completely from overbank flooding.
Marrickville (Inner West)	Starting with approx. 35,000 m^2 at 0 m SLR, the exposure in Marrickville increases to approx. 537,000 m^2 at 0.9 m SLR. Backwater flooding is initially more common (77%), with backwater flooding increasing with sea level rise.	A present day 5-year ARI event exposes approximately 169,000 m^2 exposed to inundation, 74% of which is driven by backwater processes. The area impacted increases to 323,000 m^2 at a 100-year ARI, also driven by backwater flooding. In the future, with a 0.9 m SLR, the area exposed increases to 813,000 m^2, with backwater and overbank flooding both driving inundation.
Tempe (Inner West)	Beginning with approximately 14,000 m^2 exposed at 0 m SLR, Tempe sees an increase to approximately 69,000 m^2 at 0.9 m SLR. The initial inundation is more from backwater processes, with overbank flooding becomes more significant (93%) under 0.9m of SLR.	A present day 5-year ARI event exposes approx. 20,000 m^2 of exposure with a 37% backwater component. This exposure slightly decreases to 19,000 m^2 at a 10-year ARI with a lesser backwater proportion. For a 100-year ARI with 0.9 m SLR, the area subjected to inundation increases to 189,000 m^2, predominantly overbank flooding (97%).

Table 5-3 Approximate area (m^2) of tidal inundation exposure for LGAs and suburbs with proportion of backwater and overbank inundation*

	HHWSS +0 m			HHWSS +0.2 m			HHWSS +0.5 m			HHWSS +0.9 m		
	Backwater	Overbank	Total	Backwater	Overbank	Total	Backwater	Overbank	Total	Backwater	Overbank	Total
Bayside	**49%**	**51%**	**90,000**	**37%**	**63%**	**182,000**	**40%**	**60%**	**531,000**	**48%**	**52%**	**1,745,000**
ARNCLIFFE	0%	100%	5,000	10%	90%	9,000	0%	100%	55,000	1%	99%	337,000
BANKSIA	-	-	-	2%	98%	53,000	2%	98%	76,000	5%	95%	94,000
BANKSMEADOW	-	-	-	-	-	-	-	-	-	55%	45%	1,000
BARDWELL PARK	-	-	-	-	-	-	-	-	-	0%	100%	3,000
BARDWELL VALLEY	-	-	-	-	-	-	100%	0%	1,000	0%	100%	3,000
BOTANY	56%	44%	4,000	81%	19%	14,000	50%	50%	99,000	68%	32%	190,000
BRIGHTON-LE-SANDS	6%	94%	3,000	10%	90%	7,000	6%	94%	21,000	7%	93%	52,000
KYEEMAGH	0%	100%	4,000	0%	100%	6,000	89%	11%	89,000	0%	100%	126,000
MASCOT	73%	27%	51,000	69%	31%	57,000	75%	25%	88,000	95%	5%	711,000
ROCKDALE	0%	100%	11,000	4%	96%	13,000	4%	96%	27,000	2%	98%	56,000
TURRELLA	0%	100%	4,000	12%	88%	6,000	3%	97%	10,000	4%	96%	16,000
WOLLI CREEK	54%	46%	8,000	73%	27%	17,000	18%	82%	65,000	16%	84%	156,000
Burwood	**0%**	**100%**	**2,000**	**0%**	**100%**	**2,000**	**0%**	**100%**	**3,000**	**0%**	**100%**	**4,000**
CROYDON PARK	0%	100%	2,000	0%	100%	2,000	0%	100%	3,000	0%	100%	4,000
CBC	**1%**	**99%**	**46,000**	**9%**	**91%**	**58,000**	**19%**	**81%**	**110,000**	**2%**	**98%**	**252,000**
ASHBURY	0%	100%	1,000	0%	100%	1,000	0%	100%	1,000	0%	100%	2,000
BELFIELD	-	-	-			-	0%	100%	1,000	0%	100%	1,000
CAMPSIE	1%	99%	6,000	1%	99%	6,000	3%	97%	7,000	5%	95%	9,000
CANTERBURY	4%	96%	6,000	6%	94%	7,000	6%	94%	10,000	4%	96%	19,000
CROYDON PARK	0%	100%	4,000	9%	91%	4,000	16%	84%	5,000	27%	73%	6,000
EARLWOOD	0%	100%	24,000	13%	87%	35,000	22%	78%	77,000	0%	100%	193,000
HURLSTONE PARK	0%	100%	5,000	1%	99%	5,000	21%	79%	9,000	15%	85%	22,000
City of Sydney	**1%**	**99%**	**7,000**	**2%**	**98%**	**7,000**	**2%**	**98%**	**8,000**	**0%**	**100%**	**17,000**
ALEXANDRIA	1%	99%	4,000	3%	97%	4,000	3%	97%	5,000	0%	100%	13,000
ST PETERS	0%	100%	3,000	0%	100%	3,000	0%	100%	3,000	1%	99%	4,000
Inner West	**57%**	**43%**	**54,000**	**71%**	**29%**	**85,000**	**68%**	**32%**	**288,000**	**63%**	**37%**	**711,000**
DULWICH HILL	-	-	-	-	-	-	92%	8%	13,000	0%	100%	30,000
MARRICKVILLE	77%	23%	35,000	85%	15%	64,000	72%	28%	246,000	69%	31%	537,000
MASCOT	0%	100%	1,000	0%	100%	1,000	0%	100%	1,000	97%	3%	68,000
ST PETERS	11%	89%	4,000	14%	86%	4,000	19%	81%	4,000	40%	60%	7,000
TEMPE	25%	75%	14,000	33%	67%	16,000	37%	63%	24,000	7%	93%	69,000
Strathfield	**-**	**-**	-	**-**	**-**	-	**-**	**-**	-	**0%**	**100%**	**1,000**
STRATHFIELD SOUTH	-	-	-	-	-	-	-	-	-	0%	100%	1,000

Values in this table have been rounded to the nearest 1,000 m^2 and do not include areas of the Cooks River waterways that are permanently inundated (i.e. below MLWS)

Table 5-4 Approximate Area (m^2) of coastal inundation exposure for LGAs and suburbs with proportion of backwater and overbank inundation*

	5ARI +0 m			10ARI +0 m			100ARI +0 m			100ARI +0.2 m			100ARI +0.5 m			100ARI +0.9 m		
	Backwater	Overbank	Total	Backwater	Overbank	Total	Backwater	Overbank	Total	Backwater	Overbank	Total	Backwater	Overbank	Total	Backwater	Overbank	Total
Bayside	**41%**	**59%**	**404,000**	**40%**	**60%**	**447,000**	**21%**	**79%**	**776,000**	**36%**	**64%**	**1,235,000**	**50%**	**50%**	**2,188,000**	**5%**	**95%**	**3,347,000**
ARNCLIFFE	0%	100%	23,000	0%	100%	31,000	0%	100%	223,000	0%	100%	288,000	0%	100%	379,000	0%	100%	444,000
BANKSIA	0%	100%	69,000	0%	100%	71,000	0%	100%	80,000	1%	99%	89,000	0%	100%	103,000	1%	99%	130,000
BANKSMEADOW	-	-	0	-	-	0	-	-	0	26%	74%	1,000	99%	1%	2,000	95%	5%	16,000
BARDWELL PARK	-	-	0	-	-	0	0%	100%	1,000	0%	100%	2,000	0%	100%	5,000	0%	100%	13,000
BARDWELL VALLEY	0%	100%	1,000	0%	100%	1,000	0%	100%	2,000	0%	100%	3,000	0%	100%	3,000	0%	100%	5,000
BOTANY	48%	52%	72,000	48%	52%	83,000	51%	49%	108,000	61%	39%	154,000	71%	29%	214,000	28%	72%	359,000
BRIGHTON-LE-SANDS	7%	93%	16,000	6%	94%	19,000	13%	87%	27,000	10%	90%	42,000	12%	88%	77,000	3%	97%	147,000
KYEEMAGH	91%	9%	80,000	90%	10%	84,000	1%	99%	97,000	0%	100%	115,000	1%	99%	147,000	0%	100%	182,000
MASCOT	71%	29%	70,000	71%	29%	74,000	77%	23%	107,000	92%	8%	348,000	90%	10%	967,000	0%	100%	1,543,000
ROCKDALE	4%	96%	22,000	2%	98%	24,000	2%	98%	32,000	1%	99%	46,000	5%	95%	70,000	4%	96%	133,000
TURRELLA	0%	100%	9,000	0%	100%	9,000	1%	99%	11,000	0%	100%	14,000	10%	90%	28,000	22%	78%	90,000
WOLLI CREEK	20%	80%	42,000	18%	82%	51,000	17%	83%	88,000	14%	86%	133,000	21%	79%	193,000	0%	100%	285,000
Burwood	**0%**	**100%**	**3,000**	**0%**	**100%**	**3,000**	**0%**	**100%**	**4,000**	**0%**	**100%**	**4,000**	**0%**	**100%**	**4,000**	**0%**	**100%**	**5,000**
CROYDON PARK	0%	100%	3,000	0%	100%	3,000	0%	100%	4,000	0%	100%	4,000	0%	100%	4,000	0%	100%	5,000
CBC	**16%**	**84%**	**89,000**	**18%**	**82%**	**99,000**	**8%**	**92%**	**137,000**	**2%**	**98%**	**214,000**	**2%**	**98%**	**338,000**	**1%**	**99%**	**514,000**
ASHBURY	0%	100%	1,000	0%	100%	1,000	0%	100%	1,000	0%	100%	2,000	0%	100%	2,000	0%	100%	3,000
BELFIELD	0%	100%	1,000	0%	100%	1,000	0%	100%	1,000	0%	100%	1,000	0%	100%	1,000	0%	100%	1,000
CAMPSIE	3%	97%	7,000	3%	97%	7,000	4%	96%	7,000	0%	100%	8,000	5%	95%	11,000	0%	100%	18,000
CANTERBURY	7%	93%	9,000	6%	94%	9,000	0%	100%	12,000	0%	100%	17,000	0%	100%	24,000	3%	97%	43,000
CROYDON PARK	14%	86%	5,000	16%	84%	5,000	20%	80%	5,000	25%	75%	6,000	29%	71%	8,000	30%	70%	11,000
EARLWOOD	20%	80%	59,000	22%	78%	68,000	8%	92%	100,000	0%	100%	162,000	0%	100%	257,000	0%	100%	379,000
HURLSTONE PARK	15%	85%	7,000	19%	81%	8,000	16%	84%	11,000	16%	84%	18,000	13%	87%	35,000	0%	100%	59,000
City of Sydney	**0%**	**100%**	**8,000**	**4%**	**96%**	**8,000**	**6%**	**94%**	**9,000**	**1%**	**99%**	**14,000**	**13%**	**87%**	**25,000**	**10%**	**90%**	**75,000**
ALEXANDRIA	0%	100%	5,000	6%	94%	5,000	9%	91%	6,000	1%	99%	10,000	11%	89%	20,000	6%	94%	43,000
ST PETERS	0%	100%	3,000	0%	100%	3,000	0%	100%	3,000	0%	100%	4,000	18%	82%	5,000	15%	85%	32,000
Inner West	**69%**	**31%**	**201,000**	**67%**	**33%**	**244,000**	**60%**	**40%**	**379,000**	**63%**	**37%**	**597,000**	**48%**	**52%**	**927,000**	**31%**	**69%**	**1,313,000**
DULWICH HILL	91%	9%	7,000	92%	8%	11,000	0%	100%	21,000	0%	100%	28,000	0%	100%	33,000	0%	100%	37,000
MARRICKVILLE	74%	26%	169,000	71%	29%	209,000	69%	31%	323,000	69%	31%	474,000	46%	54%	636,000	50%	50%	813,000
MASCOT	0%	100%	1,000	0%	100%	1,000	0%	100%	2,000	96%	4%	47,000	97%	3%	105,000	0%	100%	141,000
ST PETERS	17%	83%	4,000	18%	82%	4,000	21%	79%	5,000	29%	71%	5,000	92%	8%	52,000	0%	100%	133,000
TEMPE	37%	63%	20,000	31%	69%	19,000	21%	79%	28,000	9%	91%	43,000	2%	98%	101,000	3%	97%	189,000
Strathfield	**-**	**-**	**0**	**-**	**-**	**0**	**-**	**-**	**0**	**0%**	**100%**	**1,000**	**0%**	**100%**	**1,000**	**2%**	**98%**	**2,000**
STRATHFIELD SOUTH	-	-	0	-	-	0	-	-	0	0%	100%	1,000	0%	100%	1,000	2%	98%	2,000

Values in this table have been rounded to the nearest 1,000 m^2 and do not include areas of the Cooks River waterways that are permanently inundated (i.e. below MLWS)

Table 5-5 Most exposed suburbs (present day and +0.9 m SLR)

Present Tidal Inundation		Projected Tidal Inundation (0.9 m SLR)	
Mascot (Bayside)	51,000 m^2	Mascot (Bayside)	711,000 m^2
Marrickville (Inner West)	35,000 m^2	Marrickville (Inner West)	537,000 m^2
Earlwood (Canterbury Bankstown)	24,000 m^2	Arncliffe (Bayside)	337,000 m^2
Present Coastal Inundation		**Projected Coastal Inundation (0.9 m SLR)**	
Marrickville (Inner West)	323,000 m^2	Mascot (Bayside)	1,543,000 m^2
Arncliffe (Bayside)	223,000 m^2	Marrickville (Inner West)	813,000 m^2
Botany (Bayside)	108,000 m^2	Arncliffe (Bayside)	444,000 m^2

5.3 Potential Impacts on Existing Wetlands

Spatial data from Hughes et al. (2022), was used to identify where existing saltmarsh and mangrove ecosystems coincide with a migrating intertidal zone. Factors such as topographic and constructed barriers, land use and tenure were used to assess potential accommodation space for future intertidal habitat.

Figure 5-1 shows the predicted total area of mangrove and saltmarsh habitats in the Cooks River across a gradient of sea level rise (SLR) scenarios, from the current level to a 1.5-metre rise. The largest habitat areas, depicted in purple, are without urban land use restrictions. The grey bars, indicating habitats restricted to natural and low-impact land uses, and the red bars, which factor in agricultural and horticultural lands, represent more conservative estimates.

It is important to note that prolonged tidal inundation in wetlands under SRL scenarios will cause excess saltwater intrusion into soils, this may lead to mangrove and saltmarsh retreat which would cause further biodiversity implications.

The contrast between the scenarios highlights the importance of land use decisions in preserving these ecosystems in the face of rising sea levels. Without facilitating habitat migration into land currently used as green space, but not serving a 'natural habitat' function, then there will be significant reduction in suitable habitat to support mangrove and saltmarsh under future SLR scenarios.

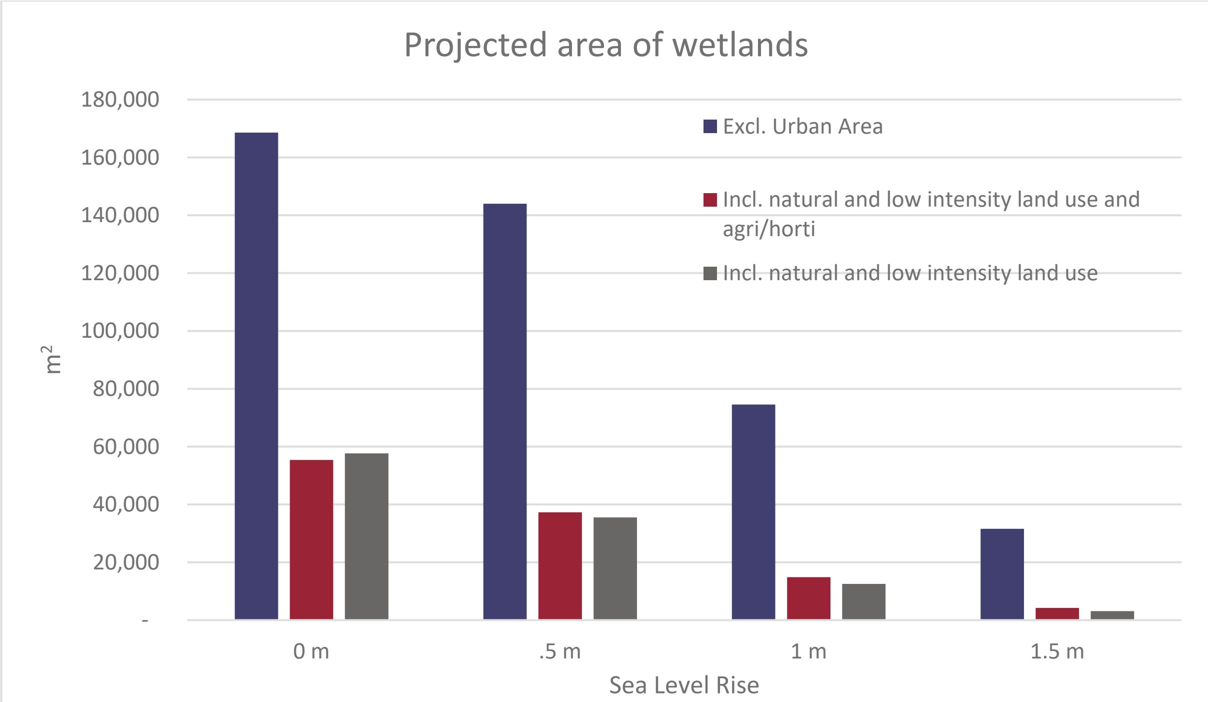

Figure 5-1 Projected habitat availability in the Cooks River Catchment CMP study area for saltmarsh and mangrove under sea level rise scenarios (Hughes et. al, 2022)

6 Potential Management Options

A thorough analysis of the Cooks River Catchment CMP study area was conducted, focusing on the varying degrees of coastal and tidal inundation risks and how they are projected to evolve over time in response to sea level rise. This information provides guidance towards the identification of potential management options.

Table 6-1 provides potential management options based on the coastal and tidal inundation hazard and impact assessment. Each option has been tailored to address specific risks and impacts identified in the hazard and impact assessment. These options should be considered for further evaluation in Stage 3 of the Cooks River Catchment CMP.

Table 6-1 Potential management options for consideration in Stage 3

#	Potential Management Option	Description
1	**Survey stormwater outlets inverts and obverts.**	Using the stormwater system spatial data as a starting point, all outlets should be surveyed to determine their invert and obvert levels. Existing mechanisms to prevent tidal ingress should be recorded and subject to a condition assessment.
2	**Vulnerability assessment for areas identified as exposed to backwater inundation.**	Using an approach similar to Rayner et. al., (2023), vulnerability can be assessed by determining how frequently the stormwater outlets are able to freely drain based on the downstream water levels and outlet geometry. Water levels determined in this study can be used, while outlet geometry would be determined via Potential Management Option 1.
3	**Develop King Tide Action Plans for known tidal inundation exposed areas.**	For areas currently experiencing tidal inundation, action plans can be developed that provide direction to minimise impacts. These plans would focus on preparation, response and recovery from short term inundation and would seek to minimise disruption to daily activities, public safety, and damage to sensitive assets. Potential elements of these plans may include alternative driving routes and asset preparation/maintenance activities.
4	**Develop local adaptation plans for high-risk areas.**	Local adaptation plans can range in scale depending on the extent and type of inundation. These should consider the specific constraints and opportunities of an area such as current and surrounding land use, and site-specific characteristics such as heritage designation or contaminated lands. Triggers for progression of adaptation pathways can be informed by the vulnerability assessment described in Potential Management Option 2. • A range of engineering mitigation options to reduce risk such as levees, filling of land, drainage improvements, planned retreat, house raising, etc.; • Where filling of the land is proposed, access to imported fill; • Land acquisition or land swaps; • Design to tie into existing surrounding ground levels; • Maintenance of property access (i.e. driveways) and management of inter-lot drainage for retained properties;

#	Potential Management Option	Description
		• Ongoing provision of services and the need for utility relocations or modifications (e.g. stormwater, potable water, sewage, telecommunications and electricity); • Drainage improvements for local rainfall events; • A costed adaptation pathway (sequence of works and timeframe); and • Multi-stakeholder involvement.
5	**Review planning controls relevant to coastal hazards.**	A critical review of existing development controls relevant to the study area can identify gaps and opportunities for strengthening resilience to future inundation. For example Councils' can attach appropriate notations on Section 10.7 (5) of planning certificates as an advisory note for properties identified as potentially affected by coastal hazard in inundation scenarios.
6	**Monitor estuarine habitats and explore activation of accommodation space to facilitate landward migration.**	Involves a strategic approach aimed at preserving estuarine ecosystems in the face of rising sea levels and other climate change impacts. This aspect involves continuous and comprehensive observation and analysis of estuarine environments including monitoring species extent and composition, water quality, sediment characteristics, and vertical accretion rates. Without activating additional accommodation space, the projected extent of estuarine intertidal macrophytes will be substantially reduced. Green spaces currently used for public recreation that will be increasingly exposed to inundation should be assessed for their potential to serve as activated accommodation space to maintain the amenity and ecological values of the Cooks River.

7 Conclusions

The Cooks River and surrounding low lying areas are facing critical present day and emerging challenges due to coastal and tidal inundation, exacerbated by climate change and sea level rise. Rising sea levels threaten the surrounding infrastructure and communities, increasing the risk of both temporary and frequent inundation with implications for the socioeconomic landscape of the region. The Cooks River estuary is also a vital ecological zone of immense local importance. It supports diverse flora and fauna, provides essential ecosystem services, and is a hub for community recreation and engagement. Coastal and tidal inundation pose a risk to the ecological integrity of the river and its surrounding areas, potentially disrupting the delicate balance of its ecosystems.

In response to these challenges, this report provides detailed and fit-for-purpose information about the current and emerging risk posed by coastal and tidal inundation. Up to date data records were used to determine water levels for a range of scenarios throughout the study area. Aligning with the CM Act objectives and the NSW Coastal Management Manual (OEH, 2018), sea level rise has been considered across multiple planning horizons, namely present day, 20 years, 50 years, 100 years and beyond. This provides short, medium, and long-term perspectives on the potential hazards.

A series of maps was produced to illustrate the extent of inundation for these scenarios along with an overview of key assets exposed. These maps visually display the emerging risk profile associated with sea level rise.

A distinction was made between overbank and backwater flooding, recognising the differences between viable adaptation options available to address each. An assessment of the evolution of backwater and overbank tidal inundation in response to sea level rise can be used to inform adaptation pathways in key areas of risk.

The potential impacts of coastal and tidal inundation on estuarine habitats are substantial, and without targeted and deliberate activation of accommodation space, there is projected to be significant declines in the extent of mangroves and saltmarsh along with the amenity and ecosystem services they provide.

Potential management options have been proposed to support the coordinated and effective adaptation of the Cooks River to coastal and tidal inundation. These will be subject to further evaluation in the next stages of developing the Cooks River Catchment CMP.

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Appendix A

Detailed Technical Methodology

Appendix B

Map Compendium

Mapping Compendium Guide

The map naming convention is as follows: **RG_XX**(Series Number)**_XX**(Location). For example, **RG_01_01** shows the study area overview tidal inundation extent.

A list of map series is provided in **Table B-1**, and map location key is provided in **Table B-2**.

Table B-1 Map series

Series Number	Series Description
RG_01 Series	Tidal Inundation Extent
RG_02 Series	Present Day Coastal Inundation Extent
RG_03 Series	Coastal Inundation Extent
RG_04 Series	Tidal Backwater Extent. A-D indicates SLR Scenarios
RG_04_exp Series	Tidal Backwater Exposure Extent. A-D indicates SLR Scenarios
RG_05 Series	MLWS Extent
RG_06 Series	Intertidal Areas Extent
RG_07 Series	Inundation Depth - MLWS 0 m SLR
RG_08 Series	Inundation Depth - MLWS 0.2 m SLR
RG_09 Series	Inundation Depth - MLWS 0.5 m SLR
RG_10 Series	Inundation Depth - MLWS 0.9 m SLR
RG_11 Series	Inundation Depth - HHWSS 0 m SLR
RG_12 Series	Inundation Depth - HHWSS 0.2 m SLR
RG_13 Series	Inundation Depth - HHWSS 0.5 m SLR
RG_14 Series	Inundation Depth - HHWSS 0.9 m SLR
RG_15 Series	Inundation Depth - 5-year ARI, 0 m SLR
RG_16 Series	Inundation Depth - 10-year ARI, 0 m SLR
RG_17 Series	Inundation Depth - 100-year ARI, 0 m SLR
RG_18 Series	Inundation Depth - 100-year ARI, 0.2 m SLR
RG_19 Series	Inundation Depth - 100-year ARI, 0.5 m SLR
RG_20 Series	Inundation Depth - 100-year ARI, 0.9 m SLR

Table B-2 Map location key*

Map Number	Map Location
RG_XX_01	Study Area Overview
RG_XX_02	Lower Cooks River
RG_XX_03	Marrickville
RG_XX_04	Mill Stream
RG_XX_05	Alexandra Canal
RG_XX_06	Earlwood
RG_XX_07	Muddy Creek

**XX denotes the map series number*

Appendix C

Results Tables

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