MIDCOAST council

MANNING RIVER ESTUARY & CATCHMENT

SCOPING STUDY 2020

Annexure A

Document Control Sheet

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This document is the Stage 1 Scoping Study for a Coastal Management Program prepared in accordance with the provisions of the Coastal Management Manual and the Coastal Management Act 2016.

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1. The Case for Change

Located on the NSW mid-north coast, the Manning River Catchment and Estuary is one of the greatest assets of the MidCoast region. It is vital to the local economy and provides social and cultural values that benefit the people that live, visit and work in the region. The estuary covers an area of approximately 32.3km2, comprising a set of complex inter-connecting channels approximately 115km in length, and drains an extensive catchment in the order of 8,420km2. The 'Coastal Environment Area' of the Manning River is located within the local government area of MidCoast Council (MCC), thus MCC has taken on the responsibility of lead agency for the preparation of the Manning River Estuary and Catchment Management Plan, a Coastal Management Program being prepared in accordance with the provisions of the Coastal Management Manual and the Coastal Management Act 2016.

The Manning River Estuary And Catchment Management Plan (hereafter referred to as the Manning River Estuary CMP) aspires to protect and improve the ecological health of the Manning Estuary and its catchment, and in doing so support the social, cultural and economic values of the region.

The scope of the CMP under the *Coastal Management Act 2016* includes consideration of *Coastal Environment Area* as it relates to the Manning River Estuary and coastal wetlands within the management area of *Coastal Wetlands and Littoral Rainforest Areas*

The primary objectives of the Manning River Estuary CMP are:

a) To maintain and improve water quality and the health of the Manning River Estuary.

b) To reduce threats to and improve the resilience of the Manning River Estuary, including response to climate change.

c) To protect and enhance natural processes and environmental values including natural character, biological diversity and ecosystem integrity of the Manning River Estuary.

d) To protect, restore and rehabilitate coastal wetlands within the Manning River Catchment, including their biological diversity and ecosystem integrity.

e) To improve the resilience of coastal wetlands to the impacts of climate change, including opportunities for ecosystem migration.

The ecological health of the Manning River Estuary is under pressure as a result of both past and present land management practices. Key threats to the ecological health of the estuary identified by the preliminary spatial risk assessment (modelling) and gap analysis include:

- Agricultural diffuse source runoff
- Stock in riparian and marine vegetation
- Floodplain drainage (acid runoff)
- Clearing and degradation of riparian vegetation and adjacent habitat
- Clearing and degradation of vegetation within the catchment including coastal wetlands
- Climate change stressors (for example coastal wetlands, acid sulphate drainage)

The Manning Estuary has an extended flushing time, thus is sensitive to catchment inputs. Spatial risk modelling in combination with existing data and local knowledge highlight that the health of the estuary is directly connected to the overall health of the river's catchment and climatic conditions.

It is clear that there are multiple pressures cumulatively impacting the health of the estuary. What is unclear is where and what actions will have the biggest improvements.

To this end, it is important to have a sound understanding of catchment processes and the source of issues that affect the health of the Manning River Estuary. The 'Forward Plan' proposed for Stage Two of the CMP aims to address key knowledge gaps in order to improve understanding of catchment and estuary processes and thus reduce uncertainty associated with the development of management actions.

Social, cultural and economic values are dependent on the ecological health of the estuary and wider catchment.

Industries directly dependent on environmental values include agriculture, aquaculture, fishing, forestry and tourism. Combined, these industries contribute gross revenue of $817 million per annum to the wider MidCoast Region, with agriculture and tourism both injecting over $210 million per annum each. The Manning Catchment at present has approximately 870,000 tourism visitors per annum of which about 60% is in the peak summer period. Economic modelling suggests that tourism (particularly Nature-based and Adventure Tourism) is projected to expand to an annual direct tourism revenue of $571 million for the Manning Catchment alone.

A large proportion of the 50,000 people that choose to call the Manning home do so because of the natural beauty, rural landscape, estuary and coastline on offer, as encapsulated by Mayor West in the statement from Council's *Community Strategic Plan* (CSP):

"We live and work in the best, most beautiful part of the world. Let's work together, having a shared vision and shared responsibility, to make it even better."
(MidCoast MCC CSP 2018, p.6)

The natural beauty of the region is the most important asset identified by community in *The MidCoast 2030 Community Strategic Plan2018-2030* (MCC CSP, 2018)

The landuse of the catchment is predominantly rural in nature and sparsely populated, although only approximately 30% of the population living within the rural environment.

The Manning Catchment is part of the traditional homelands of a number of Aboriginal nations. *Biripi* country covers most of the catchment, extending from the coast inland, where it meets *Kamilaroi* country on the New England Tablelands. South of Gloucester is *Worimi* country and west of Gloucester, incorporating the Barrington Tops is *Geawegal* country (Horton, 2018). Today approximately 7% of the community is Aboriginal / Torres Strait Islander, compared to 5.5% for Regional NSW as a whole.

A current gap in knowledge is the capacity and willingness of the community and stakeholders to contribute to the future costs of management. As discussed in the Forward Plan, during Stage Two social science research will be undertaken to improve understanding social parameters. In particular understanding barriers to adoption is fundamental to the successful implementation of management actions. After all, NRM programs have been conducted for multiple decades in Australia, yet the Manning Estuary (as is the case for many estuaries across the country) are still under pressure associated with both past and current land management practices.

MidCoast Council (MCC) raises funding for estuary and catchment management through an Environment Special Rate, set at 6% of the general rate, of which 1% is allocated to dredging projects across the Local Government Area (LGA). At present the rate generates approximately $4 million/annum of which in the order of $1.7 million is spent within the Manning on:

- Project Management and Delivery
- Management of Natural Assets e.g. Cattai wetlands
- Estuary and Water quality projects and monitoring
- Biodiversity projects

- Sustainability and Environmental Performance
- Dredging and foreshore improvement.

In addition, MCC regularly sources grant funding and partners with other public authorities to increase the extent of our work programs. Other agencies such as Local Land Services spend approximately $360K each year on catchment improvement projects in the Manning Catchment and Estuary. As detailed in the engagement strategy, public authorities will be engaged throughout the remaining stages of plan development to ensure plan adoption and implementation.

MidCoast Council is currently working on their Local Environmental Plans (LEP's) and Development Control Plans (DCP's). The preparation of the Manning River Estuary CMP will parallel to this process, thus enabling the CMP process to inform LEP and DCP development as appropriate. Furthermore, the implementation of the CMP will be guided by and integrated within MCC's Integrated Planning and Reporting Framework ensuring the ongoing implementation of the actions identified by Council.

As detailed in the Forward Plan, timelines for the preparation of the Manning River Estuary CMP are as follows:

- **Stage 2:** February 2019 - December 2019
- **Stage 3:** January 2020 - December 2020
- **Stage 4:** February 2021 – September 2021
- **Stage 5:** 2021-2031

2. Purpose and Scope

CMP Purpose

- To set the long-term strategic direction for the co-ordinated management of the Manning River Estuary and Catchment.
- To provide a framework to measure success.

Vision

The Manning River catchment and estuary and are healthy supporting the social, economic, cultural and environmental values of its people.

Program Logic

Program logic is used in natural resource management to represent the linkages and integration between inputs, outputs, outcomes and investment goals. Program logic is also used to provide a means to reflect and report on program progress and therefore informs program monitoring and evaluation.

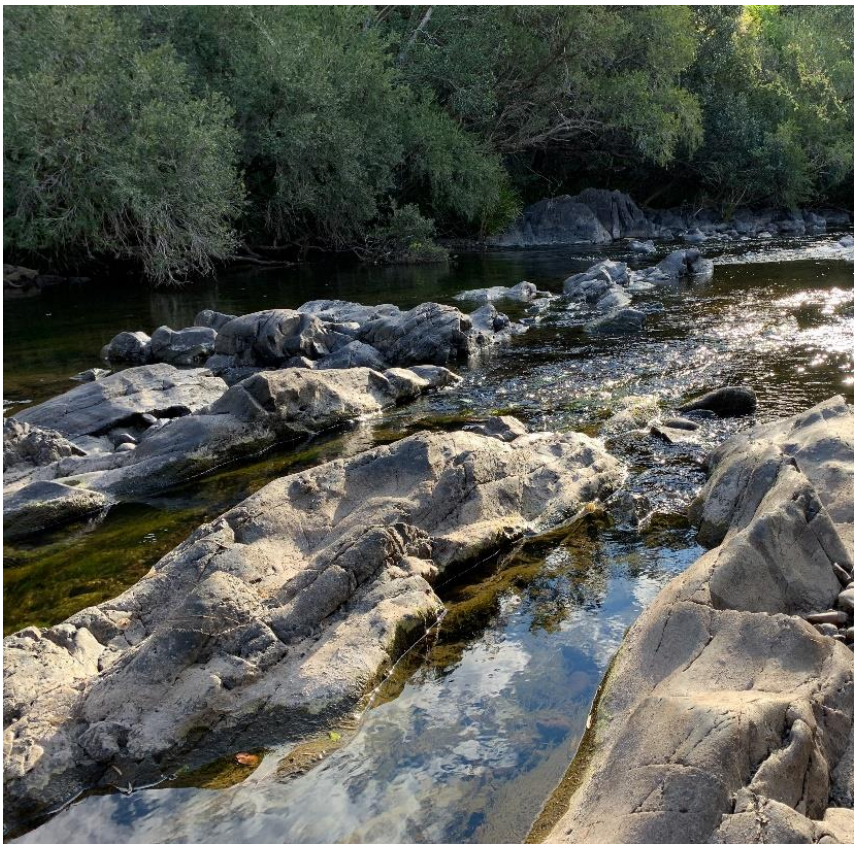
The program logic reflects the reality that many of the desired changes in natural resource management asset condition occur over longer timeframes (for example 20-50 years) than investment or planning cycles. Natural resource management outcomes should be considered within this context; outcomes are often iterative and occur at multiple or varying timeframes. The logic therefore acknowledges that to achieve and adequately report on desired outcomes there must be a focus on both the means and the ends. There are two important investment streams:

1. Investment in social, institutional and economic outcomes – (means)
2. Investment in biophysical outcomes – (ends)

Program logic describes the rationale behind a program. It identifies high-level outcomes and the steps to achieving them. Table 1 below outlines the Program Logic Framework, while Table 2 outlines the Program Logic for the Manning River Estuary CMP.

Table 1: Program Logic Framework

Outcome hierarchy	Outcome Description
Vision	The long term vision that the CMP is aiming to achieve.
Ultimate outcomes	Change in condition and extent of natural resource assets in the long term. Desired final result of investment, including changes in organisational and community capacity.
Intermediate outcomes (10 years)	Aggregate change in the medium term. How are natural resource assets managed and how has management affected on-ground results, including behaviour and practice change? Medium term outcomes as a result of outputs & thereby achievement of the vision.
Activities	Immediate products or services that are produced by a program. Activities delivered to bring change in a situation or behaviour that is expected to contribute to outcomes.
Foundational activities / capabilities	The resources or foundational activities used to produce outputs. Preliminary or 'preparatory' activities that occur before any activities associated with changing or influencing the external environment. It includes things like planning, collecting base-line data and forming partnerships.



A wild reach in the Gloucester River

Table 2: Manning River Estuary CMP Program Logic

VISION	***The Manning catchment and estuary are healthy supporting the social, economic, cultural and environmental values of its people.***				
ULITIMATE OUTCOMES **50years**	Ecological health of the Estuary meets the targets specified in the Manning River Estuary CMP.		Biodiversity targets specified in the Manning River Estuary CMP are met		A healthy catchment and estuary supports the communities' economic, social and cultural values.
INTERMEDIATE OUTCOMES **10years (2030)**	Estuary health is supported by a culture of shared responsibility	Estuary health is maintained		Health of biodiversity is maintained	Ongoing community and political support for the objectives and principles of the Manning River Estuary CMP
ACTIVITIES	Principles from the Manning River Estuary CMP are integrated into MCC and Public Authorities decision making processes.		Implement-actions within the Manning Estuary CMP, including community and stakeholder engagement		There is political and community support for the actions of the Manning River Estuary CMP
FOUNDATION ACTIVITIES	Gap analysis, Scoping study & Business case	Engagement strategy and stakeholder analysis.	Detailed studies.	Governance arrangements for plan development.	Risk Assessment.	Manning Estuary And Catchment Management Plan Developed.

Objectives

Primary:

1. To maintain and improve water quality and the health of the Manning River Estuary.
2. To reduce threats to and improve the resilience of the Manning River Estuary, including response to climate change.
3. To protect and enhance natural processes and environmental values including natural character, biological diversity and ecosystem integrity of the Manning River Estuary.
4. To identify, protect, restore and rehabilitate coastal wetlands within the Manning River Catchment, including their biological diversity and ecosystem integrity.
5. To improve the resilience of coastal wetlands to the impacts of climate change, including opportunities for ecosystem migration.

Secondary:

6. To support public participation in management and planning and greater public awareness and understanding of natural processes and management actions associated with the Manning River Estuary.
7. To support social and cultural values associated with the Manning River and its Estuary.
8. To acknowledge and support Aboriginal peoples' spiritual, social, customary and economic use of the Manning River Catchment and its Estuary.
9. To facilitate ecologically sustainable development and promote sustainable land use planning decision-making in the Manning River Catchment and its Estuary.
10. To recognise the Manning River Estuary as a vital economic zone and to support sustainable coastal economies.

Scope

The *Coastal Management Act 2016* defines the coastal zone as comprising four coastal management areas:

1. Coastal wetlands and littoral rainforests area;
2. Coastal vulnerability area;
3. Coastal environment area;
4. Coastal use area;

The scope of the Manning River Estuary And Catchment Management Plan (CMP) will cover issues and management actions for all Coastal Management Areas mapped in the Coastal Management SEPP 2018 within the Area of Interest (AOI). The AOI covers the estuary and its catchment, commencing 2 km inland from the average low tide water mark.

Concurrent to the development of the Manning River Estuary CMP, a CMP is being prepared for the 'coastal erosion hotspot' of Old Bar - Manning Point. The Old Bar -Manning Point Coastal Management Program (OBMP CMP) AOI covers from the average low tide water mark to approximately 2 km inland.

Following completion of the (Draft) OBMP CMP, an Open Coast CMP will be prepared to replace the certified and gazetted Jimmys Beach CZMP 2016, Great Lakes CZMP 2016 and Manning Valley CZMP 2018.

Figure 1 shows the Areas of Interest for each of the three CMPs and Table 3 summarises the issues and *Coastal Management Act* objectives that will be addressed in the Manning River Estuary CMP and Old Bar-Manning Point CMP currently under development.

While both plans will meet the mandatory requirements of the Coastal Management Act and address coastal hazards within their respective AOI's, the Manning River Estuary CMP will have a strong focus on the impact of land based activities on water quality in the system and the OBMP CMP will cover coastal processes and the impacts of oceanic water on the land. The CMP's are inter-related and as such ongoing communication between the two programs will be an ongoing requirement - including integration through the IP & R Framework.

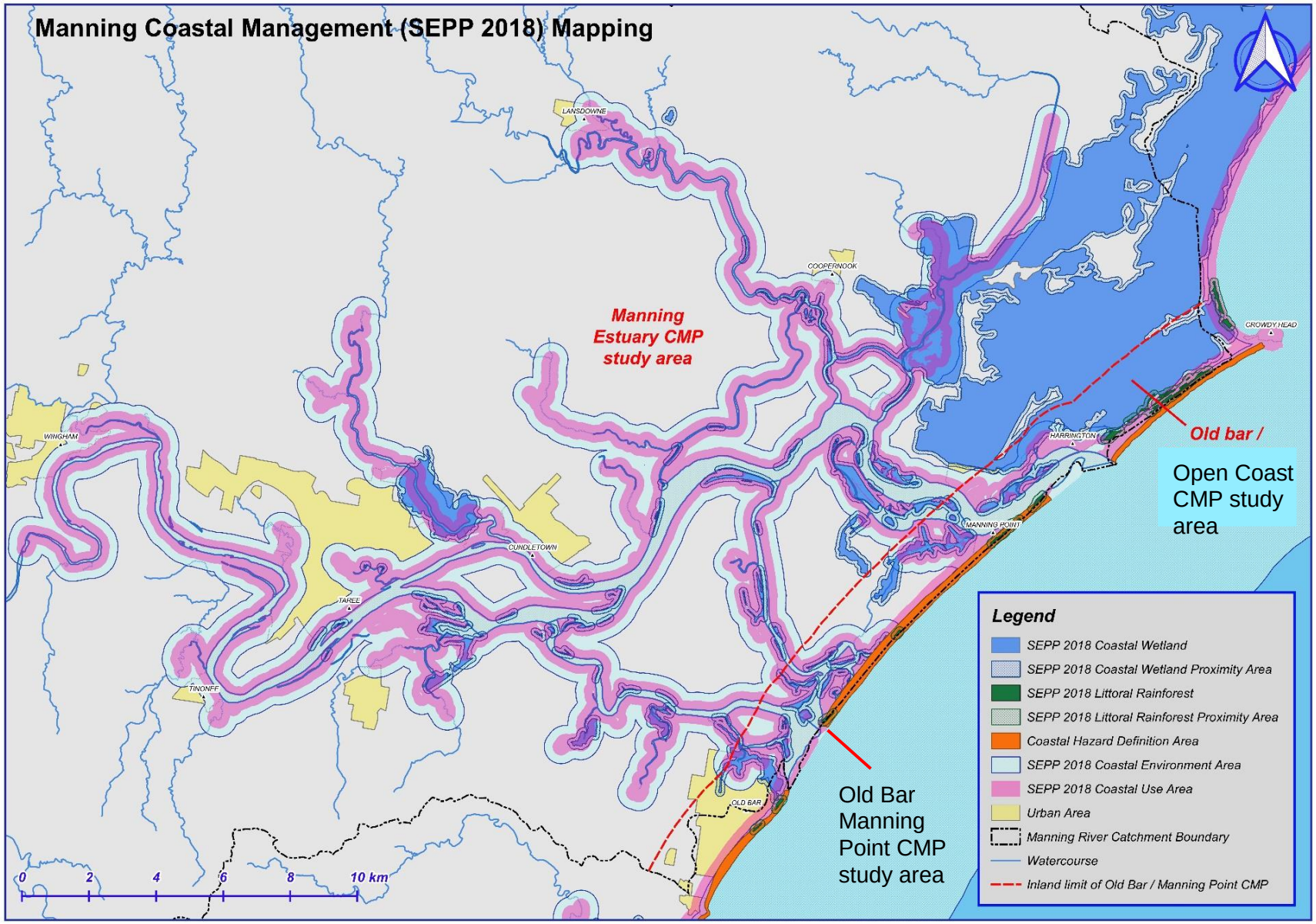


Figure 1: Areas of Interest defined for Manning River Estuary CMP and Old Bar Manning Point CMP showing the boundary 2 km inland from the coast

Table 3: Summary of Issues and Coastal SEPP Management Areas Manning River Estuary CMP and Old Bar Manning Point CMP

Issue	Which plan?	Manning River Estuary CMP	Old Bar - Manning Point CMP
Opening of Farquhar Inlet (under current management arrangements)	Both plans	Consider the impacts of the salt wedge on estuary health [3, 4]	Procedures and management of opening and impact on coastal processes [1, 2]
Entrance training	Both plans	Ecological impacts of permanently opening the entrance of the estuary and the change in the salt wedge [3, 4]	Sand movement impacts on Old Bar beach [1, 2]
Expansion of Old Bar township	Both plans	Impact of urban development on estuary water quality and health under closed conditions [3]	Risk to future properties to the impacts of coastal processes [1, 2]
Oyster health	Both plans	Impact of diffuse source pollution on oyster health [3]	Impact of Manning River opening (Harrington Farquhar) on oyster growth
Shorebird protection and management	Old Bar - Manning Point		Shorebirds predominately occupy the coastal zone at Farquhar and Manning Point [2, 3]
Boating and recreation on / in Estuary	Both plans	Boating and recreation is in the Manning Estuary, impacts of these activities are limited but these social values will be taken into consideration in the plan [3]	Boating and recreation in the Manning River between Harrington and Farquhar impacts of these activities are limited but these social values will be taken into consideration in the plan [2, 3]
Navigational dredging	Old Bar - Manning Point	Limited impact on estuary heath	Operationally aligned to coastal management [2]

Issue	Which plan?	Manning River Estuary CMP	Old Bar - Manning Point CMP
Coastal wetland management	Both	Located around the estuary, related to water quality issues and management [4]	Actions to protect, rehabilitate and improve resilience of coastal wetlands [4]
Littoral rainforest management	Old Bar - Manning Point		Actions to protect, rehabilitate and improve resilience of Littoral Rainforest , impacted by coastal processes [4]
Diffuse source runoff and water quality impacts	Manning Estuary	Relevant to estuary health and potentially impacting on socio economics of the estuary [3]	
Climate change	Both plans	Changes in hydrology in the catchment and impacts on flow and thus estuary health, inundation across the estuary and associated impacts on wetland habitats [3, 4]	Implications for erosion and inundation across the coast [1]
Coastal inundation, tidal inundation and flooding	Both Plans	Adopt coastal management strategies that reduce exposure to coastal hazards by restoring or enhancing natural defences and other actions [2, 3, 4]	Adopt coastal management strategies that reduce exposure to coastal hazards by restoring or enhancing natural defences and other actions [1, 2, 3, 4]

Coastal Management Act Objectives: 1. Coastal vulnerability areas, 2. Coastal use areas, 3. Coastal Environmental areas, 4. Coastal wetland and littoral rainforest areas

3. The Manning

The Manning River Estuary

The Manning River Estuary covers an area of approximately 32.3km^2 made up of a set of complex inter-connecting channels approximately 115km in length. It drains from an extensive and varied catchment in the order of 8,420km^2. The estuary is unique as it has two natural ocean entrances, one at Harrington and the other 12km to the south, known as the Farquhar Inlet at Old Bar.

The Manning River Estuary is a mature barrier estuary, with a wave dominated delta (Roper *et al.* 2011). As noted in the *Manning River Estuary Management Study* (2009), the main estuarine channels include The Manning River, North Passage, South Passage, South Channel and Scotts Creek.

The river is a single channel beyond Taree, with the tidal limit located in the vicinity of Abbotts Falls, a gravel bar approximately 54km from the entrance. Likewise, the lower reaches of the Lansdowne and Dawson Rivers are estuarine in nature, with the tidal limit located at Lansdowne Weir approximately 18km upstream of the confluence with the Manning. The extent of the estuary and the division into lower, middle and upper estuarine conditions are illustrated in Figure 4.

The estuary has an average flushing time of 31.6 days, compared with a State-wide median estuary flushing time of 9 days (Roper *et al.* 2011). Due to the long residence time of fresh water, the estuary is sensitive to the accumulation of catchment inputs such as sediments, nutrients, pathogens and acid runoff. These freshwater inputs can severely degrade the ecological health of both the catchment and the estuary and as a consequence detrimentally impact social and economic values, such as swimming and oyster farming.

Estuary monitoring undertaken by MCC's Waterway and Catchment Report Card program and OEH's Estuary Monitoring Program have shown that the estuary experiences both high turbidity and algal levels in response to catchment runoff. This is highlighted in the 2014 and 2018 Report Card results:

"High turbidity levels were evident following periods of rainfall in the catchment, particularly in the middle and upper sections of the estuary. Likewise chlorophyll-a concentrations were consistently high in the estuary, indicating that the system is currently acting as a massive nutrient sink" (Greater Taree City Council, 2014, p. 5.)

"The 2018 Report Card results tell the story of catchment conditions. That is an extended dry period resulted in high water clarity and low turbidity levels due to the minimal amount of catchment runoff entering the estuary. Conversely of concern was an excessive amount of algae throughout the estuary. Within the upper estuary chlorophyll-a trigger values were exceeded for over eighty percent of the samples collected, and exceedances were moderately large. Similarly, in the middle of the estuary the chlorophyll a trigger value was exceeded for more than three quarters of the sampling period. Generally, these exceedances were small to moderate. Within the lower estuary chlorophyll-a concentrations exceeded the trigger value for over half of the sampling period, but again exceedances were small. Excellent water clarity meant that algae had plenty of light to grow in combination with available nutrients from the nutrient sink within the estuary from catchment inputs as highlighted by the 2013 results. It should be noted the impacts of pH on the main river were not detected, however it is expected

acid water would be draining to tributaries such as Lansdowne River and Cattai Creek after rainfall that are not included within this sampling regime" (MCC, 2018, p.16-17).

In addition to the Waterway and Catchment Card monitoring program, the Water Services Division of Council (formerly MidCoast Water) has extensive water quality monitoring data which reflect the significance of freshwater inputs to the estuary. For example, in 2010 it became necessary to investigate the source of a high turbidity event at the drinking water off - take and extensively within the estuary evident during a period of low rainfall across the estuary. It was found that the sediment was coming from the Barnard subcatchment, as a consequence of rainfall in the upper catchment site of the upper Barnard.

During October 2018 approximately 74mm of rainfall fell in the wider Taree district over a 7 day period, resulting in the changes to surface flow as indicated by the hydrograph peaks in Figure 2. A corresponding peak in turbidity was visually evident as illustrated by the photo, taken from the Manning River at Charity Creek Bridge slightly upstream from the tidal confluence on the 19 October.

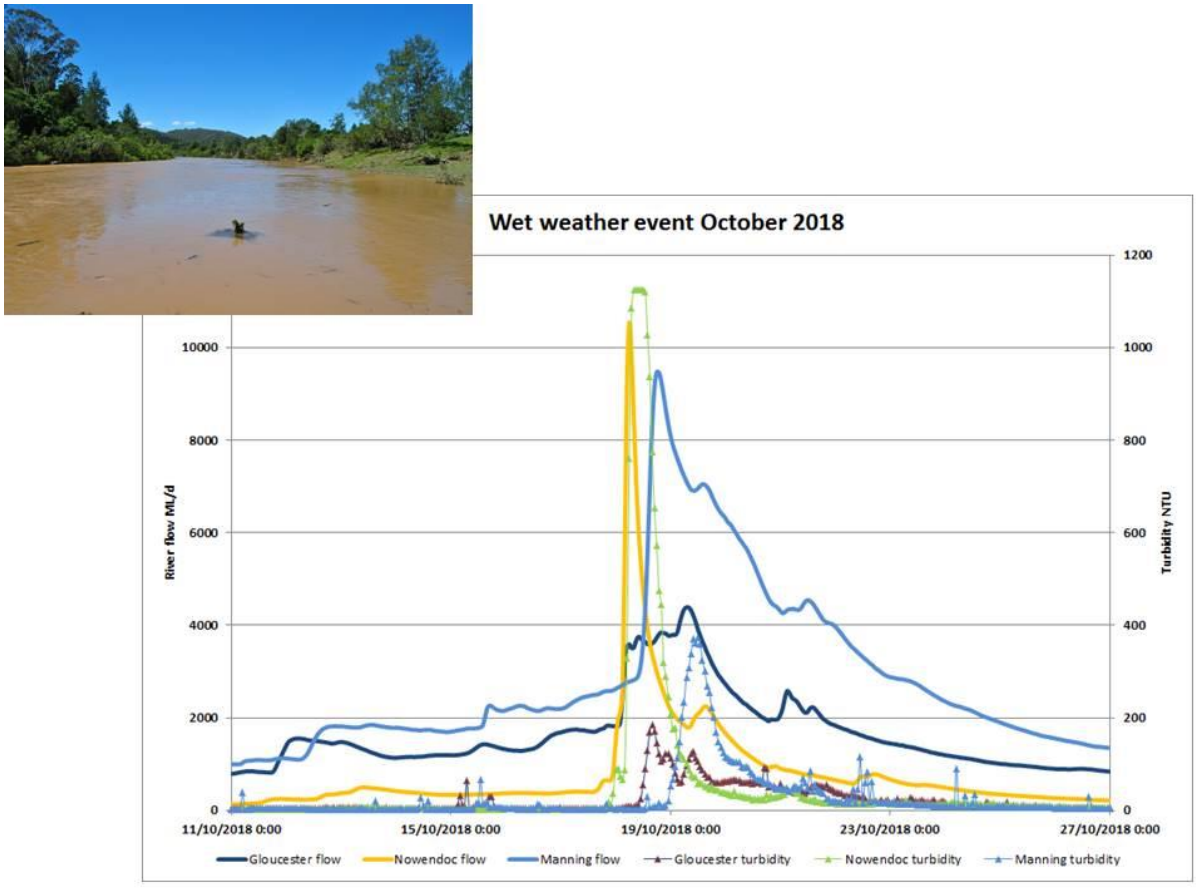


Figure 2: Hydrograph depicting Turbidity level after a wet weather event October 2018.

This event and all other Monitoring data highlights the health of the estuary is directly connected to the overall health of the river's catchment and climatic conditions. To this end, it is important to have a sound understanding of catchment processes and the source of issues that affect the Manning River and Estuary.

Acid sulfate soils (ASS) are a major issue and threat to the Estuary, with 33,797 hectares of land within the Manning Valley identified as being affected by potential acid sulfate soils (PASS) and 4,500 hectares identified as ASS hot spots by the NSW Government (MCC, undated). Over the past two centuries extensive floodplain clearing and the installation of drainage networks has separated the floodplain from the estuary and lowered the groundwater within the floodplain soils. The extensive ASS deposits on the Manning River floodplain have been exposed as a consequence of previous drainage and flood mitigation, today efficiently mobilising acidic runoff and heavy metals into the estuary (Glamore *et al.* 2016). In addition to direct acidification of water, increased levels of aluminium and other heavy metals can be toxic to aquatic flora and fauna, including those species and assemblages living in sediments. The impact on fish stocks and oyster production can be significant. The effect of acid on biodiversity in general in the estuary is yet to be established, and is a state-wide knowledge gap needing to be addressed.

In 2016 a Drainage Remediation Action Plan was commissioned to assess and rank the 15 floodplain subcatchments of the Manning River Estuary in order to prioritise ASS remediation efforts. Implementation of this plan is ongoing, with works such as land acquisition, the filling and reshaping of drains, and floodgates decommissioned so far completed.

The Manning River Estuary has a wide variety of estuarine conditions, resulting in a range of habitat types including mangrove forests, seagrass, coastal wetlands, saltmarsh, and aquatic species such as Australian bass (*Macquaria novemaculeata*). There are a range of coastal wetland types present which may be freshwater, brackish or saline. These wetlands along with littoral rainforest are protected under reformed State planning policies in the current *Coastal Management Act* 2016. Locations of coastal wetlands (SEPP 2018 mapping), littoral rainforests and the catchment boundary (as identified as coastal environment area within the SEPP 2018 mapping) are illustrated in Figure 4.

Within the broad category of coastal wetlands, the Manning Estuary has estuarine lagoons, mangrove and saltmarsh swamps, coastal floodplain forest, swamps and lagoons. Farquhar Inlet in the lower southern estuary is a typical estuarine lagoon (see

Figure 3) that is a large open body of saline or brackish water with a relatively narrow permanent or intermittent connection to the sea that operates as an Intermittently Closed and Open Lakes and Lagoon (ICOLL). A second type of coastal wetlands, mangrove and saltmarsh swamps occur in extensive areas throughout the lower and middle estuarine areas subject to tidal flooding, which support mangrove and saltmarsh vegetation. Non-tidal basins also occur on estuarine sediments adjacent to mangrove and saltmarsh areas, as well as any mudflats and small creeks which occur within or adjacent to swamps.

Other coastal wetlands present in the Manning include coastal floodplain forest or wetland dominated by forest located on the sandy sediments on the lower reaches of coastal floodplains and coastal floodplain swamps and lagoons which include shallow marshes and meadows, as well as deeper ponds and billabongs which have large areas of open water.

Mapping data of coastal wetlands is in need of finer scale survey and mapping for management, protection and ongoing planning.

Figure 3: Mangroves along the tidal shoreline of Farquhar estuarine lagoon.

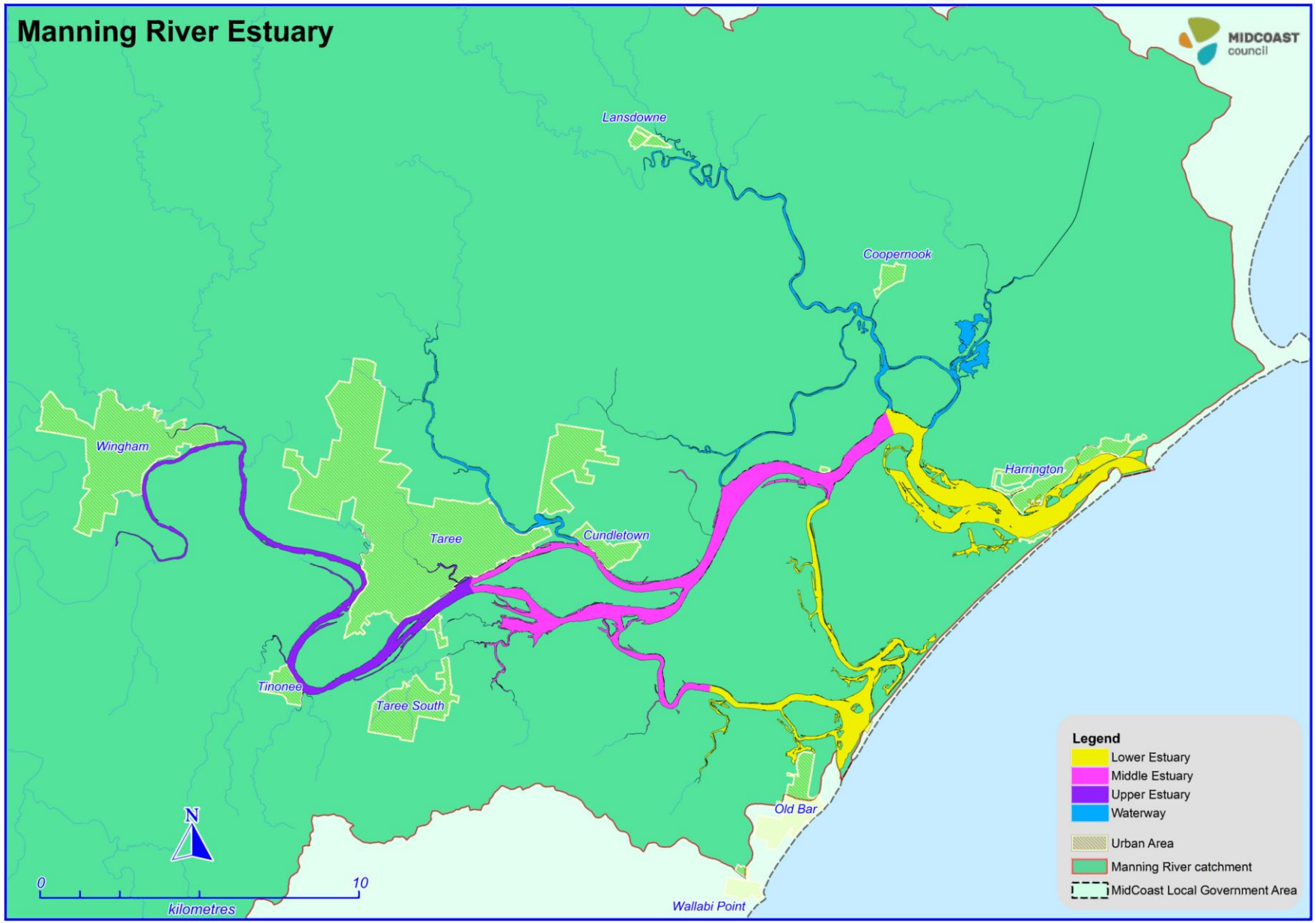


Figure 4: Manning River Estuary, showing locations of lower, middle and upper estuary, urban areas, and catchment boundary.

Catchment Characteristics

The Manning River Catchment is extensive in the order of 8,420km^2 with 163 subcatchments at the 4th order stream level. There are 5 major estuarine subcatchments and 11 freshwater subcatchments within the Manning River and Estuary, listed below and illustrated in Figure 5 overleaf.

Estuarine Subcatchments:

- Cattai Creek
- Lansdowne River
- Dawson River
- Cedar Party Creek
- Lower Manning River

Freshwater Subcatchments:

- Nowendoc River
- Myall Creek
- Barnard River
- Upper Manning River
- Bowman River
- Barrington River
- Gloucester River
- Avon River
- Waukivory River
- Dingo Creek
- Burrell Creek

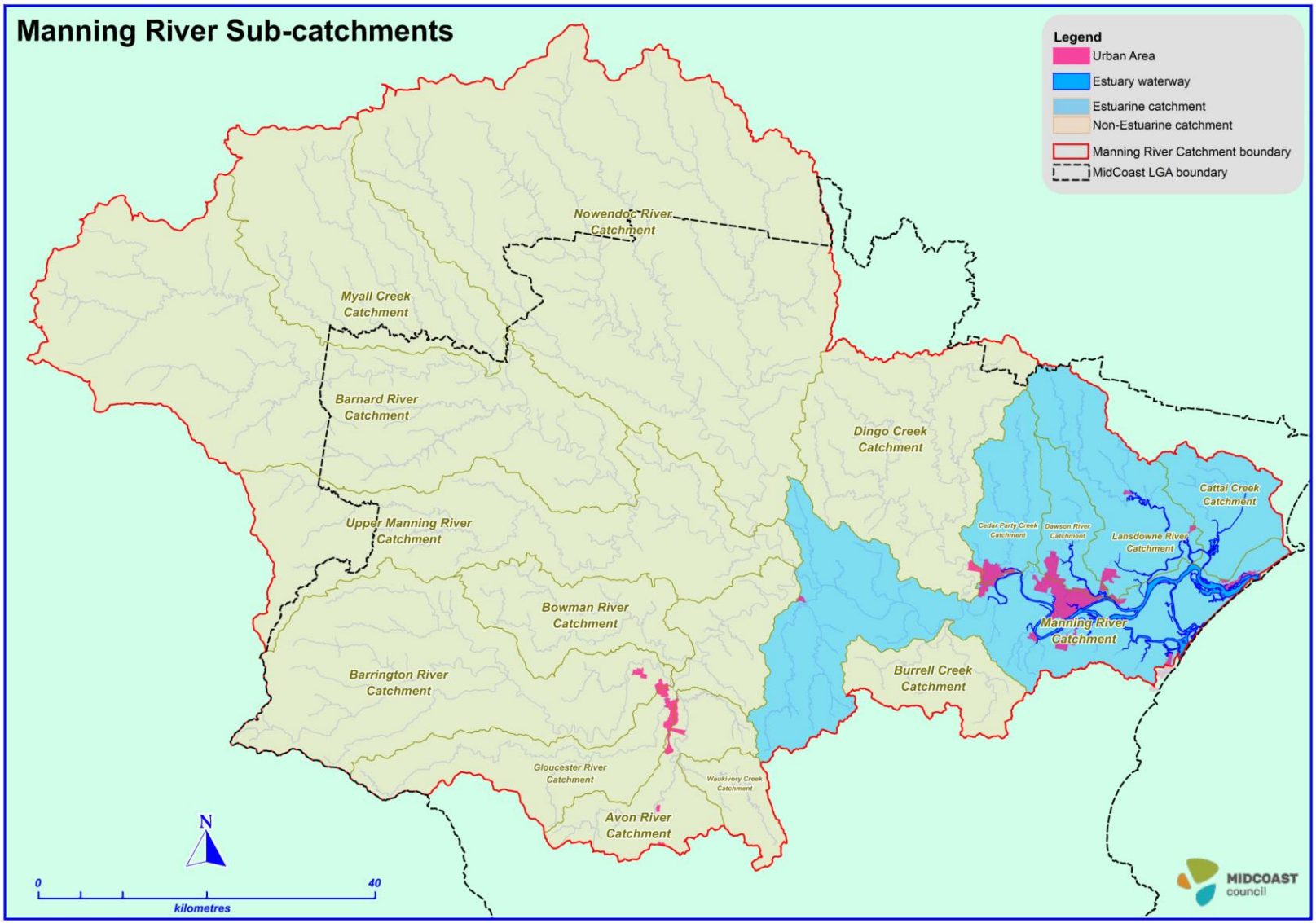


Figure 5: Major subcatchments of the Manning River and Estuary.

Natural features - geology and topology

Less modified upper catchments such as the upper tributaries of the Manning catchment reflect local geology, soil type and composition more closely than the more disturbed catchments. Areas which have a greater extent of land use change, as found in the lower Manning, reflect greater anthropogenic influences (Thurtell 2014). The headwaters of the catchment around Barrington Tops and Nowendoc consist of low rolling hills and plateaus. The bulk of the Manning Catchment's fresh waterways flow through landscapes characterised by steep hill slopes with narrow floodplain pockets. These are high energy environments which are prone to floodplain stripping and river bank erosion (Raine and Gardner, 1992). In contrast, the estuary has wide, flat floodplains and islands. There are several deep pools in the mid Manning with the deepest being Ida Lake and Bungay pool, which have the potential to act as sediment and nutrient traps. The Manning also has many wide shallow pools with dense macrophyte beds which also have a role influencing nutrient cycling (Thurtell and Bishop, 2006; Thurtell, 2009).

The geology of the catchment has been described as a range of Devonian sedimentary and metamorphic rocks overlain by Lower Permian and Carboniferous sediments and a small area of Triassic sediments, Tertiary basalt overlays Permian granite in the Barrington-Gloucester Tops area (MCC 2016). The diversity of soils reflects this geology and comprise Basaltic and alpine humus soils in the high rainfall areas of the upper catchment (plateau and dissected uplands); Weathered yellow podsolic soils throughout large areas of the catchment (uplands an alluvial valleys); Highly fertile alluvial floodplain soils (alluvial valleys and coastal riverine plains); and Hydromorphic and acid [sulphate] soils (coastal riverine plains) (MCMC 1996). The distribution of basalt caps across much of the Manning catchments headwaters is of particular importance for water quality in the river and estuary, as basalt is known to produce nutrient soils. Phosphorus binds to sediment, and weathering and erosion of phosphorus bound sediment is a source of elevated phosphorus levels in waterways (Thurtell and Bishop 2006).

Climate

The catchment experiences the highest rainfall to the south west in the Barrington Tops, and to the north east, on the Comboyne Plateau. The coast receives an average of roughly 1340 mm annually (Bureau of Meteorology figures for Harrington, 1887-2007). This decreases inland, with Taree receiving on average 1180 mm (Bureau of Meteorology figures for Taree at Robertson Street, 1881-2010), down to roughly 980 mm per annum at Gloucester (Gloucester Shire Council website cited in Hughes and Watkins 2011) and 680 mm in the far west of the catchment at Glenrock (Soil Conservation Service 1985). Light snowfall occurs in the winter months in the Barrington Tops at altitudes greater than 1100 m a.h.d. (Soil Conservation Service 1985). Temperature records for Taree show a mean summer maximum of 29^{o}C and a mean winter minimum of 5.5^{o}C (Bureau of Meteorology figures for Taree at Robertson Street, 1907-2005).

Climate Change

In New South Wales, climate change has already caused an increase in mean sea level of over 10 cm, changes in the seasonality of rainfall, increases in the average land temperature of around 0.8°C and in the average sea surface temperature of 1.5°C (Heimhuber et al 2019).

The Adapt NSW climate change data provides an overview of modelling results for the North Coast Region. While there is significant and complex variability, key trends include:

- Increased extent of dry periods by 2050, resulting in major periods of low flow potentially impacting the estuary;
- Increased intensity of rainfall and runoff events by 2050. This will increase the potential for pulse events with significant inputs of sediments to the estuary similar to conditions reported in the Great Lakes 2013 Water Quality Report Card;
- Warming climate
- Inundation within the floodplain / across the acid sulphate soils.

Pressures associated with climate change are predicted to introduce or exacerbate a number of issues in the Manning River Estuary and its catchment. In Stage 3 of the CMP process, we will investigate management options informed by the multi-report guidelines contained in the “Climate change in estuaries: State of the science & guidelines for assessment.” The guidelines were developed by the Water Research Lab at the University of New South Wales in collaboration with scientists at the NSW Office of Environment and Heritage (OEH) and Macquarie University. The guide provides a summary of the relevant climate, ocean and ecosystem science along with best-practice frameworks for prioritising risks.

Some of the existing management issues and approaches to be included in the CMP are outlined below.

Infrastructure management: MidCoast Council is developing a Climate Change Adaptation Framework to manage climate risks on Council infrastructure assets. The Framework process will be outlined in the Manning River Estuary CMP.

Acid Sulfate Soil discharge: The Lower Manning Drainage Remediation Plan (Glamore et al. 2016) examined the impact of sea level rise on the Manning River floodplain, using sea level rise projections for 2050 and 2100. The greatest issue identified is elevated low tides, which will reduce drainage from low-lying backswamps within areas identified as high ASS risk.

Coastal inundation and Flood: Increased rainfall intensities and sea level rise scenarios are projected to impact on ocean boundary conditions. These potential changes will translate into increased coastal and flood inundation, such that future planning and floodplain management in the catchment will need to take due consideration of this increased flood risk (see below).

Sea Level Rise: Sea Level Rise is attenuated as one moves landward through the estuary. For the Area of Interest covered by the Manning River Estuary CMP, the most immediate risk of Sea Level Rise to be addressed through the CMP will be impacts on coastal wetlands (see below). There is a large proportion of the Manning River floodplain where emergency management is the only reasonable management option for inundation caused by flooding and coastal inundation. However, the enduring aspect of Sea Level Rise induced by climate change will mean that at some point in the future, emergency management arrangements will be increasingly less effective as a management approach. Further study and assessment will be required to identify this threshold, and associated secondary impacts that

will require mitigation. This will be addressed in Stage 5 (implementation) of the Manning River Estuary CMP.

Coastal wetlands: are highly vulnerable to climate change impacts particularly sea level rise. Management options to protect, restore and improve resilience of coastal wetlands, including migration pathways, will be considered in the CMP.

Drought

Excessive and prolonged drought can have major repercussions for all water users, and the environment, as well as recovery and resilience of natural systems. The period 2017-19 in the Manning catchment saw drought conditions particularly significant in the north-west sections of the catchment. Data from December 2018 shows parishes including Woko and Myra are classed as 'in drought', with the remainder of the Manning catchment classified as 'drought affected' (DPI, 2018).

Flood

MidCoast Council engaged BMT WBM (2019) to prepare the Manning River Floodplain Risk Management Study and Plan. The study area encompasses the low-lying, expansive Manning River floodplain area downstream of Wingham. The principal source of flooding considered within the study is mainstream flooding of the Manning River. The impact of climate change in the form of increased rainfall intensities and sea level rise has also been considered.

There is a long and relatively frequent history of flooding within the lower Manning River catchment. The three largest floods on record occurred in 1866 (peak flood level: 5.15 m AHD), 1929 (peak flood level: 5.6 m) and 1978 (peak level: 5.45 m). In more recent years, large flood events have occurred in 1990 and 2011, with a smaller event in 2013.

The Manning River Floodplain Risk Mgmt. Study and Plan (BMT WBM 2019) defines the flood behaviour of the catchment. Through the establishment of appropriate numerical models, the study covers flood flows, velocities, levels and extents for a range of flood event magnitudes under existing and future catchment and floodplain conditions. It assesses risk to infrastructure including residential and commercial property.

The Manning River Floodplain Risk Management Study and Plan considers climate change scenarios as follows:

- Predicted increased rainfall intensity: modelled 10% and 30% increased rainfall
- Sea Level Rise (SLR): +0.28 m by 2050; and +0.98 m by 2100.
- Great Lakes CZMP: SLR scenarios include: 2050 = +0.4 m; and 2100= +0.9 m

The Floodplain Risk Management Study (FRMS) has derived an appropriate plan of measures and strategies to manage present and future flood risk in accordance with the NSW Government Floodplain Development Manual. These include flood modification measures, property modification measures, risk modification measures and emergency measures (e.g. evacuation, sandbagging etc.).

The FRMS has also identified a Flood Planning Area for the Manning River floodplain. Development of land within the Flood Planning Area is restricted and controlled by Council due to the hazard of flooding. In defining the Flood Planning Area in the MidCoast LGA, Council has considered a future flood scenario that has accounted for climate change in the form of increased rainfall and sea level rise in a combined riverine flooding and high tail

water scenario to the 1% Annual Exceedance Probability (AEP, 1 in 100-year event) plus a freeboard of 500mm.

The Plan will be benchmarked against the mandatory requirements of the Coastal Management Act and incorporated in the Manning River Estuary CMP along with other existing management approaches.

Coastal Inundation

Coastal inundation is the flooding of coastal management areas by ocean waters. According to the NSW Coastal Management Program Manual Part B Stage 2 (2018):

> *"Coastal inundation occurs when a combination of marine and atmospheric processes raises ocean water levels above normal elevations and inundates low-lying areas or overtop dunes, structures and barriers. It is often associated with storms resulting in elevated still water levels (storm surge), wave setup, wave run-up and over-wash flows.*

In the longer term, the extent of coastal inundation will be influenced by water levels that are elevated by other processes such as climate change and sea level rise."

Coastal inundation on the NSW coast is most often associated with east-coast lows (Heimhuber et al 2019). It is typically a short-term event with waters receding to normal conditions. Coastal inundation from storm surge in the Manning River Estuary is caused by a confluence of low barometric pressure, strong onshore winds, high tides, and trapped coastal waves.

Coastal inundation generally affects the open coast and low-lying areas near the entrance, such as Harrington. For the Manning River Estuary AOI, threats associated with coastal inundation include rising groundwater, impacts on coastal wetlands and vegetation, inland estuary flooding and damage to infrastructure.

The Manning River Floodplain Management Study (BMT WBM 2016) considers flood events driven by both catchment and oceanic processes, with the potential impact of climate change on flood behaviour within the catchment. It covers flooding under climate change scenarios for sea-level rise and increased rainfall shown below.

- Increased rainfall: 10% increase to design rainfall at 2050; and a 30% increase to design rainfall at 2100.
- Sea level rise increases of 0.28 m by 2050 and 0.98 m by 2100.

Storm surge is factored into tail-water levels. In general, coastal inundation causes more frequent nuisance flooding while riverine flooding is less frequent but causes more damage. Impacts include reduced efficiency of stormwater infrastructure and increased groundwater levels.

Modelling in the MRFMS (2016) shows that in storm events, the impact of water across land from high rainfall and riverine flooding will always be higher than the impact of coastal inundation. The flood mitigation, planning and emergency response measures set out in the MRFMS and Plan (2019) should therefore provide an effective management approach to coastal inundation.

This picture is complicated by Heimhuber et al (2019), who state that while "east coast lows have the potential to simultaneously trigger storm surges and catchment flooding, there are few recorded instances of large catchment flooding coinciding with extreme sea levels along the NSW coast." The authors advise this may be because the NSW coastal database contains only 20 years of continuous water level data, which is not adequate to capture a

statistically significant number of major floods. In the Manning River Estuary, there is historic anecdotal evidence that coastal inundation has led or combined with riverine flooding in some locations.

The current priority is to understand impacts of coastal inundation on Acid Sulfate Soil and coastal wetlands, to inform MCC's strategy to acquire and restore ASS. A study is underway by DPIE to evaluate the impact of climate change including coastal inundation on the distribution of mangroves and saltmarsh under three sea level rise scenarios (0.5m, 1.0 and 1.5m on the open coast, noting that the amount of SLR will be different at different locations inside the estuary). This assessment was undertaken on a State (NSW) basis in 2019. Several NSW estuaries are being assessed in more detail through local case studies, one of these includes the Manning Estuary. The research project is being undertaken by Science Division, Environment, Energy and Science, Department of Planning, Industry and Environment (DPIE) and will be a valuable input to the CMP Stage 3.

Heimhuber et al (2019) provide guidance on estimating the ocean boundary for flood risk assessment in estuaries, including coastal inundation. It is anticipated that there will be management options in the CMP relating to mapping and risk management for coastal inundation hazards in the estuary under climate change scenarios. Strategies will be needed in the future to protect infrastructure assets such as roads and stormwater systems.

Mapping will inform a future planning proposal for a Coastal Vulnerability Zone to be added to the Coastal Management SEPP, to identify and plan for the adaptive management and protection of land that may be affected by coastal inundation in the future. This will occur in Stage 5 (implementation) of the CMP.

Tidal Inundation

The Coastal Management Program Manual Part B Stage 2 (2018) defines Tidal Inundation or nuisance flooding as "the inundation of land by tidal action under average meteorological conditions."

It causes short term nuisance flooding in low-lying coastal areas.

Tidal inundation is mapped in the Manning River Floodplain Management Study (MRFMS 2016), using the High High Water Spring tidal signature provided in the Flood Risk Management Guide (DECCW 205) for locations south of Crowdy Head as the ocean water level boundary.

The MRFMS 2016 covers tidal inundation due to sea-level rise in base-flow conditions, for HHWS(SS), HHWS(SS)+2050 SLR and HHWS(SS)+2100SLR. HHWS(SS) means High High Water Springs (Solstice Spring) which is essentially HAT (Highest Astronomical Tide i.e. no storm surge or anomaly included).

In the NSW Estuary Tidal Inundation Exposure study (NSW Department of Planning, Infrastructure and Environment DPIE 2018) assessed the exposure of current development to tidal inundation associated with a range of potential, future sea level rise (SLR) scenarios. Types of infrastructure assessed include properties, roads and powerlines.

The study focused on exposure to tidal inundation at the High High Water Solstice Springs (HHWSS) level and/or berm height in mostly closed coastal lakes and lagoons. The HHWSS tidal plane is consistent with levels for higher (king) tides. SLR scenarios of 0.5 m, 1.0 m and 1.5 m are assessed. The use of a 0.5 m water level offset also allows a first order estimation of effects of less frequent inundation at around the 100-year annual return level associated with storm surge and other non-tidal processes (excluding wave setup, run-up and riverine flooding effects).

Results show that the Manning River has been classified as a Mature Barrier Estuary. These estuaries are characterised by relatively narrow and shallow entrance channels of relatively constant width and constant depth, consisting predominantly of sandy bed sediments. The shallow nature of the channels promotes tidal resonance which is counter-balanced by energy losses across entrance shoals and frictional dissipation at the sandy bed. Consequently, the tidal range along the estuary nearly always displays initial attenuation, followed by mild amplification before complete damping at fluvial gravel and sand bars around the head of the estuary (NSW Government 1992). Thus three kilometres upstream from the estuary mouth, the tidal range is only 50% of the ocean value because of the dissipative effects of the entrance bar.

The Manning river was placed in the North Coast region of this study. For the entire North Coast region 6,816 properties are exposed to tidal inundation (HHWSS) with 0.5 m of SLR, 15,593 with 1 m, and 22,808 with 1.5 m.

The 10 most exposed estuary systems in the North Coast region are shown in Figure 6 (DPIE 2018). The Manning is included in these systems.

Recommendations to manage risk associated with increased tidal inundation under future sea level rise scenarios are included in the study. These will be considered during Stage 3 of the Manning River Estuary CMP.

The Manning River Floodplain Management Study and Plan (BMT 2019) notes that flood gates are fitted in several locations in the lower Manning estuary to limit inundation from both riverine flooding and tidal inundation. The gates provide immunity from more regular events and impede saltwater flow into stormwater infrastructure. Some of these gates contribute to a significant reduction in flood risk; for example, the large western piped culvert under Manning Point Road at Manning Point is fitted with gates which provide immunity up to the 20% AEP event. Another example is the historic flood gate on Croakers Creek, Oxley Island which provides protection from daily tidal inundation and from minor, more frequent riverine flooding events to a significant portion of Oxley Island.

With the increasing risk of climate change related sea level rise and more frequent tidal inundation events, flood gates will take on even greater importance. The FRPMSP (BMT 2019) notes that the constant exposure of floodgates to a marine environment means they have a finite life. The recommendation that all floodgate infrastructure is surveyed, maintained, replaced or upgraded as required will be incorporated into the most appropriate of Council's management approaches and noted in the Manning River Estuary CMP.

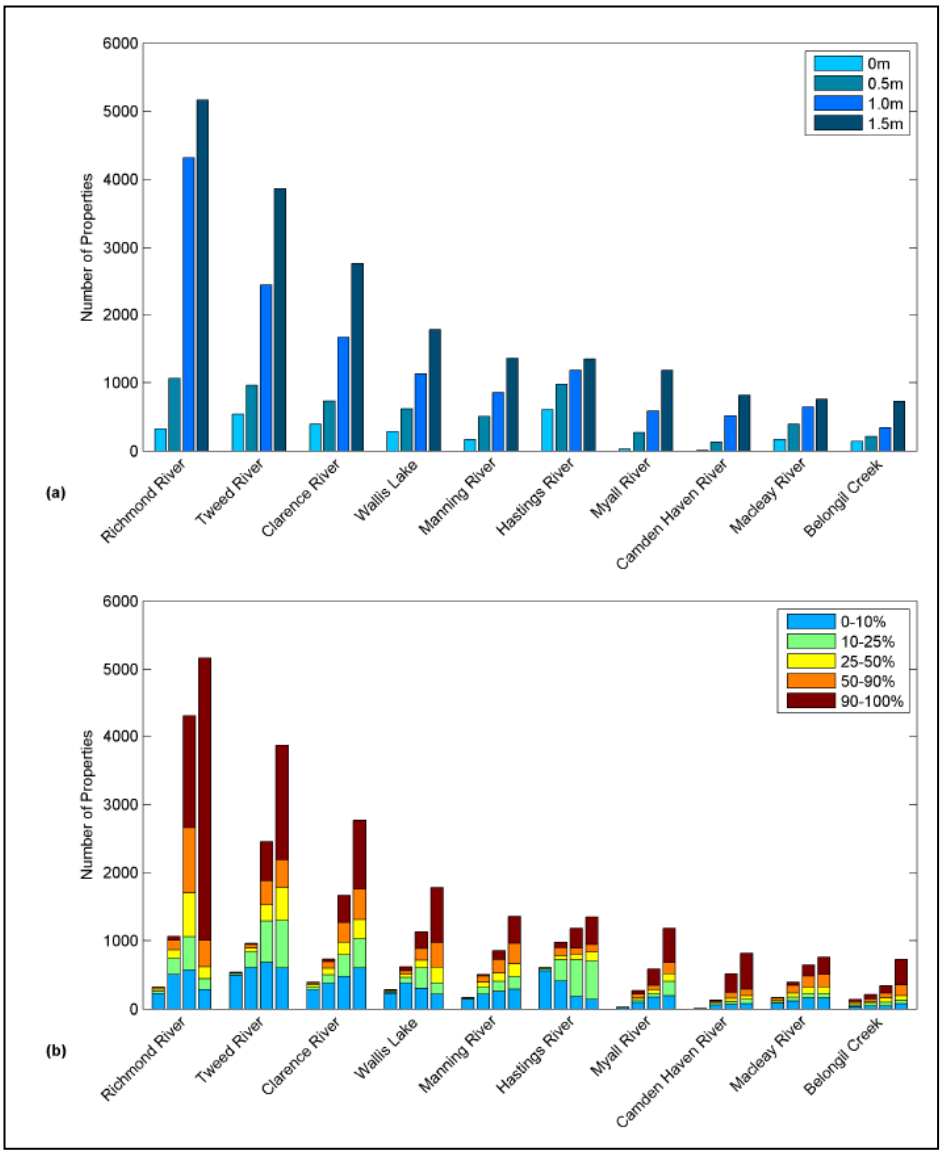


Figure 6: Total numbers of properties exposed to inundation (HHWSS) for the 10 most exposed estuaries in the North Coast region.

Hydrology

The Water Services Division of Council has extensively monitored catchment hydrology, identifying:

- The Manning River supplies a mean annual discharge of 1,854 GL/yr.
- The Gloucester Catchment supplies between 25 and 58% of the flow,
- The Nowendoc Catchment supplies between 12 to 33% of the flow,
- The Barnard Catchment supplies 8 to 32% of the flow,
- The Little Manning supplies less than 7% of the flow, and
- Dingo Creek contributes 1 to 10% of the flow.

Coastal wetlands

Manning Estuary has significant areas of coastal wetlands including large areas of mangrove forest, brackish wetlands, in areas like Cattai and Big Swamp; open freshwater lagoons and wet heaths in Crowdy Bay National Park and forested wetlands characterised by swamp mahogany and broadleaved paperbark and swamp oak.

The Stage 1 scoping study gap analysis identified a need better for spatial information, description and assessment of coastal wetlands. A meeting of the CMP Technical Working Group held in December 2018 ranked coastal wetland assessment as a priority action for the research program to be undertaken in Stage 2. Consultants were engaged to undertake fine scale mapping and description of coastal wetlands in the manning Catchment, with a view to proposing an amendment to the Coastal Management SEPP and developing management actions to protect, restore and improve the resilience of coastal wetlands in the Area of Interest.

The coastal wetlands study in the Manning River Estuary had the following objectives:

- better understand the distribution and condition of wetland systems
- improve the accuracy of State Environmental Planning Policy (SEPP) mapping
- provide data to help model the anticipated effects of climate change
- develop CMP strategies to avoid, mitigate or offset the predicted negative impacts on wetlands and their values

Key activities included a literature review and gap analysis, 3D Aerial Photo Interpretation (API) and a ground-truthing field survey involving rapid and full floristic plots. Innovative methods used included DEM elevation data and surface models to determine wetland locations and extent; and aerial video transects captured using remotely piloted aircraft. Many otherwise inaccessible wetlands were surveyed from waterways using a boat.

The project produced the following outputs:

- Detailed wetland maps in hard and soft copy
- Description of wetland types / vegetation communities / floristics
- Assessment of tenure, condition and threats
- Basic prioritisation of wetlands for conservation and management
- Overall recommendations for restoration and protection

At the request of DPIE, an overview of the results of the coastal wetlands study has been included here in the Scoping Study revision. The full report has been uploaded to Council's *Our Manning River* web page as a supporting document to the CMP. An example of the wetland mapping produced in the study is provided in Figure 7.

Thirteen wetland types totaling 8,906 hectares were mapped across three vegetation formations and six vegetation classes. A total of 51 discrete units were mapped, which included a number of variants of wetland types and intergrades (complexes) which occur between them.

Wetlands were generally mapped in good/excellent condition (69%), whilst wetlands in fair condition accounted for 19% of the total area mapped and poor/very poor condition equated to 12%. The majority (86%) of all wetland types mapped are already identified and protected under State or Commonwealth legislation.

Wetlands areas across the study area were noted as having been variously disturbed and modified since European occupation, however due to the waterlogged and saline soils,

wetlands of considerable conservation significance were found to still occur in the study area. This includes large wetlands at Taree (Dawson River), Kundle Kundle, Cattai Wetlands, Big Swamp, Manning Point and Crowdy Bay National Park.

The following major immediate and long term risks to coastal wetlands were identified: environmental weeds; urban and agricultural development; accessibility; isolation and fragmentation; inappropriate fire regimes and climate change (particularly sea level rise). Management options to address these risks will be considered in Stages 3-4 of the CMP.

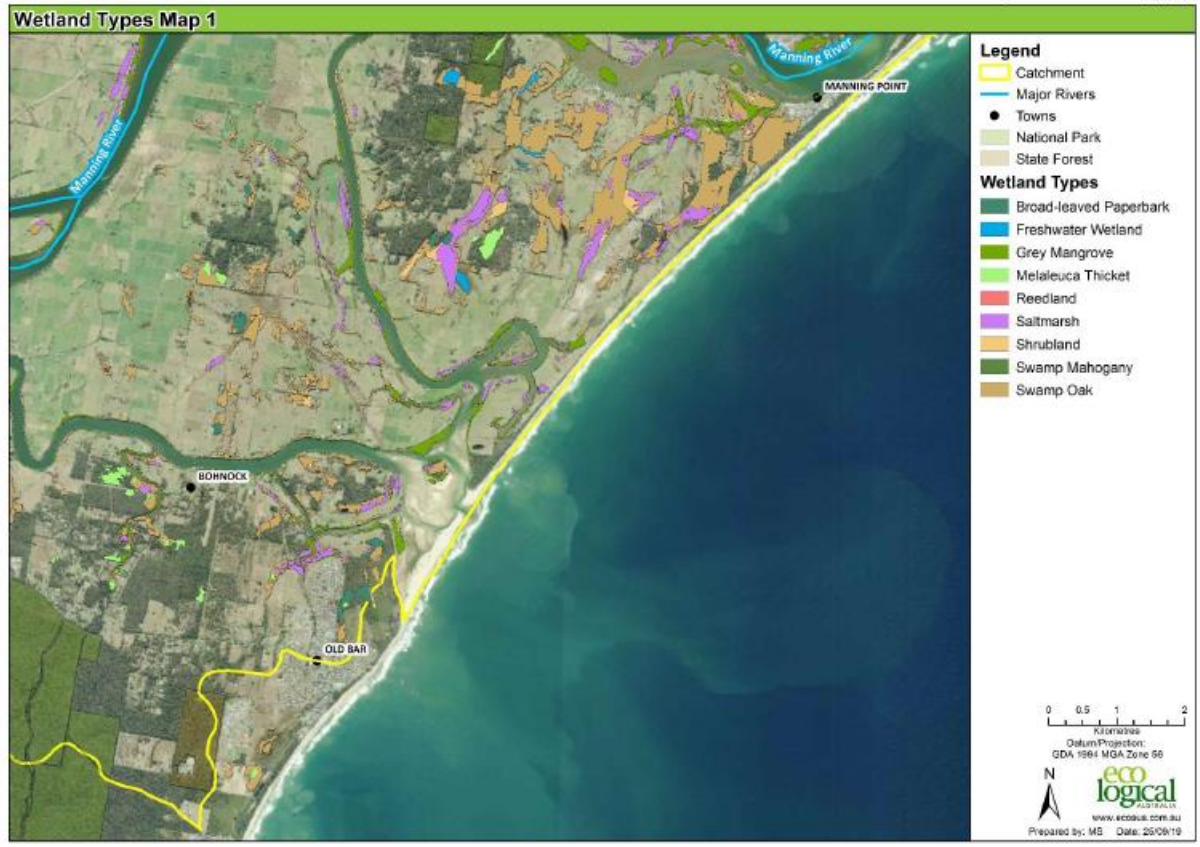


Figure 7: Example of coastal wetland mapping produced for the manning River Estuary CMP, covering Old Bar to Harrington.

Subsequent to the first draft of the Scoping Study, a research project is being undertaken by Science Division, Environment, Energy and Science, Department of Planning, Industry and Environment (DPIE) to understand the predicted distribution of mangrove and saltmarsh under three sea level rise scenarios (0.5m, 1.0 and 1.5m on the open coast, noting that the amount of SLR will be different at different locations inside the estuary). This is firstly being completed at a broad state level, with a subset of representative estuary types assessed in detail as case studies. As at April 2020, the broad assessment had been completed for the Manning Estuary, with The Estuary being selected as a local case study The Manning provides an excellent opportunity for this project due to the development of the Coastal Management Program, the interest and investment in research and management of the floodplain, availability of current LIDAR and DEM (Digital Elevation Model) and the recently completed fine scale coastal wetlands mapping outline above.

The methods and actions completed to date include:

- 1. 2m x 2m combined topography/bathymetry DEM used for the MCC Manning flood modelling study, provided to DPIE. Fine scale coastal wetlands spatial data and report for the Manning Estuary has also been supplied.2. preliminary mapping outcomes was provided by DPIE in December 2019. This indicated:
- Mapping predicted distribution of mangrove/saltmarsh was completed for present day, using the mangrove/saltmarsh mapping undertaken by DPI.
- The overall model accuracy is high.
- Three SLR scenarios considered: projected mangrove/saltmarsh distribution under a sea level rise of +0.5, +1.0 and +1.5m on the open coast (the amount of SLR will be different at different locations inside the estuary)
- images in sequence clearly provided where wetland areas migrate and where saltmarsh areas transition to mangroves.
- The predictions for the three sea level rise scenarios assumed that existing land-use constraints hold in the future.

The state and local study results of this project will be used to inform coastal wetland management options in both the Manning River Estuary CMP and Old Bar Manning Point CMP.

Note there is no Littoral Rainforest within the Area of Interest for the Manning River Estuary CMP, as such it has not been considered in the Scoping Study Review.

Social and Cultural Landscape

Approximately 50,000 people choose to call the Manning Catchment home, of which around 34,000 people reside within the estuarine or coastal landscape of the catchment. A large proportion of the population choose to live in the area due to the natural beauty, rural landscape, estuary and coastline on offer. The trend of 'coastal living' is likely to continue to add pressure on the estuary, with the population forecast to grow by approximately 18% on the coast by 2036 (Australian Bureau of Statistics and .id, the population experts 2018).

The Manning Catchment at present has approximately 870,000 tourism visitors per annum of which about 60% is in the peak summer period. Modelling of tourism trends (particularly Nature–based and adventure tourism) to 2030 indicates that the Manning Catchment has the potential to attract in the order of 2.16 million tourists per year of which approximately 70% would be in the lower catchment (2iis 2016).

The landuse of the catchment is predominantly rural in nature and sparsely populated with only approximately 30% of the population living within the rural environment. The main townships include Taree, Wingham, Harrington, Old Bar and Gloucester and smaller towns include Barrington, Lansdowne, Marlee, Bobin and Nowendoc.

The Manning Catchment is part of the traditional homelands of a number of Aboriginal nations. Approximately 7% of the community are Aboriginal / Torres Strait Islander, compared to 5.5% for Regional NSW as a whole (ABS and .id 2018). *Biripi* country covers most of the catchment, extending from the coast inland, where it meets *Kamilaroi* country on the New England Tablelands. South of Gloucester is *Worimi* country and west of Gloucester, incorporating the Barrington Tops is *Geawegal* country (Horton 2018).

The Manning Catchment includes a number of Aboriginal cultural sites that are identified though environmental planning instruments. Of relevance to the Manning Catchment is Schedule 5.10 of the *Greater Taree Local Environment Plan 2010*, and the *Gloucester LEP*

2010. These LEP's identify and make provisions for the management and protection of these heritage conservation areas and items, including artefacts, so that their economic, environmental and social benefits are retained for future generations.

Economic context

The Manning River catchment supports various land uses such as agriculture, light industrial uses, and urban development as shown in Figure 8 and Figure 9 overleaf. Land tenure is primarily private, with areas of public reserves incorporating National Parks, State Forests and some Nature Reserves and State Conservation Areas.

Within the agricultural sector the grazing industries of dairy and beef dominate, with localised areas of prime lambs and egg production. There is a wide variation in the intensity of the 'grazing industries' across the catchment;

Figure 9 provides an indication of landuse intensity through spatially representing the total number of livestock within each major subcatchment. The raw data of livestock numbers was provided by Hunter Local Land Services, and then intensity categories were randomly allocated based on local knowledge of the relationship between livestock numbers and regionally relevant intensity levels. It is evident that the floodplain of the Manning River from the estuary to upland areas has the highest number of livestock. The Barnard, Barrington and Gloucester also had high stock numbers in comparison to other subcatchments.

Catchments on the northern boundary of the floodplain were primarily ranked as low-medium stock numbers, whilst the Myall Creek subcatchment has negligible livestock.

The Manning regional economy is intrinsically linked to the natural values of the catchment and estuary. Industries directly dependent on environmental values include agriculture, aquaculture, fishing, forestry and tourism. Combined, these industries contribute gross revenue of $817 million per annum to the wider MidCoast Region, with agriculture and tourism both injecting over $210 million per annum each (REMPLAN 2018), as shown in Table 4.

Table 4: Annual Gross Revenue by Key Industry Sector

Industry	Gross Revenue (per annum)
Agriculture (dairy, beef, sheep)	$217.048 million (MCC area)
Forestry	$10.134 million (MCC area)
Tourism	$211.4 million (Manning Catchment 2014) $570.4 million (MCC area)
Aquaculture & fishing	$19.816 million (MCC area)
Total	$817.398 million (MCC area)

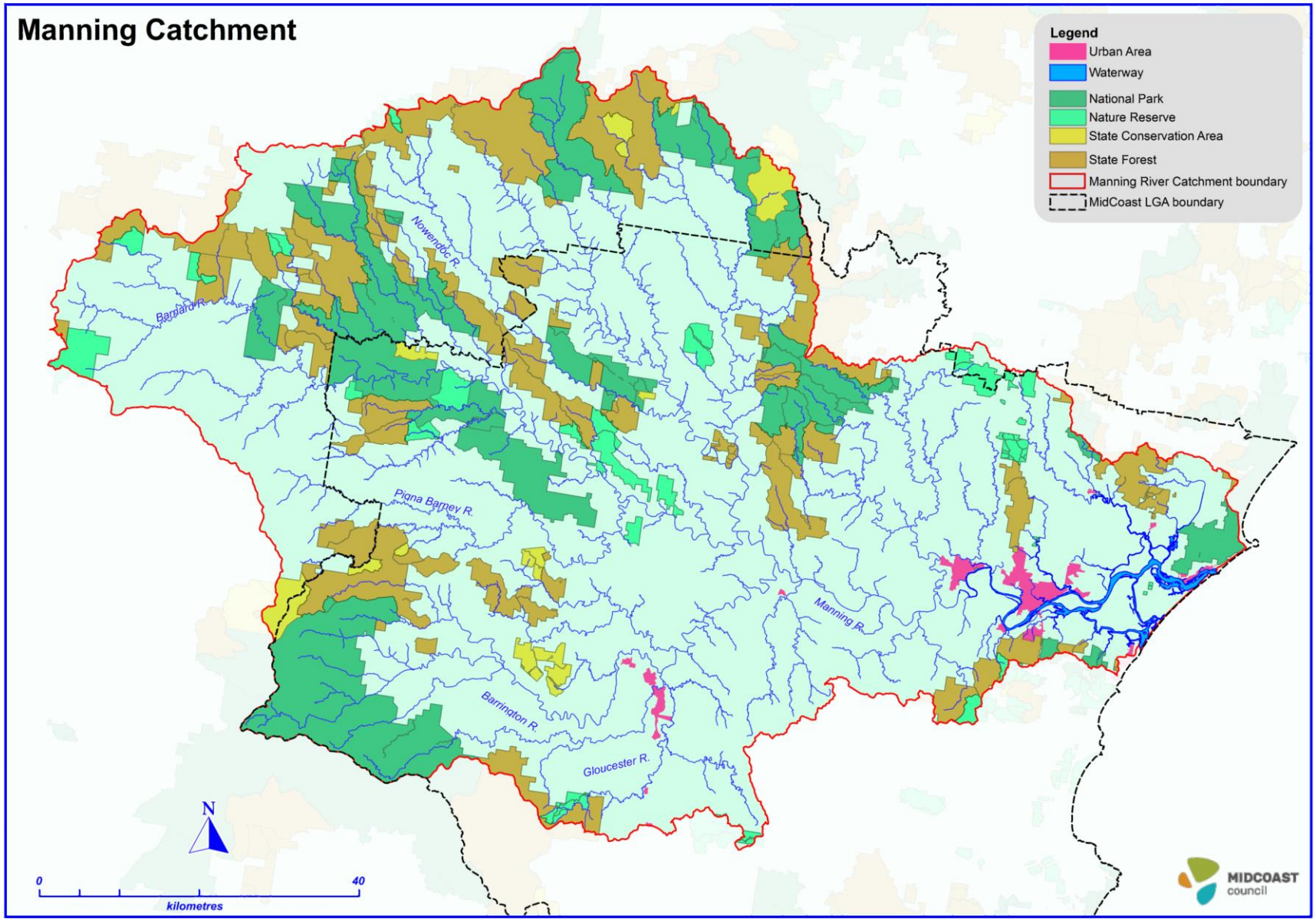


Figure 8: Major Landuse Types within the Manning River Catchment.

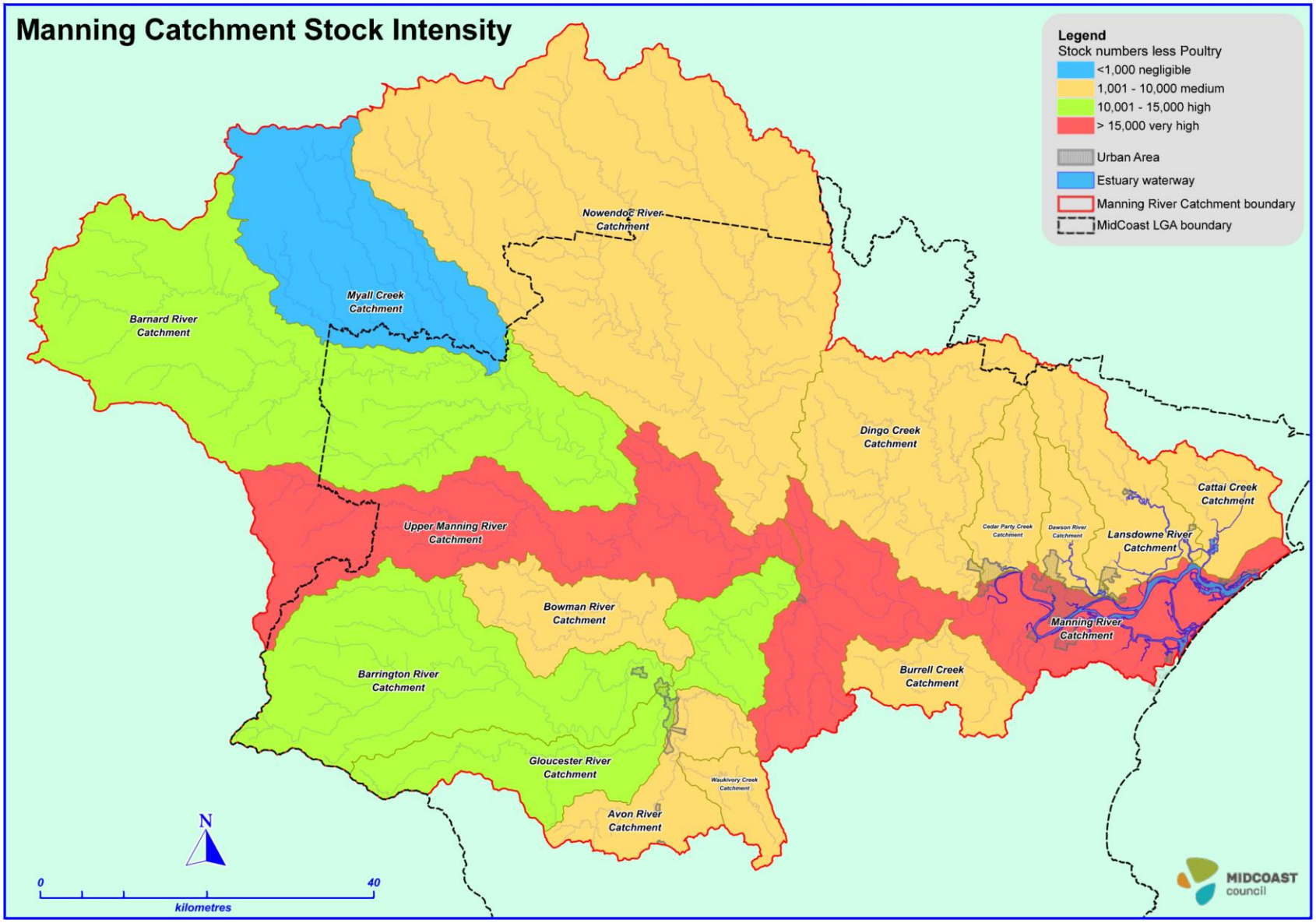


Figure 9: Manning River Catchment Livestock Intensity (reflected as total livestock numbers).

Economic modelling suggests that tourism (particularly Nature-based and Adventure Tourism) is projected to expand to an annual direct tourism revenue of $571 million for the Manning Catchment alone, based on tourism visitation of approximately 2.16 million people per annum visiting the catchment (2iis 2016).

As a reflection of the age demographic of the catchment and unemployment levels, only 34% of the catchments population is in the labour force. The catchment has relatively high unemployment, with an unemployment rate of 9.3%, compared with a rate of 6.6% for NSW. The average weekly income in the catchment is $626.26, compared with a regional median weekly income in regional NSW of $1,166.00. 68% of individual income per week is $799 or less (.id, 2018).

Three sectors dominate employment within the catchment, healthcare and social assistance 18.95%, agriculture, forestry and fishing 18.21% and 13.01% within retail trade (ABS and .id 2018) (see Figure 8).

Willingness to pay for on ground catchment and estuary works is a current gap in knowledge, however employment data and income levels suggests capacity to pay is limited.

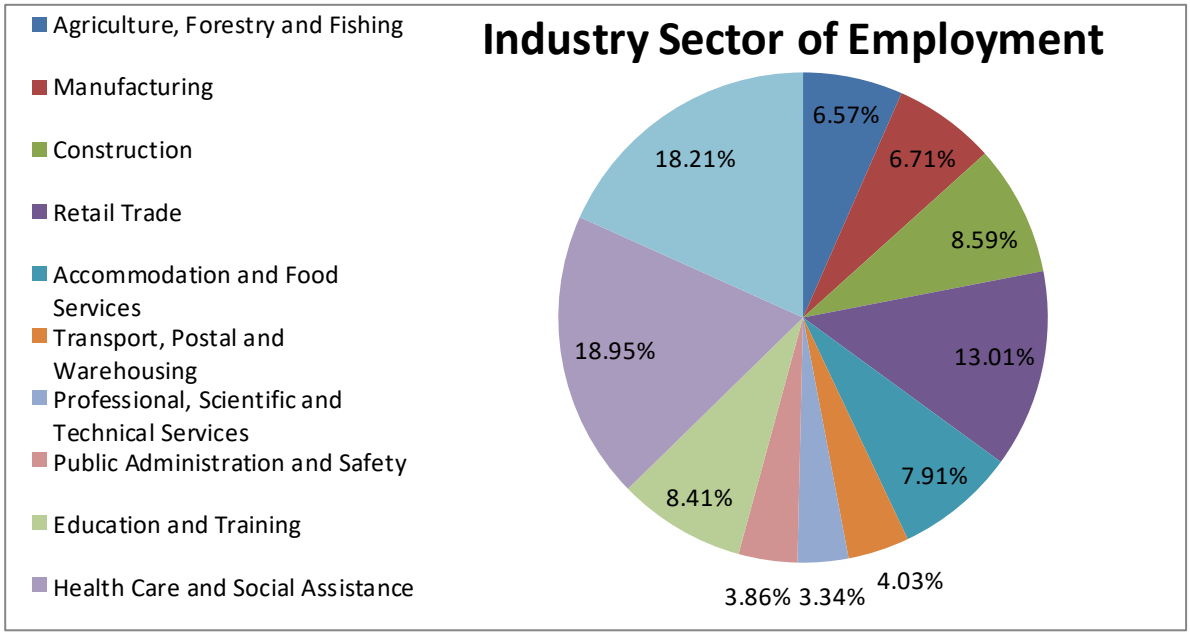


Figure 10: Industry Sector by Employment in the Manning Catchment

Legal and Political Context

The primary piece of legislation guiding the development of the Manning River Estuary CMP is the *Coastal Management Act 2016,* including provisions within the *State Environmental Planning Policy (Coastal Management) 2018*, with a focus on *Division 1 Coastal wetlands and littoral rainforests areas* and *Division 3 Coastal environment area.* Closely aligned and integrated within the Manning River Estuary CMP - Scoping Study is the *Marine Estate Management Act 2014*, particularly in relation to water quality impacts on the estuary and wider marine environment.

Additional layers of State and Commonwealth legislation relevant to the Manning River Estuary CMP include the following:

- Local Government Act 1993
- Environmental Planning and Assessment Act 1979
- Biodiversity Conservation Act 2016
- Water Management Act 2000
- Crown Lands Act 1989
- National Parks and Wildlife Act 1974
- Local Land Services Act 2013
- State Environmental Planning Policy (Vegetation in Non-Rural Areas) 2017
- Fisheries Management Act 1994
- Environment Planning and Assessment Act 1979
- Protection of the Environment Operations Act 1997
- Rural Fires Act 1997
- Environment Protection and Biodiversity Conservation Act 1999 and Environment Protection and Biodiversity Conservation Regulations 2000

The 'Coastal Environment Area' of the Manning River is located within the local government area of MCC, thus MCC has taken on the responsibility of lead agency for the preparation of the Manning River Estuary CMP.

Some reaches of the catchment are located in alternative LGA's, as illustrated above in Figure 5:

- Walcha Council: upper reaches of the Nowendoc subcatchment,
- Upper Hunter Shire Council: upper reaches of both the Barnard and Upper Manning subcatchments,
- Port Macquarie-Hastings: a very small section of the Dingo Creek subcatchment, and
- Tamworth Regional Council: a small section of the headwaters of the Barnard subcatchment.

Given the risk assessment (Section 5) and gap analysis (Section 6) identifies the significant influence of the wider catchment to estuary health, the entire catchment will be assessed for risk and each of these other Councils consulted. MidCoast Council will consult all four Council's during Stage 2 of the CMP; in particular, to seek input into the risk based mapping, ground truthing and social science as applicable. In the event that these localities are a high priority risk to values in the estuary, MCC will collaborate in the development of management options at a later stage.

Governance arrangements and relationship to other public authorities is discussed within the Engagement Strategy, as well as opportunities to use key enablers/ influencers for river and estuary management. In parallel to the Manning River Estuary CMP, the Old Bar Manning Point CMP is likewise in preparation, this plan specifically deals with the coastal planning challenges. As previously discussed, Table 3 outlines the management responsibilities of each plan.

It is also recognised that some studies undertaken to inform preparation of the Manning River Estuary CMP have the potential to improve existing mapping data and management practices in relevant local and State environmental planning instruments.

Local Environmental Planning Instruments

As a legacy of merger into one Council in May 2016, MidCoast Council is presently functioning under:

- three Local Environment Plans (LEPs) – Gloucester LEP 2010, Great Lakes LEP 2014 and Greater Taree LEP 2010;
- three Development Control Plans: Gloucester, Great Lakes and Greater Taree; and
- multiple development policies.

MidCoast Council is currently working through a strategic planning program to inform the preparation of a new MidCoast LEP and MidCoast DCP. The preparation of the Manning River Estuary CMP is scheduled in parallel to this process, thus enabling the CMP process to inform the new suite of planning tools as appropriate.

In particular, this may include the improved identification of lands potentially affected by natural hazards including but not limited to coastal wetlands, flooding and tidal inundation; and adaptive management policies and practices for these lands (consistent with State legislative requirements and provisions).

State Environmental Planning Policy (Coastal Management) 2018

Coastal Wetlands: As a result of the coastal wetland mapping project outlined above, the Manning River Estuary CMP will include evidence and supporting documents for a proposed amendment to the SEPP for Coastal Wetlands across both the Manning River Estuary and Old Bar Manning Point CMP Areas of Interest.

Coastal Vulnerability Area (CVA): The Coastal Management Act defines the CVA as land subject to current and future coastal hazards. There are seven types of coastal hazard defined by the Act:

(a) beach erosion,

(b) shoreline recession,

(c) coastal lake or watercourse entrance instability (linked to OBMP CMP)

(d) coastal inundation,

(e) coastal cliff or slope instability,

(f) tidal inundation,

(g) erosion and inundation of foreshores caused by tidal waters and the action of waves, including the interaction of those waters with catchment floodwaters.

For the Manning River Estuary CMP Area of Interest, coastal inundation, tidal inundation and flooding are relevant hazards. These hazards are currently managed through the Manning River Estuary Floodplain Management Plan.

Mapping of coastal inundation under future climate change scenarios using best-practice scientific methodologies has not been undertaken for the Manning Estuary. Rather than undertaking mapping during Stage 3 of the CMP process, MCC will be recommending mapping and a planning proposal of the CVA takes place in the Stage 5 implementation phase, when the scientific method has been more comprehensively trialled. Assigning thresholds and triggers in the Monitoring and Evaluation Plan will assist with the prioritisation and timing of a planning proposal to introduce or amend coastal vulnerability area mapping within the Coastal Management SEPP.

Previous Plans

There is no current gazetted CZMP in place for the Manning River Estuary. Studies of the Manning Estuary were undertaken in 1990, 1997 and 2009 respectively (NSW Department of Public Works and Services, 1990 cited in Patterson Britton and Partners, 2009; Webb, McKeown and Associates, 1997; Patterson Britton and Partners, 2009). The *Manning River Estuary Management Plan* was completed in 2009 (Patterson Britton and Partners, 2009). In 2014 a review of the Plan was undertaken and an updated Implementation Schedule developed. The plan and review focussed on the estuary and immediate surrounds, primarily in the floodplain zone.

Whilst not considered a CZMP, the *Lower Manning River Drainage Remediation Plan* was completed in 2016; which assessed 15 floodplain sub-catchments of the Manning River estuary for the amelioration of the effects of acidic runoff on estuarine values. This Plan forms a significant component of the risk assessment and gap analysis within this Scoping Study and will be important to guide the development of long term management actions.

Diverse interests

There are diverse interests within MCC and the community that may constrain or add complexity to the Manning River Estuary CMP's development and implementation. For example, there are community barriers to participation in natural resource management; poor collaboration across levels of government and inefficient funding cycles. There is a diverse mix of stakeholders working in the Manning region with responsibilities for managing the river and the estuary, including multiple government agencies, community stakeholders and private landowners. Similarly, within MCC there is a range of priorities that will inform the interest and influence of internal stakeholders involved in development of the Manning River Estuary CMP.

In order to overcome the diversity of the roles, responsibilities and values of these stakeholder groups we will need to work together to be effective and find solutions. The Community and Stakeholder Engagement Strategy provides tools which will assist the Manning River Estuary CMP project team to overcome barriers.

4. Values

Mayor West encapsulates the sentiment of the wider MidCoast Community in the statement from Council's *Community Strategic Plan* (CSP):

> *"We live and work in the best, most beautiful part of the world. Let's work together, having a shared vision and shared responsibility, to make it even better." (MCC 2018, p.6)*

The Manning River is located at the margins of temperate and subtropical climatic zones, and features unique species, habitats and natural environments, making the catchment and estuary an important resource, particularly in light of projected climate change impacts.

The natural environment of the region is the most important asset identified by community in *The MidCoast 2030 Community Strategic Plan 2018-2030* (MCC, 2018). During the development of the Community Strategic Plan (CSP) from 2016-2018 over 3,000 people throughout the LGA were consulted on key values which should support the CSP. Figure 11 shows the results of a community poll to prioritise key focus areas for 'our values' during the development of the CSP. The value of the natural environment clearly stands out as a key value to the community.

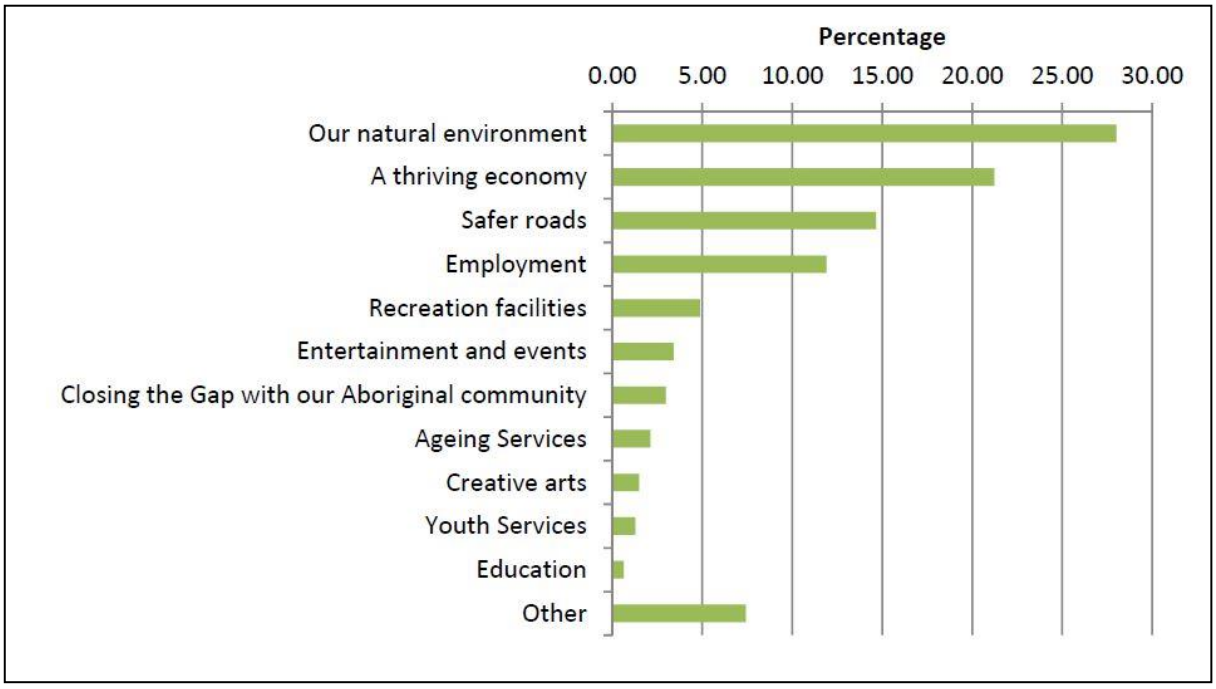


Figure 11: Prioritisation of Focus Areas for Our Values: MidCoast 2030 Community Strategic Plan.

The value of the natural environment is further reflected in the communities' vision statement:

> *"We strive to be recognised as a place of unique environmental and cultural significance. Our strong community connection, coupled with our innovative development and growing economy, builds the quality of life we value."*
>
> (MCC CSP, 2018, p. 7)

MidCoast 2030 CSP outlines 'Our Environment' as a key value with the objective that

> *"Our natural environment is protected and enhanced, while we maintain our growing urban centres and manage our resources wisely"* (MCC 2018, p. 8).

Key strategies associated with 'Our Environment' relevant to the Manning River Estuary CMP include:

- Protect, maintain and restore water quality within our estuaries, wetlands and waterways;
- Ensure climate change risks and impacts are understood and managed;
- Value, protect, monitor, and manage the health and diversity of our natural assets, wildlife and ecosystems;
- Improve the capacity of industry and the community to achieve the best possible outcomes for the natural environment
- Ensure our natural assets are maintained to a standard appropriate to their use;
- Ensure growth and new development complements our existing natural assets, cultural assets and heritage sites and
- Optimise land use to meet our environmental, social, economic and development needs.

The NSW Water Quality Objectives (OEH, 2006) are the agreed environmental values and long-term goals for NSW's surface waters. To determine NSW Water Quality Objectives for the Manning River, community consultation identified a wide range of environmental and socio economic values to protect. In the Manning, values identified included recreation and tourism, agriculture, aquatic ecosystems, drinking water, and production of shellfish and crustaceans in the lower estuarine areas. It was identified that there was strong support for achieving high level of water quality that would support ecological health as well as social, cultural and economic values including:

- Safe swimming;
- Natural beauty;
- Drinking water;
- Secondary contact recreation e.g. boating;
- Irrigation, stock and domestic uses;
- Producing clean, healthy oysters supply; and
- Spiritual and cultural aspects

Similarly, the *NSW Marine Estate Management Strategy 2018-2028* (MEMA 2018) identified the health of the marine estate, and estuaries in particular as assets of high value. Environmental assets within the strategy focus on natural beauty and clean water which support abundant and healthy marine life. Social and cultural values focus on a 'coastal culture' including activities such as surfing, social gatherings, engaging with nature, as well as the spiritual significance for Aboriginal people. From a state-wide economic perspective, the marine estate is valuable for trade, tourism, ports, nature based tourism and seafood industries.

The supply of clean, abundant drinking water is a very significant community value in the Manning. The Manning Catchment is the main water supply within the MidCoast Region, servicing approximately 30,000 households and businesses in areas such as Gloucester, Taree, Wingham, Forster, Tuncurry, Pacific Palms, Nabiac, Dyers Crossing, Harrington, Coopernook, Halliday's Point and Lansdowne. Whilst drinking water extraction is undertaken within the catchment, as opposed to

the estuary, management of the catchment for drinking water is synonymous with managing many of the threats to estuary health, in particular diffuse runoff.

The *Manning River Estuary Management Plan* (Patterson Britton & Partners 2009) identified ecological, social and economic values for the Manning Estuary (Table 5: Values of the Manning Estuary identified by the Community (Patterson Britton & Partners 2009)). Many of these values parallel those identified in the NSW Water Quality Objectives, as well as those in community consultation undertaken in the development of the MCC CSP '*MidCoast 2030'* (MCC, 2018).

Table 5: Values of the Manning Estuary identified by the Community (Patterson Britton & Partners 2009)

Ecological Values	Social Values	Economic Values
Breeding ground for water birds	Recreational fishing	Tourism
Endangered water birds	Aesthetic values	Dairy industry
Fish and crustaceans	Picnicking and foreshore access	Beef production
Mangroves	Swimming / snorkelling	Oyster / aquatic industry
National Parks and reserves	Camping and caravan parks	Industry
Seagrass beds	Sailing and sailboarding	Commercial fishing
Aquatic mammals	Cultural heritage sites	Sand and gravel resources
Coastal wetlands (formerly SEPP 14 wetlands)	Rowing, kayaking and canoeing	Commercial boating - cruises and hire boats
Pockets of subtropical rainforest	Boat launching ramps	
Saltmarsh / sedges / rushes	Recreational power-boating and water-skiing	
Coastal swamps	Wharves and jetties	
Terrestrial fauna	Houseboats	
Dry open forest	Boat cruises	
Freshwater macrophytes	Residential areas	
Riparian vegetation / corridors		

Aboriginal Values

Maintaining health of our waterways and adjacent lands is important to our local Aboriginal people, as the waterways and associated ecological features hold cultural significance. For example, 'cobra' is a shell fish, used traditionally as a food and medicine, but is an animal currently at risk, due to its sensitivity to contaminants in the water from livestock manure. Cobra rely on intact riparian zones to persist, as such, maintaining good condition riparian zones are needed to ensure ongoing protection of the species and local cultural heritage.

In addition to significant food and medicine species local Aboriginal people have representative totems association with particular plants or animals. Totems are used culturally to classify all things including plants, animals, birds and people; providing a link between the natural world and kinship relationships with spiritual beliefs and personal responsibilities. The relationship to totems extend beyond the physical, including ongoing association with The Dreaming and looking to their totems for particular signs. Bass are an example of a Biripi totem of cultural importance. Bass are closely aligned to the tidal estuary perch, which also features in Biripi totemic beliefs. The shark, eagle, kangaroo, bass, stingray, porpoise and crab are further examples of Biripi totems (MidCoast Library 2009).

The Manning estuary includes a significant number of Aboriginal cultural sites and artefacts with widespread presence of Aboriginal occupation (Klaver and Keffernan,1991). An early map of the Manning estuary dated 1827 by John Armstrong for the Australian Agricultural company records a ‘native camp’ on the south edge of Oxley Island. The Manning is home to sites with deep cultural significance, records include 24 midden sites at Farquhar Inlet, open camp sites, scarred trees, ritual and burial sites (Byrne and Nugent, 2004).

One of many notable sites of cultural importance to the Biripi Aboriginal People is the Cattai Wetlands. Cultural heritage sites identified include stone artefact scatters, a corroboree site located on the Spring Hill ridgeline, and a possible burial and potential massacre site at Skeleton Ridge, although there are different versions of oral history regarding the area (Gondwana Consulting, 2014).

The preliminary values identified within the Scoping Report will be used as the basis to refine values in conjunction with the community and public authorities as outlined in the engagement strategy during Stage 2-3 of CMP development.

5. Spatial Risk Assessment

Background

The Office of Environment and Heritage (OEH) is leading a water quality initiative to improve the management of urban and rural Diffuse Source Water Pollution (DSWP) in NSW, as part of their commitment to implementing the Marine Estate Management Strategy 2018-2028 (MEM Strategy). A key approach to delivering this initiative is to adopt the 'Risk-based framework for considering waterway health outcomes in strategic land use planning decisions' (*Risk-based Framework*).

The *Risk-based Framework* is a protocol that decision makers, such as NRM Managers, planners and environmental regulators can use to help manage the impact of landuse activities on the health of waterways in NSW. The intent of this assessment is to help identify strategic priorities for managing nutrient and sediment runoff in the catchment so that estuary health is protected, maintained or improved.

The *Risk-based Framework* brings together the principles and guidelines recommended in the National Water Quality Management Strategy (NWQMS), which the NSW government adopted in 1992. The overarching principle of the NWQMS is that healthy waterways support the community's environmental values and uses – these are what the community believes are important for a healthy ecosystem, for public benefit, welfare, safety or health.

In May 2017, OEH and the NSW Environment Protection Authority released an introductory resource on the *Risk-based Framework*, in response to three years of consultation on its need to inform urban planning and wider catchment management. It consists of five main steps, which provide a clear line-of-sight between the management targets being set; the community's environmental values and uses they address; and the management or mitigation options needed to achieve them. Since the release of the introductory resource, the *Risk-based Framework* has been identified as a key tool for achieving healthy waterways in a range of strategic plans including the Coastal Management Manual (to meet objects of the *Coastal Management Act 2016*).

OEH in collaboration with MCC have applied the first two steps of the *Risk-based Framework* to produce a first-pass risk map for the Manning River Estuary (Figure 15). This will help inform Stage 1 of preparing a CMP for the Manning Estuary as per the Coastal Management Manual. The map will be used to spatially prioritise where management actions in the catchment will contribute to achieving outcomes for the Manning estuary in accordance with our program logic and objectives as well as some of the management objectives specified in the *Coastal Management SEPP 2018*.

Method

Risk of impacts to the ecological health to the Manning River Estuary from total suspended solids, (TSS), total nitrogen (TN) and total phosphorous (TP) has been modelled and spatially mapped at a subcatchment level for the Manning Catchment. The risk map is underpinned by spatial modelling and mapping of likelihood and consequence as subsequently described.

The maps are underpinned by an effects based assessment (EBA), which addresses Step-2 of the *Risk-based Framework*. A typical EBA for estuaries in NSW has been well established by the Estuaries and Catchment Team of OEH. The EBA consists of a coupled series of catchment, hydrodynamic and ecological response models. The intent of the models is to predict:

i) the quantity and quality of runoff from the catchment;

ii) transport of runoff and pollutants in the estuary; and

iii) subsequent ecological response in terms of changes to algal biomass, changes to water clarity and seagrass cover in the estuary.

The coupled series of models was designed to operate at the catchment scale and serve as a 'first pass' assessment. This means that the modelled outputs provide a good representation of spatial trends to identify relative priorities but do not provide absolute values to allow decisions on the amount of nutrients or sediments that need to be mitigated, or provide predictions on the absolute amount of algal biomass within the estuary. The models informing this assessment are described below.

I. Catchment models to inform estuary health risk assessment

The catchment models are based on a nutrient and sediment export coefficient modelling approach, where the catchment is divided into different land use types, and the area of each land use type is multiplied by an export coefficient (see Roper *et al*, 2011). The export coefficient is defined as the rate at which TN, TP or TSS loads from each land use type is exported to the estuary. The total export or load of TN, TP or TSS from a subcatchment is the sum of the export for each land use type in the subcatchment.

Specific local export coefficients were generated, to capture the spatial variability in the climate zones, soil types (Great Soil Group) and land uses in NSW (see Roper *et al*., 2011). The export coefficients were expressed as kilograms per hectare of the catchment per year, and derived by multiplying modelled surface flows (SF) (Littleboy *et al*., 2009) with measured TN, TP or TSS export concentration data (per landuse) from the published literature and state government monitoring projects (Roper *et al*., 2011). Surface flows were modelled using 2CSalt (Littleboy *et al*., 2009), which is part of a suite of Australian catchment modelling tools available in the eWater Toolkit. The model was originally developed to predict water and salt inputs to inland rivers but was found to be directly applicable to the coastal catchments (Littleboy *et al*., 2009). The model was calibrated for the period between 1975 and 2008 to provide average long term 'steady state' surface flows for each hectare in the catchment. This period was chosen because it captured the dry, wet and average rainfall years in NSW. Model predictions were tested against measured flow data available for NSW (r^2 = 0.98, see Littleboy *et al*. 2009;).

II. Estuary models (hydraulic, hydrodynamic or ecological response) to inform estuary health risk assessment

A 1D Branched Model has been applied to the Manning River Estuary. Branched models treat the main estuary branch as a linear representation of the estuary, but also include multiple tributaries joining the main branch to create a simple and accurate representation of the more complex system.

The 1D-Branched Model considers how nutrient and sediment inputs from the heads of the main branch and tributaries are transported due to the advection of catchment runoff (moving downstream) and the propagation of the tides (moving upstream/downstream). The model also accounts for friction along the estuary floor (bottom friction), which allows for accurate dissipation of tidal energy and vertical mixing in the water column. This interaction of catchment runoff, tides and bottom friction provide a reliable estimate of the upstream transport of brackish water and downstream transport of freshwater. This results in metrics for estimating the residence times or flushing times as a function of distance along the estuary, which is a one of the drivers of primary production in estuary systems. For the mapping, the 1D Branched Models were run to produce two metrics: base exceedance and extent of potential impact (Figure 12). TN loads arising from small rainfall events (*i.e.* 1 year ARI) were used as inputs to the 1D Branched Model on the assumption that the catchment runoff from these small, but frequent events will be retained within the estuary and hence pose the greatest risk of impacts on estuary health. Base exceedance was determined

for each subcatchment, by increasing the total TN loads for one subcatchment by 20% and re-running the model. The increase in TN concentrations within the estuary relative to the base or ambient TN concentrations (i.e. base exceedance) provide a relative measure of the magnitude of impact of that one subcatchment. Figure 12a shows that subcatchment 88 has the greatest base exceedance and would pose the greatest risk of impact, if this metric was considered alone. Figure 12b shows that extent of potential impact (*i.e.* transport of runoff in the estuary) posed by subcatchment 88 is localised. In comparison, subcatchments 115 and 86 have relatively high base exceedance and have a more systemic impact because the runoff from these subcatchments is transported to a larger area of the estuary.

base exceedance and extent of potential impact are expressed as percentages, ranging from 0 to 100. A base exceedance of 100% indicates a doubling of the base or ambient TN concentrations in the estuary. Similarly, if the extent of potential impact is 100%, then the TN loads from the subcatchment are transported to all areas of the estuary.

Note that both the

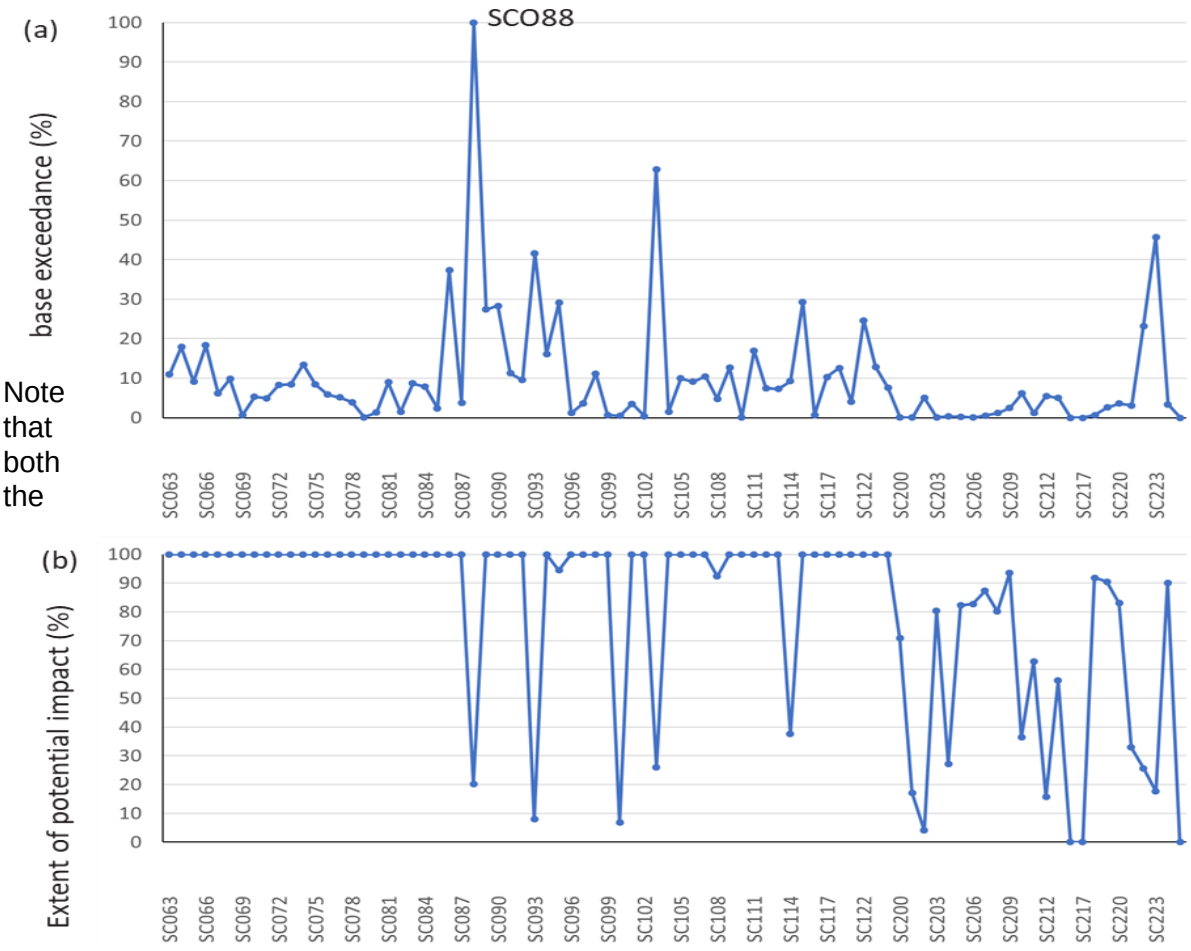


Figure 12: Plots showing (a) the base exceedance and (b) extent of potential impact of TN loads in the Manning River ('SC' denotes subcatchment number)

III. Estuary Health Risk analysis

The outcomes of the catchment and estuary models were classified into either likelihood or consequence criteria and integrated via a risk matrix (Table 8). Each square in the risk matrix represents a unique pairing of the consequence and likelihood risk criteria and, therefore, a risk level. As described in the results, likelihood criteria included SF, TN, TP and TSS loads from the

subcatchment or loads per hectare. Consequence criteria included base exceedance and extent of potential impact (for 1D-Branched Model).

Risk scores for the likelihood or consequence criteria were based on quantiles. Specifically, the modelled data were discretised into quantiles and attributed with a score of 1 if they were ≤ 25th percentile, a score 2 if they were >25th and ≤ 50th percentile, a score of 3 if they were > 50th and ≤ 75th percentile or a score of 4 if they were > 75th percentile.

Subcatchments that drain directly to the estuary were also attributed with a likelihood score of 4 to denote a high likelihood of risk of impacts on the ecosystem health of the estuary due to proximity. All other subcatchments were attributed with a very low likelihood score of 1.

The risk matrix resulted in 16 discrete risk levels, is used to identify the current risks of impacts of TN loads from individual subcatchments to the ecosystem health of the estuary and the priority with which each of the risks need to be addressed (Table 8). The score for each risk level in the matrix was determined by simply multiplying the likelihood and consequence scores.

Three spatial datasets underpin the ecological health risk mapping undertaken for the Manning River Estuary and Catchment:

1. *Estuary Subcatchment Nutrient Loading*
2. *Estuary Nutrient Load Flow'*
3. *Estuary Subcatchment Health Risk*

The dataset referred to as '*Estuary Subcatchment Health Risk'*, is a shape-file of the catchment of the Manning River estuary, as shown in Figure 15. The upland catchment has been subdivided into smaller drainage areas, or subcatchments, based on the ≥ 3rd order streams. The shape-file has three main data attributes: likelihood scores, consequence scores and risk scores.

Likelihood scores represent the extent and intensity of land use pressure from each subcatchment, with a score of 1 indicating the lowest likelihood of impact and a score of 4 the highest likelihood of impact on estuary health. Consequence scores represent the extent of impact on estuary health, with a score of 1 indicating lowest chance of impact and a score of 4 indicating the highest chance of impact. Risk is a product of the likelihood and consequence scores (likelihood x consequence = risk), with a maximum risk score of 16 indicating the greatest risk and the lowest risk score of 1 indicating the lowest risk. The method for calculating risk scores follows the procedure outlined in the NSW Treasury Risk Management Toolkit.

Table 6: Likelihood scores define the chance that runoff from a subcatchment will have an impact on the ecological health of the Manning River Estuary

LIKELIHOOD	SCORE	DESCRIPTION
High	**4**	Ecological health of estuaries have a high chance of impact from the subcatchment because they receive the largest inputs of total and/or per hectare surface flows, and TN, TP and TSS loads from a subcatchment. Large inputs are those in the > 75th percentile of the dataset.
Moderate	**3**	Ecological health of estuaries have a moderate chance of impact from the subcatchment because they receive the moderate inputs of total and/or per hectare surface flows, and TN, TP and TSS loads from a subcatchment. Moderate inputs are those in the > 50th and ≤ 75th percentile of the dataset.
Low	**2**	Ecological health of estuaries have a low chance of impact from the subcatchment because they receive relatively low inputs of total and/or per hectare surface flows, and TN, TP and TSS loads from a subcatchment. Low inputs are those in the ≥ 25th and < 50th percentile of the dataset.
Very Low	**1**	Ecological health of estuaries have a very low chance of impact from the subcatchment because they receive the very lowest inputs of total and/or per hectare surface flows, and TN, TP and TSS loads from a subcatchment. Very low inputs are those in the < 25th percentile of the dataset.

Table 7: Consequence scores define the extent of impact on the ecological health of the Manning River Estuary

CONSEQUENCE	SCORE	DESCRIPTION
High	**4**	Impacts on the ecological health of an estuary are high because the TN and Chl *a* concentrations, water clarity, base exceedance and/or extent of potential impact metrics are in the >75th percentile of the datasets.
Moderate	**3**	Impacts on the ecological health of an estuary are moderate because the TN and Chl *a* concentrations, water clarity, base exceedance and/or extent of potential impact metrics are in the > 50th and ≤ 75th percentile of the datasets.
Low	**2**	Impacts on ecological health of an estuary are low because the TN and Chl *a* concentrations, water clarity, base exceedance and/or extent of potential impact metrics are in the > 25th and ≤ 50th percentile of datasets.
Very Low	**1**	Impacts on the ecological health of an estuary are very low because the TN and Chl *a* concentrations, water clarity, base exceedance and/or extent of potential impact metrics are in the ≤ 25th percentile of the datasets.

Table 8: Risk matrix to prioritise or rank subcatchments according to their risk of impacts on the ecological health on the Manning River Estuary

		LIKELIHOOD (catchment runoff – subcatchment totals and/or per hectare)			
		4	**3**	**2**	**1**
CONSEQUENCE (estuary health)	**4**	16	12	8	4
	3	12	9	6	3
	2	8	6	4	2
	1	4	3	2	1

The dataset referred to as '*Estuary Subcatchment Nutrient Loading'*, provides context for the likelihood scores. There are 8 main data attributes, based on exports of surface flows (SF), total nitrogen (TN) loads, total (TP) phosphorus loads and total suspended sediment (TSS) loads. The exports are presented as the total export from the subcatchment or the average export from one hectare in the subcatchment (otherwise known as export rate or generation rate). Figure 16 illustrates export of TN from each subcatchment draining to the Manning River. Note the difference in spatial trends provided by the maps, which is a result of the area of the subcatchment. For example, the smaller subcatchments around the periphery of the lower Manning River are identified as high risk in Figure 16b where TN loads are expressed as kg/ha/y, but not in Figure 16a where TN loads are expressed as total loads exported from the subcatchment (in kg/y).

Likelihood scores in the '*Estuary Subcatchment Health Risk'* dataset were based on both types of export data, however, the likelihood scores can be re-calculated using a subset as has been done for the Manning River. In this case, likelihood scores only reflect the average exports of SF, TN, TP and TSS loads from one hectare of the subcatchment. Using only the average export rate (kg/ha/y) places greater emphasis on the intensity of the land uses from the subcatchment. It's worth noting that the likelihood of impact of the total loads from the subcatchment are inherently captured in the consequence scores (see methods)

The dataset referred to as '*Estuary Nutrient Load Flow'*, is a raster file with a grid size of one hectare (100 x 100 m) with 7 main data attributes that provide further content for the likelihood scores. Attributes such as the climate zone, soil type and land use were used in the catchment runoff modelling to produce modelled estimates of the SF, TN, TP and TSS loads. Figure 17 Figure 17 illustrates the maps that that were used to provide context and/or to assist with more site specific determinations of management actions within the prioritised subcatchment (see discussion).

Figure 13 represents the process diagrammatically for the Manning River Catchment, with the dataset *'Estuary Subcatchment Nutrient Loading'* equating to the likelihood map, whilst the dataset "*Estuary Nutrient Load Flow*' is represented as the consequence layer. The *'Estuary Subcatchment Health Risk'* dataset is represented by the ecological health risk map.

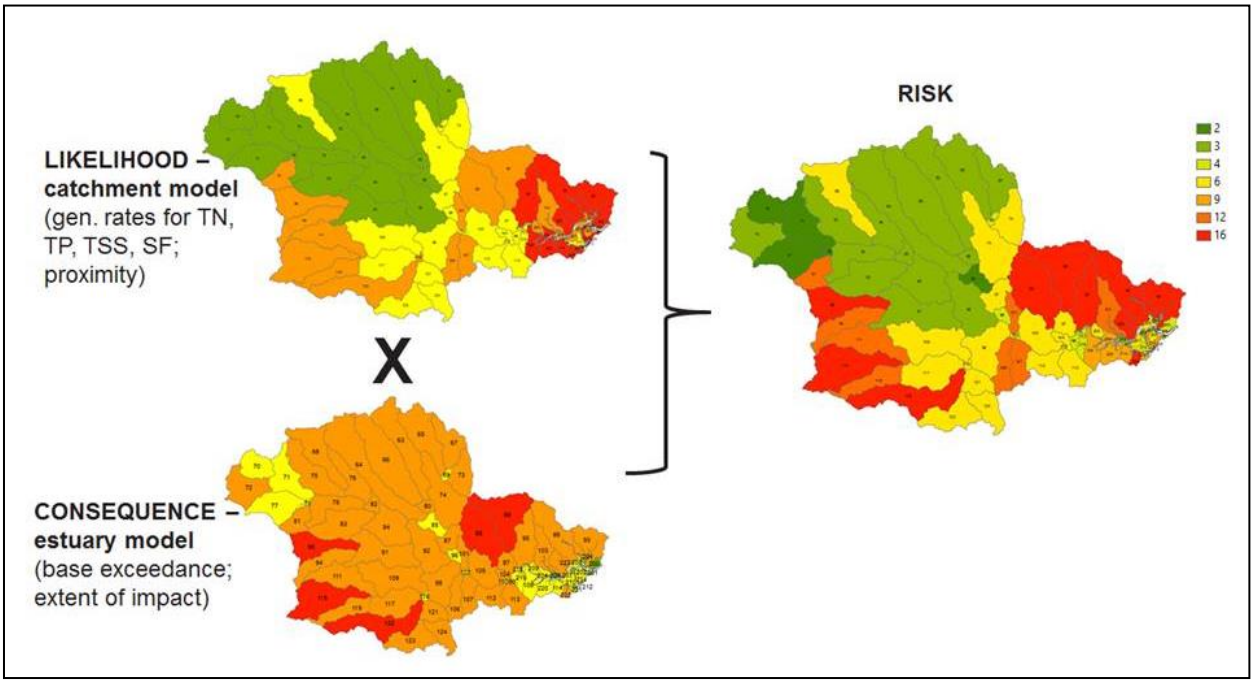


Figure 13: Diagrammatic Representation of Risk Assessment Process

IV. Acid sulphate soils spatial prioritisation

Acidic runoff associated with the extensive acid sulphate soils on the Manning floodplain, was not included in the spatial risk model during the scoping phase for the CMP. The work undertaken within The Lower Manning River Drainage Remediation Action Plan (2016) (Glamore *et al.* 2016) was considered as sufficient to use in its place. In this study a Multi-Criteria Priority Assessment methodology was applied to rank the flood mitigation drains and larger drainage sub-catchments of the Manning River floodplain.

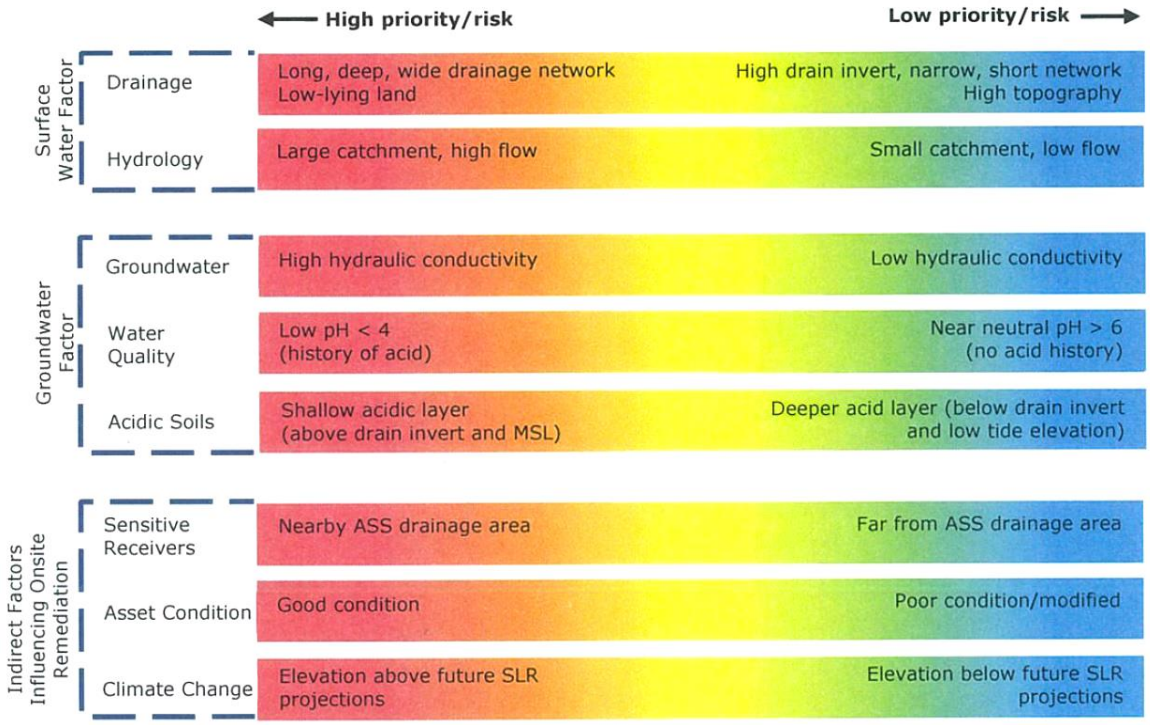


Figure 14: Factors Influencing the Risk of Environmental Impacts from ASS Discharge from the Manning River Floodplain (Glamore, 2016, p. iv)

The method was underpinned by field data including floodplain drainage, catchment characteristics, acid concentrations, soil parameters, asset condition, sensitive receivers and drainage capacity to objectively rank 15 large drainage sub-catchments adjoining the Manning Estuary. Furthermore, the impact of rising sea-levels as predicted for 2050 and 2100 was assessed for each drainage sub-catchment with this study.

Results

Estuary Health Risk Assessment

Results from the estuary health risk assessment show that subcatchments in the north east and south west have risk scores of 12 (red) and hence pose the greatest risk to the ecological health of the Manning Estuary (Figure 17). The identified high risk areas in the north east include localities of Dingo Creek, Wherrol Flat, Storkyard Flat, Upper Lansdowne and Coopernook. In south west, the high risk areas include Gloucester Tops and Tomalla.

The catchment areas shown to pose the lowest risk to the ecological health of the Manning River Estuary (those ranked 2-3 and represented by green shading) are predominately found throughout central north west parts of the Manning Catchment (Figure 17). These identified low risk areas represent localities such as Woko, Curricabark, Bretti, Mares Run, and Dewitt and include such rivers as the Mummel, Rowleys, Cells, Cooplacurripa and Nowendoc. It is noted that these subcatchments are those further from the estuary and predominately vegetated as show in Figure 17c. The southern catchments and some of the smaller catchments adjoining the estuary show moderate risk (yellow) with a mix of lower (green) and higher risk subcatchments (orange and red) along the estuary margins in the south east.

Importantly the risk assessment also highlights that a driving force behind nutrients and sediments within the estuary is from diffuse catchment runoff as opposed to urban runoff.

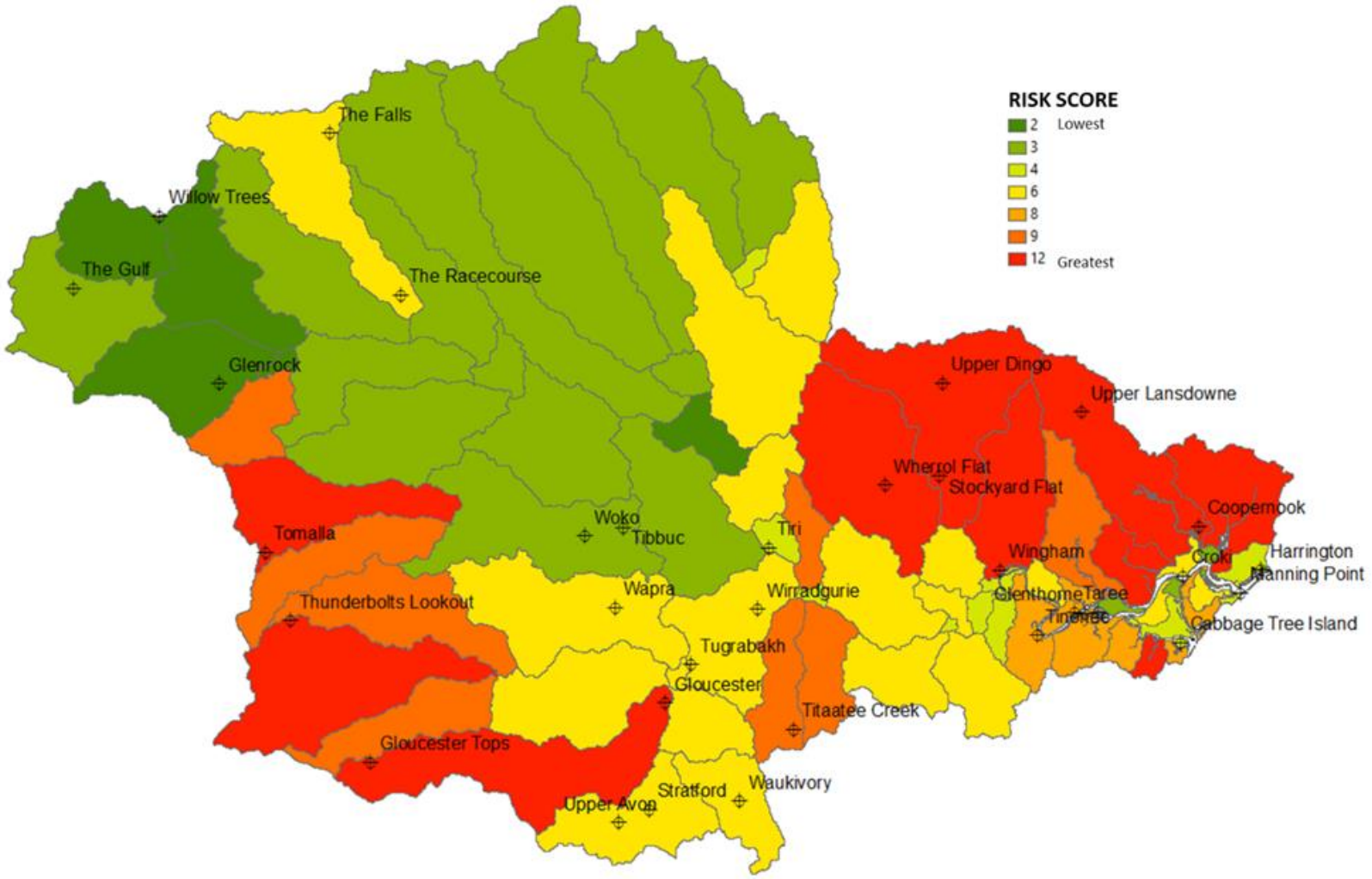


Figure 15: Map ranking subcatchments (2-12) based on relative risk to ecological health of the Manning River

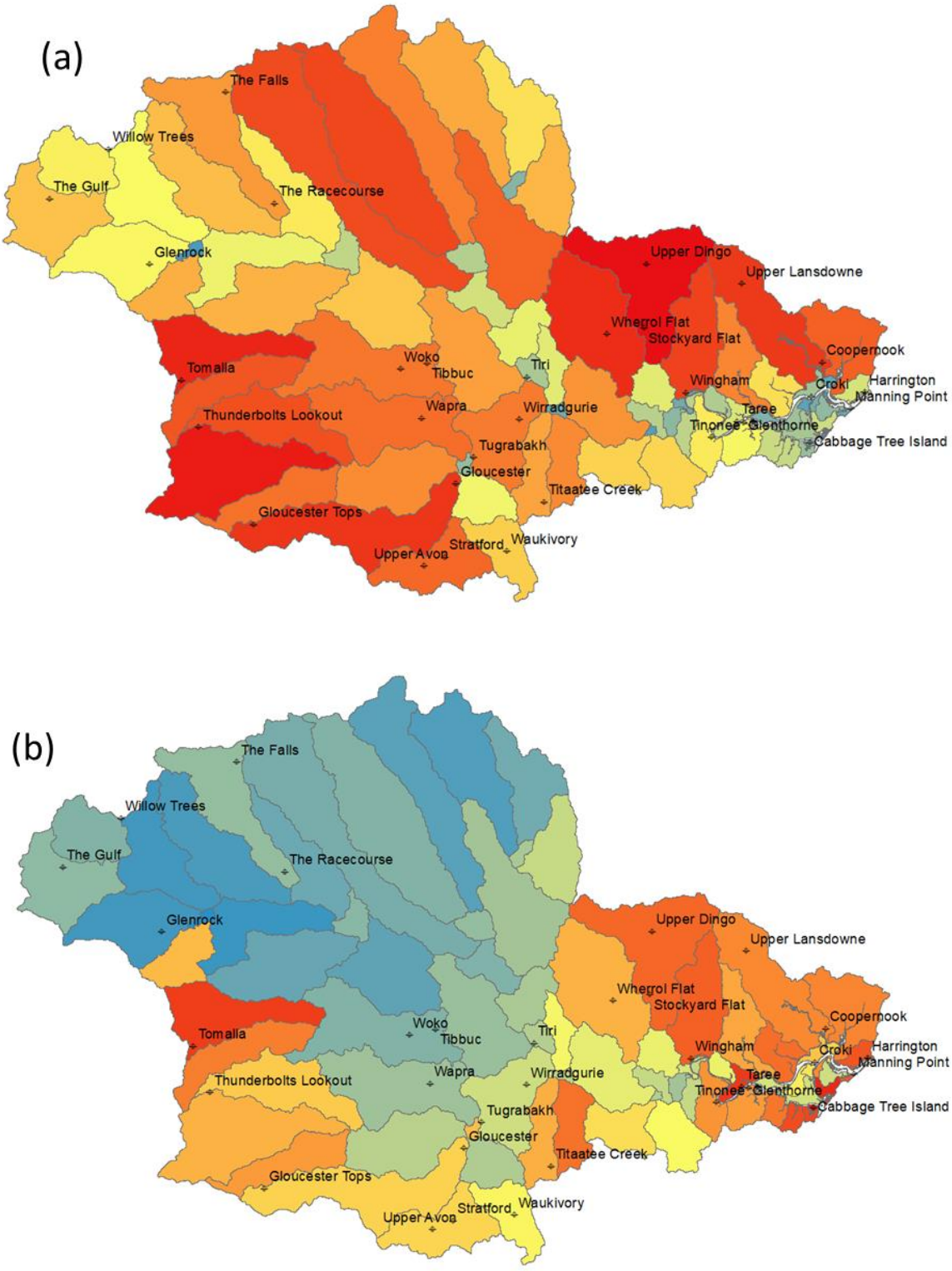


Figure 16: Maps showing total nitrogen loads exported from subcatchments draining into the Manning River.

Exports are presented as the (a) annual total load from the subcatchment, kg/y, or the (b) average export of TN from 1 hectare of the subcatchment, kg/ha/y

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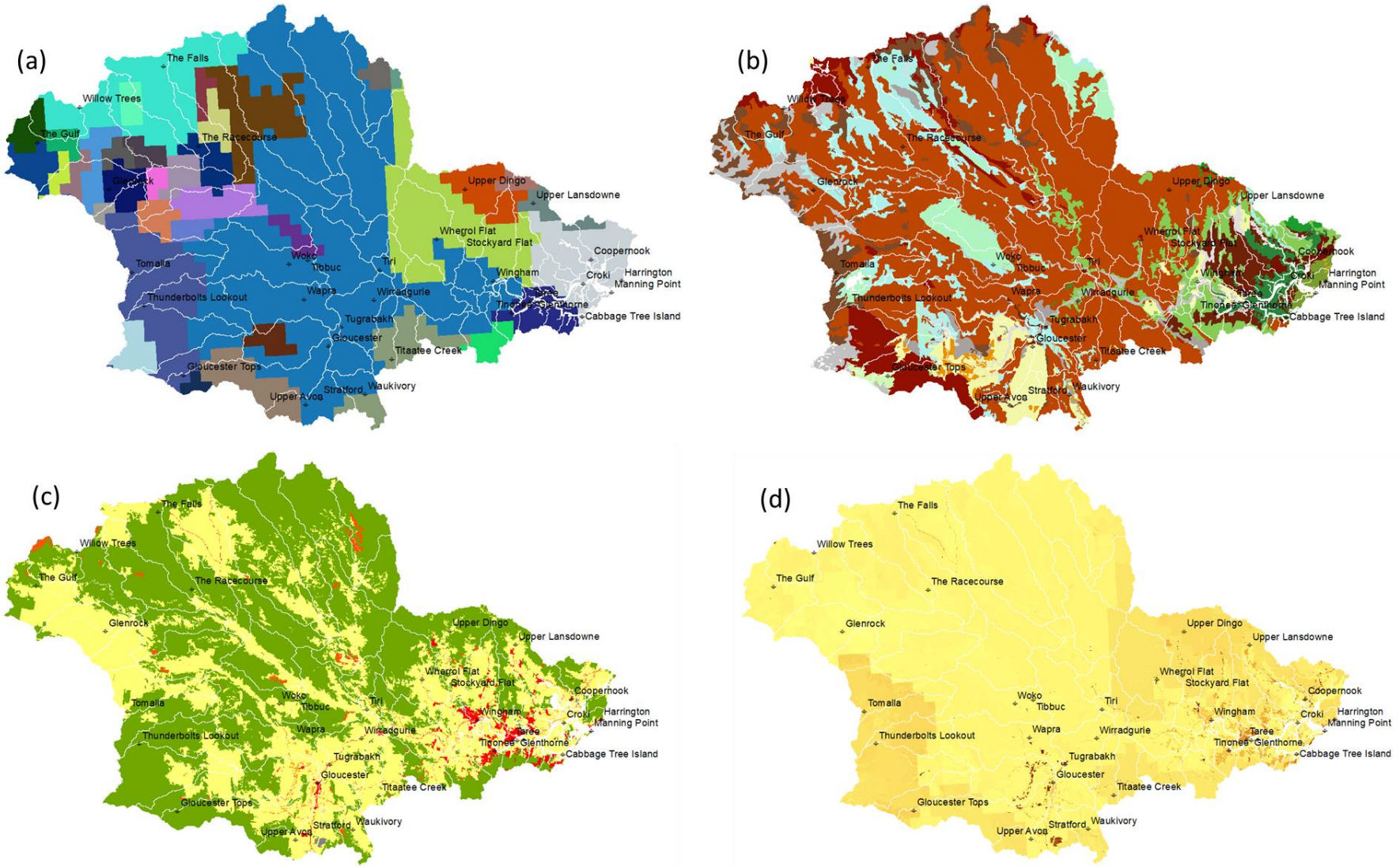


Figure 17: Maps showing the spatial variability in (a) climate zones, (b) soil types, (c) dominant land use and (d) total suspended solid exports from the upland catchment of the Manning River.

Acid sulphate soils spatial risk assessments

Results from *The Lower Manning River Drainage Remediation Action Plan* (Glamore *et a*l. 2016) indicated that the highest priority subcatchments are primarily located on the northern side of the estuary and include Moto, Ghinni Ghinni and Big Swamp (Figure 18). It is noted in the report that these areas are estimated to be contributing over 80% of the total acid discharging to the estuary. When considering the impact of rising sea-levels as predicted for 2050 and 2100 the greatest issue identified was the elevated low tides which will reduce drainage from low-lying backswamps. Moto, Ghini Ghini, Big Swamp, Coopernook and North Oxley Island have the highest risk and impact associated with elevated low tides.

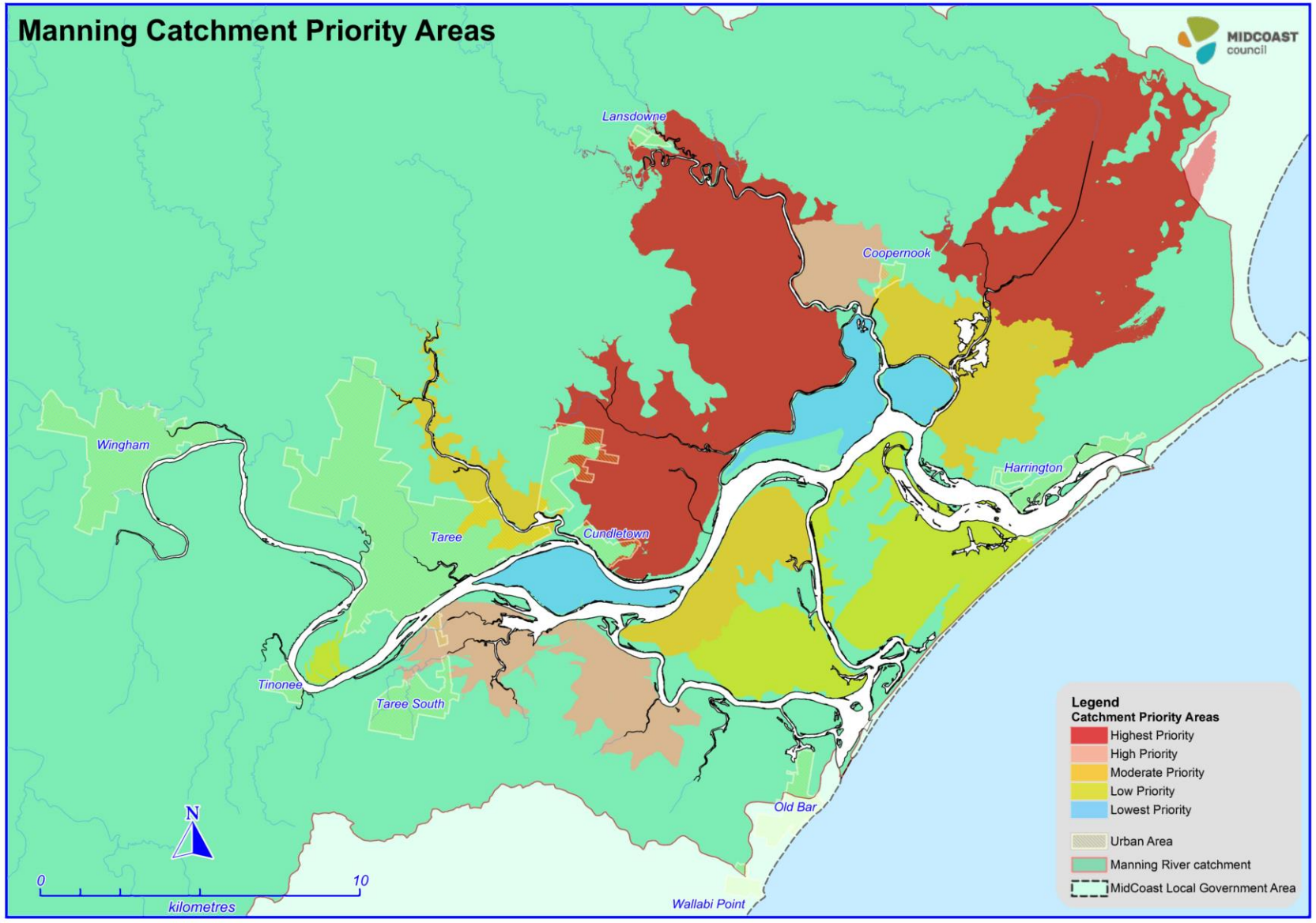


Figure 18: Manning River Estuary Subcatchment Health Risk: Acid Runoff

6. Gap Analysis & Current Management Practices

Methods

A gap analysis was undertaken to help identify and prioritise studies proposed for Stage Two in the CMP process. This is an essential step in guiding MCC to formulate appropriate strategies and actions in later stages of the planning process. The four stages involved in the analysis are outlined in the following. These were undertaken concurrently with a review of current management practices.

Stage One - Literature Review

The first stage of the gap analysis involved an extensive literature search and review.

A wide-ranging search was undertaken for hard and soft copy reports, scientific literature, web searches, databases and spatial datasets pertaining to the Manning River Estuary and Catchment. Subjects searched included but were not limited to the following, based on guidelines in the *Coastal Management Manual Part B* (2017):

- existing plans and strategies
- each of the coastal management areas
- existing mapping of coastal management areas
- natural, social, cultural and economic coastal values and assets
- socioeconomic information
- spatial datasets
- water quality monitoring programs and data
- climate change projections
- environmental flows within the catchment and estuary
- ecological health of the catchment and estuary including stream condition, ecology and water quality
- threatened species and endangered communities
- flora and fauna surveys, species habitat modelling
- catchment and hydraulic modelling
- flood surveys
- land use
- macro invertebrate surveys and
- threats to estuary health such as Acid Sulphate Soils.

In addition, representatives and/or experts internally and from key public agencies including NSW Office of Water, Consultants and former MidCoast Water staff were consulted to obtain information, data and viewpoints on major knowledge and understanding gaps and current management practices of the Manning River Estuary and wider catchment.

The information gathered was reviewed, summarised and assessed for knowledge gaps with the information and consolidated, in an excel database by subject heading. A bibliography with key search terms is provided in the appendices and the excel database can be provided on request.

Stage Two - Application of TARA and MidCoast Council Risk Assessments for the Manning

The second stage of the gap analysis involved assessing these knowledge gaps for the Marine Estate to the Manning River Estuary under categories of threats listed under the Regional Threat and Risk Assessment (TARA) using the MCC corporate Risk Assessment template (2017). A copy of the assessment within the scope of the Manning River Estuary CMP is provided in the appendices along with MCC's risk assessment Criteria. TARA Regional threats were used as "Project Component", "Risk name" was divided into environmental, social and financial risk and the definition of risk and consequence for each has been identified as a Risk Category. Resultant inherent and residual risks were rated as either low, medium, high or extreme in line with the Criteria.

Manning-relevant risks were then assessed using the TARA framework for ratings as per ranked threats to environmental and socio economic assets by the northern region of NSW (refer to MEMA 2017, Table 3-5 Ranked Priority Threats to Environmental Assets (by region), p39 and Table 4-3 Ranked Priority Threats to Social, Cultural and Economic Benefits (by region) p54).

Adequacy of existing knowledge, and knowledge gaps contained in the literature review and risk ratings within the MCC assessment were then evaluated against TARA risk relevant to the Manning. From the MCC assessment, social and economic risks were combined to align with TARA-based methodology.

Gaps identified in research and management, recommendations for future studies, out-dated data sets and discontinued studies were included in a synopsis of key issues within the excel database. Representatives and experts from key public agencies were consulted separately for their viewpoint on major knowledge and understanding gaps and detailed studies to fill these.

Stage Three - Technical Work Group Review

In the third stage, all moderate to high-tier risks identified through MCC and the TARA framework were reviewed at a workshop involving the Technical Working Group and other key agency representatives to develop threat-based rankings. Risk rankings considered both ecological and socio economic values of the Manning River Estuary.

The workshop held on 14th November 2018 included the following:

- Alisha Madsen: Catchment Officer - Manning Catchment, MCC
- Brian Hughes: Estuary and Marine Officer, Hunter LLS
- Debbi Delaney: Catchment Co-ordinator, MCC
- Geoff Le Messurier: Senior Local Land Services Officer, NRM Extension and Advisory, Hunter LLS
- Georgie Dawson: Environmental Technician, Estuaries and Catchment Science, OEH
- Gerard Tuckerman: Manager Natural Systems, MCC
- Dr. Graeme Watkins: Manager, Water Management and Treatment, Water Services, MCC

- Dr. Jamie Ruprecht: PhD Candidate, Water Research Laboratory, School of Civil & Environmental Engineering, UNSW
- Dr. Joselyn Dela-Cruz: Principal Scientist, Water Wetlands & Coast Science Branch, NSW OEH
- Dr. Karen Bettink: Catchment Officer - Ecosystem Management, MCC
- Mathew Bell: Senior Ecologist, MCC
- Neil Kelleher: Senior Natural Resource Officer, Water Floodplain and Coast, Hunter Central Coast Branch, Conservation and Regional Delivery Division, OEH
- Dr. Peter Scanes: Senior Team Leader, Estuaries and Catchment Science, OEH
- Prudence Tucker: Water Quality and Estuary Management Program Co-ordinator, MCC
- Tanya Cross: Sustainability and Natural Assets Co-ordinator, MCC
- Dr. Will Glamore: Associate Professor and Principal Research Fellow, Water Research Laboratory, School of Civil & Environmental Engineering, UNSW

Results

A summary of the analysis that was workshopped by the Technical Working Group is shown in *Table 9: Technical Working Group Assessment of TARA Risks*. The table summarises the threat; risk to ecological, social, cultural and economic values; current management practices; current knowledge; gaps in knowledge; management and recommendations for action. The recommendations for action are grouped based on their priority using the following categories:

- Immediate - Source funding in Stage 2 to undertake further research
- High - Source additional funding to undertake further research
- Moderate - Undertake during plan development if opportunity arises
- Ongoing - Address the gap in the CMP as an action.

Stock degrading riparian vegetation is a key risk to water quality downstream.

Table 9: Technical Working Group Assessment of TARA Risks

ACTIVITY / THREAT (Regional TARA risks refined for the Manning)	Risk to ecological values	Risk to social, cultural & economic values	CURRENT MANAGEMENT	CURRENT KNOWLEDGE	INFORMATION and MANAGEMENT GAP(S)	PRIORITY FOR ACTION
Agricultural diffuse source run-off: Nutrients	Moderate-High	High	• Dairy effluent plans for selected properties in the lower Manning in conjunction with LLS • Pelican Bay - contracted fieldwork to identify the sources of poor water quality and possible remediation actions • LLS extension program	• Intensity of landuse (2017) across the catchment (i.e. livestock numbers / ha) • Preliminary modelling of the export rate of TSS, TN, TP at subcatchment level and branched assessment of estuary impact. Modelling of acid runoff within the estuary Sinks/deep pools (Ida Lake and Bungay) within mid-Manning acting as sediment & nutrient traps • Trends from Water Services data: Barnard River contributes high TP, TN, sediment levels. Mid to lower river subcatchments (e.g. Bowman, Gloucester, Barnard) N enriched from land use/catchment run-off. P levels high in mid to upper sites (e.g. Little Manning). Dingo Creek associated with high NO3 • Nutrient concentrations in lower Manning River are highly variable reflecting differences in discharge, runoff patterns and land use. Implications of high nutrients incl. declining river health, shift from a diverse ecological community to a system dominated by organisms tolerant to organic pollution • Decline in health of aquatic biodiversity e.g. macroinvertebrates, seagrass • Report card estuary monitoring data (high chl-a levels, high turbidity associated with high flow events from catchment, changing macrophyte condition)	A. Calibration of Risk Model including: – TSS inputs as a separate layer to nutrients – Revise landuse intensity mapping to reflect livestock/ha overlayed with landuse type and integrate into model. – Integration of local water quality data from Water Services including nutrients, TSS, pathogens. – Incorporation of additional cultural values i.e. totems and social values e.g. swimming, drinking water into the consequence layer(s) of the model – Calibrate with local information / ground-truthing B. Social, cultural and economic barriers to the adoption of best practice nutrient & sediment management. C. Export rates of nutrients and sediments under different management regimes and current rates of adoption D. Scale of management is not commensurate with the scale of diffuse runoff E. Impact of climate change on catchment hydrology and therefore diffuse pollutant transport into the Manning Estuary F. Estuary Health: Monitor TSS, Chl-a, as per OEH methodology G. Catchment Health baseline condition assessment: AusRivas, nutrients, Chl-a, reach and riparian condition.	A. Immediate B. Immediate C. Moderate D. Moderate E. Moderate F. High G. High
Agricultural diffuse source run-off: Sediments	Moderate-High	High	• LLS Extension program			
Agricultural diffuse source run-off: Pathogens (e.g. E coli)	Moderate	High	• Some dairy effluent plans on selected properties on the lower Manning. • No program targeting hotspot localities for effluent management or diffuse runoff of manure • Legislation in place, but not actively monitored	• Water services water quality data. • Potential to reduce social values in particular e.g. drinking water, swimming etc.		
Agricultural diffuse source run-off: Pesticides & chemicals	Moderate	Moderate	• Legislative controls re: use of pesticide and chemicals.	• Water services monitor for pesticides and chemicals: nil detection in samples to date	• No additional data required	

ACTIVITY / THREAT (Regional TARA risks refined for the Manning)	Risk to ecological values	Risk to social, cultural & economic values	CURRENT MANAGEMENT	CURRENT KNOWLEDGE	INFORMATION and MANAGEMENT GAP(S)	PRIORITY FOR ACTION
Stock in riparian and marine vegetation	High	Moderate-High	• Some ad-hoc exclusion of stock and placement of rock fillets by landholders in conjunction with public authorities	• Stock in riparian and marine environments is a widespread practice impacting ecological, social , cultural and economic values	A. Priority locations for remediation. B. Scale of management is not commensurate with the scale of issue	A. Immediate in high risk locations B. Ongoing
Urban stormwater discharge	Moderate-High	High	• Neutral or beneficial effect is applied to new subdivisions in accordance with the Manning Region LEP	• Pollutant loads are low comparatively to catchment loads	A. Additional protection could be achieved by applying controls to large developments (e.g. commercial or industrial development)	A. Ongoing
Floodplain drainage (ASS)	High	High	• Land acquisition program to remediate high priority localities as funds permit. • Drain Maintenance Guidelines are an appendix to the Greater Taree DCP. • No co-ordinated community capacity building program in place re: management of drains / floodgates, ASS remediation strategies on private properties • Assistance provided to landholders to source funds to undertake floodgate modifications where it reduces ASS runoff. • An example of current management of ASS on the Manning floodplain is included in the case study below.	• Lower Manning River Drainage Remediation Action Plan including prioritisation of floodplain catchments and remediation plans developed.	A. Ecological response of estuary / Measure impact on acid runoff on values B. Current management is not commensurate with the scale of the issue within the Manning Floodplain. Consideration to be given to this in the development of the CMP.	A. Moderate B. Ongoing
Clearing and degradation of riparian vegetation and adjacent habitat	High	Moderate-High	• Some adhoc management by private landholders in conjunction with public authorities • Riparian vegetation mapping and prioritisation project underway (LLS, Griffith University) • MCC currently undertaking detailed littoral rainforest mapping • Some restoration of coastal wetlands	• Extensive clearing and degradation of riparian and associated terrestrial habitat throughout catchment and estuary • Livestock in the river • Course level regional mapping of connectivity.	A. Inclusion of riparian vegetation within Risk Modelling B. Application of riparian management practices C. Condition of riparian vegetation - priority and most effective areas to target restoration and protection D. Connectivity mapping -identification of areas in catchment as barriers for connectivity, most effective areas to implement corridor restoration E. Scale of management is not commensurate with the scale of issue	A. Immediate B. Ongoing C. Immediate in high risk areas D. Ongoing E. Ongoing

ACTIVITY / THREAT (Regional TARA risks refined for the Manning)	Risk to ecological values	Risk to social, cultural & economic values	CURRENT MANAGEMENT	CURRENT KNOWLEDGE	INFORMATION and MANAGEMENT GAP(S)	PRIORITY FOR ACTION
Clearing and degradation of vegetation within the catchment and estuary including coastal wetlands.	High	Moderate-High	• Land acquisition program by MCC as funds permit • Big Swamp and Cattai wetland program by MCC • Some wetland management on private property in conjunction with public authorities.	• Loss of habitat within catchment resulted in loss of species diversity of plants, animals, invertebrates and degradation of natural environment - audit and address land degradation including wind and water erosion, scalding, loss of nutrients, soil acidity, decline in soil structure, loss of biodiversity	A. Threatened, iconic, indicator species distributions, habitat mapping (modelling), habitat preferences, population studies, identify and quantity impacts of threats to inform and direct management. B. Identification and mapping of biodiversity hotspots in the Catchment and development of priority conservation targets C. Coastal wetlands and saltmarsh mapping and audit D. Scale of management is not commensurate with the scale of issue	A. Ongoing B. Ongoing C. Immediate D. Ongoing
Modified hydrology/hydraulics and flow regime, Modified freshwater flows	High	High	• 78,100 ML of surface water licensed for extraction with an annual average flow of 2,530,000 ML • Approximately 20% of licenses are active; the balance is 'sleeper' licenses • Town water extracted at Barrington and Bootawa. Up to 2010 - average extraction of 27 ML/d from the Manning River at Bootawa for the Manning Supply. The Gloucester supply extracts on average about 1 ML/d from the lower Barrington River • 10-year Water Sharing Plans for water sources within the Catchment. Cease to pump regulations imposes access restrictions when flows fall below a set level. No new extraction licences - must purchase entitlement from existing access licences. High Peak extraction demand exceeds available flows in December leading to high hydrological stress -impact on instream health and sustainability.	• Entrance opening modifies salinity / freshwater exchange in the estuary • Hydrodynamic model for lower estuary (WRL) • Medium sensitivity of the estuary to changes in freshwater inflows • Low flow periods obstruct species' passage (e.g. fish, turtles), increase exposure to predation (e.g. platypus). Salt water intrusion into in upper estuary around Wingham results in plant deaths (e.g. water ribbons). Changes in biological structure and function • Current WSP conditions have high ecological risks as a result of the paucity of ecological information used to determine an appropriate CTP threshold • Low flow - periphyton biomass increases, reduces available habitat and variability for macroinvertebrates, changes in food resources, reduced taxa richness	A. Effect on hydrology of climate change (altered flows) and extractions B. Highly variable discharge volumes in two decades - extent these differences between years mask long-term temporal changes in water quality C. The ecology of the groundwater-dependent ecosystems and karsts not well understood D. Importance of different flow regimes to tributaries and river's environment E. Monitoring or enforcement of regulations	A. Moderate B. Ongoing C. Ongoing D. Ongoing E. Ongoing
Entrance modifications, including dredging, opening and permanent entrance training	Moderate-High	Moderate-High	• Permanent entrance opening at Harrington through previous break wall construction • Sand dredging program at Harrington and Farquhar Inlet for boating navigation and access (*Manning River Maintenance* • Dredging Strategy 2010**)** • *Farquhar Inlet Opening Plan* (2010) triggered by flood river level	• Permanently opening the entrance of the estuary at entrances has/will have a range of ecological impacts and result in changes in the salt wedge • Ecological and geomorphological impacts from dredging addressed through REF process	A. Full extent of ecological, geomorphology and salt wedge changes from permanently opening Harrington, Farquhar Inlet and opening below flood trigger level 1 at Farquhar.	A. Ongoing [1]

ACTIVITY / THREAT (Regional TARA risks refined for the Manning)	Risk to ecological values	Risk to social, cultural & economic values	CURRENT MANAGEMENT	CURRENT KNOWLEDGE	INFORMATION and MANAGEMENT GAP(S)	PRIORITY FOR ACTION
Unsealed roads	Moderate-High	Moderate-High	• Sediment and erosion management training provided to MCC staff in the past	• Unsealed road crossings observed increasing turbidity significantly locally during wet weather • Impaired water quality within estuary (high turbidity in high flow periods). • Branched estuary health risk map • Report card monitoring indicates decline in extent and condition of seagrass in estuary	A. Mapping of unsealed roads intersecting stream crossings B. Extent that runoff of sediment into waterways from unsealed roads contribute to sedimentation in waterways, subcatchments, river and ultimately the estuary	A. Ongoing B. Ongoing
Climate change stressors 20 year timeframe	High	High	• LEP (2010) provision for development compatible with flood hazard taking into account projected sea level rise • Water Sharing Plans do not consider projections, only past climate and flow data. • No measures in place to build resilience of freshwater ecosystems such as freshwater protected areas.	• Regional projections for climate change for temperature, hydrological variables such as run-off and water availability Increased extent of dry periods by 2050, altering hydrology and ecology - long periods of low flow. Increased intensity of rainfall and runoff by 2050. Warming climate. Sea level rise • Analysis of impact of inundation on floodplain with Lower Manning River Drainage Remediation Action Plan • Coastal wetlands are highly vulnerable to climate change impacts particularly sea level rise	A. Impact on coastal wetlands: Predicted changes in biodiversity under climate change conditions - how systems respond to flows and water quality. B. Localised predictive modelling, long term ecosystem and sensitive species monitoring C. Building resilience to climate change impacts, including impacts to EECs, littoral rainforest	A. High B. Ongoing C. Ongoing
Sewage effluent and septic runoff	Moderate	Moderate-High	• MCC currently undertaking risk assessment for septic runoff	• Preliminary modelling of catchment stressors	A. Impact of septic tanks runoff /pathogens e.g. E coli as a layer within catchment and estuary modelling	A. Immediate
Pests and diseases	Moderate-High	Moderate-High	• MCC control programs for high priority aquatic and environmental weeds • MCC pest animal control programs in priority areas such as Cattai/ Big Swamp, Manning Entrance (fox), SOS Manning Estuary shorebirds site control plan • LLS management program	• Introduced plants, animals and diseases are present throughout the catchment and estuary, incl. deer, pigs, European fox, Indian mynah, gambusia, goldfish • Sharp rush displacing native species, degrade coastal wetlands and limit the ability to filter out nutrients • Invasive species contribute to the degradation of EECS, coastal wetland, littoral rainforests, estuary and river values • Senegal tea impacting on water quality, displacement of native species, loss of sand nesting turtle species	A. Scale of management is not commensurate with the scale of issue	A. Ongoing
Water pollution on environmental values - litter, solid waste, marine debris and microplastics	Moderate	High	• Some gross pollutant traps in Taree • Clean up days and • education program re: waste management • Women in Dairy silage recycling program"	• Potential sources of contaminants, include urban areas, tourism sites, agriculture etc.	A. Quantification of contribution of litter etc. within waterways	A. Ongoing

ACTIVITY / THREAT (Regional TARA risks refined for the Manning)	Risk to ecological values	Risk to social, cultural & economic values	CURRENT MANAGEMENT	CURRENT KNOWLEDGE	INFORMATION and MANAGEMENT GAP(S)	PRIORITY FOR ACTION
Commercial fishing - estuary prawn haul, estuary general	Moderate-High	High	• DPI regulations: risk to stocks managed with controls/regulations in place		A. Extent of illegal or excessive take is unknown B. Inadequate/adequate regulation C. Impacts not quantified for example commercial fisheries impacts on Australian bass	A. Ongoing B. Ongoing C. Ongoing
Recreational fishing -shore and boat-based line and trap fishing, hand gathering	Moderate	Moderate	• Manning River estuary designated as a Recreational Fishing Haven, only recreational fishing is permitted downstream from Ghinni Ghinni and Berady Creek (including Scotts Creek)		A. Impacts not quantified	A. Ongoing
Oyster aquaculture (in estuaries)	Moderate	High	• Environmental Management System for Manning River Oyster Farmers (2013) • Growers encouraged to work with Authorities to develop Emergency Response Plans to help prepare for fires, explosions, fuel & oil spills, release of hazardous chemicals, effluent spill/release • Pelican Bay desktop study/plan and implementation " • LLS Farm Profile Program • Tarred & treated timber is being phased out for polyurethane trays, plastic sleeved timber posts, plastic baskets, pillows, tumblers	• Oyster bed dredging (the Manning River is the only estuary in NSW that farms oysters in this way)- towing a dredge along estuary floor to collect wide populations of oysters.	A. Impacts from pollutants not quantified	A. Ongoing

[1] A review of environmental factors would be required if changes to entrance management were to be proposed this risk has therefore not been identified for further action at this stage

7. Case Study

Monitoring indicators of ASS remediation, Pipeclay Canal (Big Swamp)

Acid sulfate soils are natural sediments that contain iron sulfides that when disturbed or exposed to air can release acid and other heavy metals, which can have severely damaging effects on aquatic ecosystems.

MidCoast Council is undertaking remediation of a State recognised acid sulfate soil (ASS) hotspot through the staged implementation of the Big Swamp project.

The Big Swamp is a 2000-hectare coastal floodplain at Coralville currently a mix of farmland and remnant coastal wetland, it was once a large wetland that fed into Cattai Creek and supported an extensive array of wildlife, particularly birdlife. It was extensively cleared and drained for agriculture. During the early 1900's a large portion of the Big Swamp was drained under a public works program to 'reclaim' the land for agriculture, but by 1912 the Pipeclay Canal project was declared a failure. An article published in the Sydney Morning Herald reported on its failings and the associated environmental effects, which we now know as acid sulfate soils.

In 1999 the State Government identified twenty-six acid sulfate soil hot spots in NSW, four of which are in the Greater Taree local government area. Leading experts in the field recognise the Cattai Creek-Pipeclay Canal area as one of the worst hot spots in NSW. Acidity in this area has had pH readings as low as 2.4 (in comparison, saltwater has a pH of 8).

The generation and discharge of ASS pollution into the Manning River Estuary has significant adverse impacts on water quality, aquatic ecology, oyster production and commercial and recreational fishing.

With funding provided through the NSW Estuary Management Program and MCC's Environmental Levy, MCC has recently purchased an additional 170 hectares of ASS affected land, building on the 700 hectares of land already acquired and remediated through the project to date.

Remediation activities have included extensive drain modification works such as filling of over 14kms of paddock drains, removal of floodgates and levees and creation of two new tidal swales, to help to reinstate the natural hydrology of the landscape and introduce tidal flows to reduce the

amount of acid runoff entering the River. A long-term water quality and vegetation monitoring program has been established, along with monitoring of a range of environmental indicators on site to determine how successful the project has been and to guide future remediation efforts.

One of these indicators currently being monitored are fish assemblages in Pipeclay Canal and Creek, in the Big Swamp area upstream of the wetlands on Cattai Creek. Commencing in 2017, three sites are surveyed by consultants biannually, with fish species recorded along with basic water quality parameters of temperature, salinity, and pH.

Recent monitoring at one of the sites recorded pH level of 2.6 to 4.4 between tidal periods. Cox's gudegon (*Gobiomorphus coxii)* were recorded during lower acid levels, with a range of other species caught at other sites, including perchlets, sea mullet, gudgeons, prawns and occasionally crabs.

Longer term data collected in such surveys will be important for determining the effectiveness of remediation actions, and help provide insight to otherwise poorly understood ecological response of the lower estuary to acid inputs.

8. Forward Program: Stages 2-4

This forward program for the Manning River Estuary CMP summarises the findings of this scoping study and identifies the actions required to fill the information gaps identified in the gap analysis section of this document (Table 9). Where activities in the gap analysis were identified as immediate they have been included as a key activity and the source of funding identified. High priority information gaps have also been included and these will be addressed during Stage 2 if additional funding can be sourced from OEH Coastal and Estuary Grants Program or other funding sources. In the event that these are not able to be funded during Stage 2, they will become priority actions for funding during plan implementation (Stage 5). It is not yet determined if a planning proposal to amend local or State environmental planning instruments will be required as a result of developing this CMP, therefore the timeframes for developing a planning proposal have not been included here and the timeframes would largely depend on the scope of works.

Table 10: Studies proposed for Stage 2 and CMP Forward Plan

Future Studies / Actions	Why is it needed	How it will be used	Activities (What)	Location (Where)	Responsibility/Partners/ Enablers (Who)	Time frame	Indicative cost	Funding options
Stage 2 - Determine the risks, vulnerabilities and opportunities								
Calibration of ecological health Risk Model (Likelihood & Consequence Datasets)	Agricultural diffuse source runoff is identified as high risk to social, cultural and economic values and moderate - high risk to ecological values. The preliminary ecological health risk model shows rural catchments present high risk to estuary health. Refining	To more accurately identify locations within the catchment placing the greatest pressure on the Manning Estuary. To be able to differentiate the scale / extent of pressures and where they occur in the catchment. To incorporate local socio-economic values into	1. Develop risk maps for TSS, nutrients (TN, TP) inputs. 2. Calibrate landuse intensity layer: overlay livestock numbers with landuse type to determine livestock numbers/ha within agricultural landuse types. Consider parameters to classify intensity	Manning Catchment	MCC with assistance from OEH / consultants	Feb - May 2019	$15K	MCC and OEH Coast & Estuary Grants

Future Studies / Actions	Why is it needed	How it will be used	Activities (What)	Location (Where)	Responsibility/Partners/ Enablers (Who)	Time frame	Indicative cost	Funding options
	models will help to further evaluate which catchments and issues are high risk to inform the management actions in Stage 3.	assessment of consequence into the model. To prioritise the risk of landuse activities on the health of the Manning River Estuary. To identify priority areas in the catchment for managing estuary health. To inform multi-objective spatial planning during stage 3. To inform the development of management actions (treatment types and priority locations) during Stages 3-4.	(e.g. percentile vs local ranking of intensity). 3. Integration of local water quality data from Water Services including nutrients, TSS, pathogens. 4. Inclusion of a pathogens layer as a pressure to socio-economic values. To include data re: risks associated with septic tanks. 5. Incorporate existing ASS data into risk model. 6. Incorporate extent of riparian zone layer (currently under development by Griffith University in collaboration with Hunter LLS). 7. Incorporate cultural values i.e. totems and social values e.g. swimming,					

Future Studies / Actions	Why is it needed	How it will be used	Activities (What)	Location (Where)	Responsibility/Partners/ Enablers (Who)	Time frame	Indicative cost	Funding options
			drinking water into the consequence layer(s) of the model 8. Incorporate ground truthing into model. 9. Update Risk Assessment.					
Ground truthing: Collect field data in high risk catchments	Agricultural diffuse source runoff is identified as high risk to social, cultural and economic values and moderate - high risk to ecological values. The preliminary ecological health risk model shows rural catchments present high risk to estuary health. More accurate field data in high risk subcatchment will help assess type and extent of pressure to calibrate risk model.	To evaluate high risk subcatchments in the field identified in preliminary spatial risk assessment. Identify hotspot areas: type and extent of pressure. To calibrate models with local data. To inform the development of management actions (treatment types and priority locations) during Stages 3-4.	Field assessment to identify subcatchment specific management actions. Field assessment to include measures of bank erosion severity, high level riparian vegetation condition, riparian buffer width and current agricultural management pressures. Incorporate data and finalise Risk model.	High risk Sub - catchments of the Manning Catchment.	MCC. Note: currently exploring options for collaboration with Hunter LLS &/or use of contractors.	March 2019 - August 2019	$30K	MCC and OEH Coast & Estuary Grants

Future Studies / Actions	Why is it needed	How it will be used	Activities (What)	Location (Where)	Responsibility/Partners/ Enablers (Who)	Time frame	Indicative cost	Funding options
Ground truthing: Wetland mapping	Coastal wetlands are under significant threat from multiple pressures, including climate change. To improve understanding of coastal wetland systems in the Manning to enable effective and targeted management. To provide a platform for community conversation re: the role and function of wetlands and ecological and socio-economic values	To inform the development of management actions during stages 3-4. To update SEPP maps during Stage 5.	Wetland mapping across all land tenures, including: • API and field survey to map wetland boundaries • Describe wetland types / vegetation communities / floristics • Assess condition and threats to identify areas to restore, protect, forget and prioritise for CMP actions. • Update SEPP coastal wetland maps.	Coastal wetlands in the Manning catchment	Consultant	Feb 2019 - June 2019	$50k	MCC and OEH Coast & Estuary Grants
Social Science Research: Barriers to Adoption	Despite multiple decades of NRM programs across Australia, the Manning Estuary is still under pressure from diffuse agricultural runoff. Understanding	Social data will be used to inform the development of management actions during stage 2-3 which address barriers to adoption. To inform implantation of the engagement	Undertake social science research focussing on: • Barriers to adoption / change management • Willingness to change	Manning Catchment, targeting of high risk sub - catchments	Social Scientist	March 2019 - Oct 2019	$30k	MCC and OEH Coast & Estuary Grants

Future Studies / Actions	Why is it needed	How it will be used	Activities (What)	Location (Where)	Responsibility/Partners/ Enablers (Who)	Time frame	Indicative cost	Funding options
	social parameters, in particular barriers to adoption is fundamental to the successful implementation of management actions.	strategy.	management practices and drivers of such. • Capacity and willingness of the community to contribute to future costs of management.					
Community & Stakeholder Engagement	To build motivation and confidence to positively influence the health of the Manning River Estuary. We believe that because communities hold local knowledge, observe 'mother nature', and are able to identify management solutions, they are core to the success of the Manning River Estuary And Catchment Management Plan.	Implement Engagement Strategy.	Collaborate with community and stakeholders to define community values, aspirations, using pragmatic optimism questioning. Understand and interpret social science.	Manning River Catchment	MCC	Jan 2019 - Dec 2019	$15k	MCC and OEH Coast & Estuary Grants
High priority projects to source additional funding								

Future Studies / Actions	Why is it needed	How it will be used	Activities (What)	Location (Where)	Responsibility/Partners/ Enablers (Who)	Time frame	Indicative cost	Funding options
Baseline Condition Assessment: a) Estuary health b) Catchment health	To provide a baseline assessment of current condition of the estuary and catchment.	To enable development of potential water quality targets in order to protect, maintain or improve water quality during stage 3-4. To enable change over time to be monitored, thus assess the success of CMP implementation (Stage 5).	a) Estuary Health: Monitor TSS, Chl-a, as per OEH methodology b) Catchment Health: AusRivas, nutrients, Chl-a, reach and riparian condition.	a) Manning River Estuary b) Select sites form upper, mid and lower catchment	OEH under contract	March 2019 - March 2020 [1]	a) $34k b) $120k	OEH Coast & Estuary Grants
Increasing resilience to climate change - wetland systems	Estuarine and floodplain wetlands occupy a landscape position placing them susceptible to sea level rise through inundation, changed salinity or other hydrological changes. The rate of sea level rise may outpace the adaptive capacity of wetland systems. The legacy of wetland loss and the impacts of development and land use in and near	To understand the existing landscape, elevation, geomorphology and hydrology of wetland systems To model the likely sea level change scenarios and describe the anticipated impacts on wetland systems To predict the natural adaptability or resilience of wetland systems. To develop a range of	Define the landscape, elevation, geomorphology and hydrology of each estuarine and floodplain wetland system using existing map-sets, LIDAR data, ground-truthing and other sources Model the likely sea level change scenarios in the context of the mapped wetland systems Predict and describe the likely impacts of sea level rise scenarios on	Coastal wetlands of the Manning catchment	DPIE is currently (2019-20) undertaking research to understand the predicted distribution of mangrove and saltmarsh under three sea level rise scenarios (0.5m, 1.0 and 1.5m on the open coast, noting	June 2019 - June 2020	$70k	MEMA or OEH Coast & Estuary Grants

Future Studies / Actions	Why is it needed	How it will be used	Activities (What)	Location (Where)	Responsibility/Partners/ Enablers (Who)	Time frame	Indicative cost	Funding options
	wetland systems are likely to restrict the ability for wetlands to naturally migrate. There is a need to better understand wetland systems, model the anticipated effects of sea level rise and develop strategies to avoid, mitigate or offset the predicted negative impacts on wetlands and their values.	short, medium and long-term adaptive management responses to ensure that impacts to wetland systems are avoided, mitigated or offset.	wetland systems including wetland loss, wetland change and wetland creation Develop short, medium and long-term adaptive management actions to ensure that impacts to wetland systems from sea level rise is avoided, mitigated or offset (as far as is practicable)		that the amount of SLR will be different at different locations inside the estuary).			

[1]The high priority projects identified here (if able to be funded) will occur outside of Stage 2 timeframes however it is anticipated that they will still be able to inform Stage 3 and 4 and therefore the management actions in the CMP.

Step	Tasks	Lead	Timing	Budget
STAGE 3				
STEP 1: **CONFIRM STRATEGIC DIRECTION**	Confirm spatial boundary of planning areas - Check LEP zonings and tenure from Harrington to Crowdy Head - Check wetland boundaries - Map and write rationale for Manning CMP and OBMP CMP	MCC	End April 2020	
	Stakeholder engagement: Share science Results of Rapid Assessment and Risk Model - Prepare Risk Model technical summary - Present risk model and rapid assessment to external stakeholders (TWG, LLS/Landcare via Skype or Zoom)	MCC	End May 2020	
	Determine if an Emergency Sub-Plan is required - Is there land within a CVA with active erosion, coastal inundation or cliff instability? - Is there an existing, effective emergency plan?	MCC	End May 2020	
	Stakeholder analysis - ADKAR, snowball technique		End May 2020	
	Stakeholder engagement: Community Consultation Vision, issues, opportunities and management options for input to technical consultation Step 2 - One-on-one semi-structured telephone interviews with Reference Group - Total of 3 x focus groups/workshops in priority catchments - Consult stakeholder groups identified in stakeholder analysis - Consult Councillors	MCC & Consultant	End August 2020	$21,750

Step	Tasks	Lead	Timing	Budget
	Stakeholder engagement: Aboriginal consultation Values, sites, issues, actions, priorities - Review MCC Aboriginal Action Plan - Map AHIMS-listed sites in study area - Consult Aboriginal leaders on-country	Consultant	End December 2020 Allows for COVID	$20,000
STEP 2: **IDENTIFY MANAGEMENT OPTIONS** **Use DPOP/IP&R format**	Document & assess existing management approach: - Host MCC skype workshop and prepare flow chart of MCC plans/programs - Review and document management plan's as they intersect with CMP - Consult TWG discussion groups on existing management approaches and MER – what's working, what's not, opportunities and innovation?	MCC TWG	End May 2020	
	Stakeholder Engagement: Technical consultation on Management Options, MER 2 x iterative consultation workshops - Internal MCC Stakeholder Group - Technical Working Group	MCC & Consultant	End Sept 2020	$15,000
	Identify risk and management options for future scenarios - Scope future risk level across time horizons in planning area: coastal inundation, tidal inundation, flood (immediate, 20, 50, 100 years; 0.5, 1, 1.5 m SLR) - Write sections to meet legislative requirement.	Consultant	End Sept 2020	$25,000
STEP 3:	Evaluate Feasibility Legal/technical/engineering/confidence in performance	MCC & Consultant	End Nov 2020	$10,000

Step	Tasks	Lead	Timing	Budget
EVALUATE AND SELECT MANAGEMENT OPTIONS	- TWG, consultant			
	Evaluate Viability: - Rate actions against economic assessment matrix (B3.26). - Economic assessment/CBA/funding mechanisms - Distribution analysis (who pays?)	MCC & Consultant	End Nov 2020	$20,000
	Evaluate Acceptability: Stakeholder Engagement Multi-stakeholder analysis or paired comparison analysis to rank and select preferred options - Reference Group consultation - Community consultation	MCC & Consultant	End Nov 2020	$20,000
	Document Evaluation process - Complete feasibility, viability and acceptability report	Consultant	End Nov 2020	$5,000
	Rank, select and document actions to progress into CMP - Management actions/timeframe/measurable performance criteria	MCC & consultant	End Nov 2020	$5,250
STEP 4: **BUSINESS PLAN**	Document Adaptive Management Pathways - Consider tables: issue, location, action, priority, budget, responsibility, timeframe (short, medium, long-term) - All actions must fit into DPOP/IP&R framework OR Land-use Planning System and public agency planning - ID Thresholds and triggers for change - Plan monitoring program	MCC & Consultant	End Dec 2020	$20,000
	Financial Plan - Capital, operational and maintenance costs of the CMP	Consultant	End Dec 2020	$20,000

Step	Tasks	Lead	Timing	Budget
	- CBA results (from above) - ID how funding will be secured for short, medium and long term actions - Mechanisms for partnership projects: finance, scheduling, delivery			
STEP 5: **SEPP AMENDMENT**	SEPP amendment supporting document for CWLR - Prepare evidence and information that can be forwarded along with a (future) planning proposal to the Minister to inform a Gateway determination under section 3.34 of the EP&A Act - Consult TWG, MCC	MCC NS and Strategic Planning	End Dec 2020	$3,500
STAGE 4				
STEP 6 **WRITE PLAN**	Write/compile the CMP - Section 1 Introduction - Section 2 and appendix: Stakeholder consultation - Section 3 Snapshot of Issues - Section 4 Management Actions - Section 5 SEPP amendment - Section 6 Business Plan (in above contract) - MER Plan - Maps (Include planning area, CM areas, any proposed updates already identified) - Reference List	MCC Consultant	End Jan 2021	$12,250
CONSULTATION	Stakeholder Engagement: Review Document V1	MCC/Consultant	End March	$10,500

Step	Tasks	Lead	Timing	Budget
	- TWG - MCC Internal Stakeholder group - CMP Reference Group - Public agency authorisations - Community - DPIE - Councillors		2021	
STEP 7 **EXHIBITION**	Stakeholder Engagement: Review Document V2 - Communications material - Council Report - Exhibition - Public drop-in days - Submissions Report	MCC	End June 2021	$7,000
FINAL DRAFT ADOPTION	Review and revision - Council Report, adoption	MCC	End Sept 2021	$1,050

Future Actions	Why is it needed	How it will be used	Activities (What)	Where	Who	Time frame	cost	Funding options
Stage 5 - Implement, monitor, evaluate and report								
Implement, monitor, evaluate and report	To maintain, and improve the health of the Manning River Estuary	TBC	TBC	Manning River Catchment and Estuary	TBC	2021-2031	TBC	TBC

Future Actions	Why is it needed	How it will be used	Activities (What)	Where	Who	Time frame	cost	Funding options
Community & Stakeholder Engagement	To build motivation and confidence to positively influence the health of the Manning River Estuary. We believe that because communities hold local knowledge, observe 'mother nature', and are able to identify management solutions, they are core to the success of the Manning River Estuary And Catchment Management Plan.	Implement Engagement Strategy	Report on-ground works Pay attention and monitor the results. Keep community informed on status of management actions	Manning River Catchment and Estuary	TBC	2021-2031	TBC	TBC

9. Appendices

i. Engagement Strategy, including Roles and Responsibilities

See attached document.

ii. Risk Assessment (used to inform Gap Analysis)

Risk No.	Project Component	Risk name	Risk description	Causes of risk	Financial	People	Servi	Comp	Environme	Reputation	Project B	Project Tin	Highest Risk	Inherent Conse	Inherent Likelihoo	INHERENT F	Existing key controls	Control effectiveness	Residual Conse	Residual Likelih	RESIDUAL RI	Proposed risk treatment	Responsible Offi
Allocate a number to each risk	You may group your risks in line with project components, such as Project Management; Funding; Approvals; Procurement; Contractors; etc This is optional.	What could happen to impact your ability to successfully achieve your project objectives? Example: Poor overall project management	What are the consequences of the risk occurring? Example: Poor overall project management leads to errors, omissions, delays, missed opportunities, poor outcomes, substandard construction, additional costs, damage to reputation	How could the risk to occur? Example: Lack of staff resources; inadequate staff accountability; insufficient staff skill for project type This list is not expected to be exhaustive.	*Risks that have a financial impact on the organisation (revenue, expenses, assets, liabilities, reserves)* *(Tick applicable risk consequences - refer attached Risk Assessment Criteria - click on paperclip to left of row)*	*Risks that impact the safety and wellbeing of staff and the community*	*Risks that impact the ability to deliver internal / external services and/or the expected level of service delivery*	*Risks that impact compliance with legislation and regulatory requirements*	*Risks that impact the natural environment*	*Risks that impact Council's reputation with the community, media & government*	*Risks that impact the ability to deliver project outcomes within budget*	*Risks that impact the ability to deliver project outcomes within timeframe*	1. From the drop down list, select the consequence which has the highest rating for the risk being assessed 2. Rate the risk in the next columns using Council's attached Risk Assessment Criteria	Rate the highest risk consequence - before controls are in place: 1 = Insignificant 2 = Minor 3 = Moderate 4 = Major 5 = Catastrophic	Rate the risk likelihood - before controls are in place: 1 = Rare 2 = Unlikely 3 = Possible 4 = Likely 5 = Almost Certain	Do not type in this field. The risk rating will automatically calculate	List processes, systems, plans, etc. currently in place to reduce the risk. Type one control per row (insert rows as required)	1. Using the attached Risk Assessment Criteria, select from the drop down list how effective the existing controls are (on a whole) at reducing the risk. 2. Re-rate the risk in the next columns with consideration of control effectiveness	Re-rate the highest risk consequence - after controls are in place: 1 = Insignificant 2 = Minor 3 = Moderate 4 = Major 5 = Catastrophic	Re-rate the risk likelihood - after controls are in place: 1 = Rare 2 = Unlikely 3 = Possible 4 = Likely 5 = Almost Certain	Do not type in this field. The risk rating will automatically calculate	What controls do you need to implement or improve to reduce the risk? Type one risk treatment per row (insert rows as required)	Who will be responsible to implement / monitor the proposed risk treatment?
R001A	Agricultural diffuse source run-off: Nutrients	Environment	Elevated nutrients in the Manning River and estuary, causing excess macrophyte and algal growth, declines in water quality and seagrass extent and condition Decline in health of aquatic biodiversity quality and extent, including macro	Excess fertilizer use Farm effluent used on pasture Dairy and other effluent direct inputs to waterways Lack of effluent management Stock in waterways	TRUE	TRUE			TRUE				Environmental	3	5	High	Limited number of dairy effluent plans in lower Manning Pelican Bay study and remediation works LLS Extension Program	Somewhat effective	3	5	High	Need to fill knowledge gaps relating to: Overall ecological response (model) of the estuary, including specific species, eg fish & associated habitats, collection of data to ascertain estuary health trends, where management response is required.	Manning CMP process, stakeholders in Manning
R001B		Social				TRUE							People	3	5	High		Somewhat effective	3	5	High		
R001C		Economic			TRUE								Financial	3	5	High		Somewhat effective	3	5	High		
R002A	Agricultural diffuse source run-off: Sediments	Environment	Diffuse runoff from agriculture contributes sediment, leading to elevated turbidity in estuary, sedimentation, reduction in seagrass productivity, available habitats	Stock in waterways Clearing of riparian and adjacent vegetation Forestry Run off from non-perennial pastures		TRUE			TRUE				Environmental	3	5	High	Limited number of dairy effluent plans in lower Manning Pelican Bay study and remediation works LLS Extension Program						
R002B		Social				TRUE							People	4	5	Extreme		Ineffective	4	5	Extreme		
R002C		Economic			TRUE								Financial	4	5	Extreme							
R003A	Agricultural diffuse source run-off: Pathogens (e.g. E coli)	Environmental	Current practices associated with the management of effluent	Run off of manures, irrigating pasture with effluent, stock in					TRUE				Environmental	2	3	Medium	MCC Water Services monitoring	dairy effluent plans for selected proper	2	3	Medium		
R003B		Social	Potential to reduce social values (eg. swimming) due to contamination of estuary	waterways		TRUE			TRUE				People	5	4	Extreme		Somewhat effective	5	3	High		
R003C		Economic			TRUE								Financial	4	3	High			4	3	High		
R004A	Agricultural diffuse source run-off: Pesticides & chemicals	Environment	Diffuse runoff of pesticides and herbicides	Current farm and forestry practices					TRUE				Environmental	3	3	Medium			3	3	Medium		
R004B		Social				TRUE							People	3	3	Medium			3	3	Medium		
R004C		Economic			TRUE								Financial	2	3	Medium			2	3	Medium		
R005A	Stock in riparian and marine vegetation	Environment							TRUE				Environmental	4	4	High	Some fencing works being undertaker	Somewhat effective	4	4	High		
R005B		Social				TRUE							People	3	4	High			3	4	High		
R005C		Economic			TRUE								Financial	3	4	High							
R006A	Urban stormwater discharge	Environment				TRUE			TRUE				Environmental	2	4	Medium		Somewhat effective	3	3	Medium		
R006B		Social				TRUE							People	3	4	High			3	4	High		
R006C		Economic			TRUE								Financial	3	4	High			3	4	High		
R007A	Floodplain drainage (ASS)	Environment	Extensive acid sulphate runoff across the floodplain.						TRUE				Environmental	5	4	Extreme	Drainage prescriptions included as a p	Effective	4	3	High		
R007B		Social				TRUE							People	4	4	High			4	4	High		
R007C		Economic			TRUE								Financial	4	3	High			4	4	High		
R008A	Clearing and degradation of riparian vegetation and adjacent habitat	Environment							TRUE				Environmental	5	4	Extreme			5	4			
R008B		Social				TRUE							People	4	3	High			4	3			
R008C		Economic			TRUE								Financial	4	3	High			4	3			
R009A	Clearing and degradation of vegetation within the catchment and estuary including coastal wetlands	Environment							TRUE				Environmental	5	4	Extreme	Coastal Management Act (2016) planning protection on coastal wetlar		5	4			
R009B		Social				TRUE							People	3	4	High			3	4			
R009C		Economic			TRUE								Financial	2	4	Medium			2	4			
R010A	Modified hydrology/hydraulics and flow regime, Modified freshwater flows	Environment	Affect on hydrology of climate change (altered flows) and extractions	Entrance opening modifies salinity / freshwater exchange in the estuary, water licenses for extraction, climate change					TRUE				Environmental	4	4	High	Water sharing plans	Somewhat effective	4	3			
R010B		Social				TRUE							People	4	4	High			4	4			
R010C		Economic			TRUE								Financial	3	4	High			3	4			
R011A	Unsealed Roads	Environment	Run-off of sediment from unsealed roads causing impaired water quality within estuary (high turbidity in high flow periods	Unsealed road crossings increase turbidity significantly locally during wet weather					TRUE				Environmental	3	4	High	Sediment and erosion management training provided to Council staff in the past Some mapping of unsealed roads intersecting stream crossings in Greater Taree	Ineffective	3	4			
R011B		Social				TRUE							People	2	3	Medium			2	3			
R011C		Economic			TRUE								Financial	2	3	Medium			2	3			
R012A	Climate change stressors 20 year timeframe	Environment	Increased intensity of rainfall and runoff by 2050. Warming climate. Sea level rise. Impacts on highly vulnerable coastal wetlands	Human-induced climate change, greenhouse gas					TRUE				Environmental	4	5	Extreme	Regional climate change modelling	Ineffective	4	4			

Risk No.	Project Component	Risk name	Risk description	Causes of risk	Financial	People	Servi	Comp	Environme	Reputation	Project B	Project Tin	Highest Risk	Inherent Conse	Inherent Likelihoo	INHERENT F	Existing key controls	Control effectiveness	Residual Conse	Residual Likelih	RESIDUAL RI	Proposed risk treatment	Responsible Offi
Allocate a number to each risk	You may group your risks in line with project components, such as Project Management; Funding; Approvals; Procurement; Contractors; etc This is optional.	What could happen to impact your ability to successfully achieve your project objectives? Example: Poor overall project management	What are the consequences of the risk occurring? Example: Poor overall project management leads to errors, omissions, delays, missed opportunities, poor outcomes, substandard construction, additional costs, damage to reputation	How could the risk to occur? Example: Lack of staff resources; inadequate staff accountability; insufficient staff skill for project type This list is not expected to be exhaustive.	*Risks that have a financial impact on the organisation (revenue, expenses, assets, liabilities, reserves)* *(Tick applicable risk consequences - refer attached Risk Assessment Criteria - click on paperclip to left of row)*	*Risks that impact the safety and wellbeing of staff and the community*	*Risks that impact the ability to deliver internal / external services and/or the expected level of service delivery*	*Risks that impact compliance with legislation and regulatory requirements*	*Risks that impact the natural environment*	*Risks that impact Council's reputation with the community, media & government*	*Risks that impact the ability to deliver project outcomes within budget*	*Risks that impact the ability to deliver project outcomes within timeframe*	1. From the drop down list, select the consequence which has the highest rating for the risk being assessed 2. Rate the risk in the next columns using Council's attached Risk Assessment Criteria	Rate the highest risk consequence - before controls are in place: 1 = Insignificant 2 = Minor 3 = Moderate 4 = Major 5 = Catastrophic	Rate the risk likelihood - before controls are in place: 1 = Rare 2 = Unlikely 3 = Possible 4 = Likely 5 = Almost Certain	Do not type in this field. The risk rating will automatically calculate	List processes, systems, plans, etc. currently in place to reduce the risk. Type one control per row (Insert rows as required)	1. Using the attached Risk Assessment Criteria, select from the drop down list how effective the existing controls are (on a whole) at reducing the risk. 2. Re-rate the risk in the next columns with consideration of control effectiveness	Re-rate the highest risk consequence - after controls are in place: 1 = Insignificant 2 = Minor 3 = Moderate 4 = Major 5 = Catastrophic	Re-rate the risk likelihood - after controls are in place: 1 = Rare 2 = Unlikely 3 = Possible 4 = Likely 5 = Almost Certain	Do not type in this field. The risk rating will automatically calculate	What controls do you need to implement or improve to reduce the risk? Type one risk treatment per row (Insert rows as required)	Who will be responsible to implement / monitor the proposed risk treatment?
R012B		Social				TRUE							People	4	4	High			4	4			
R012C		Economic			TRUE								Financial	5	4	Extreme			4	4			
R013A	Sewage effluent and septic runoff	Environment	Pathogens e.g. E coli within catchment and estuary	Septic tanks leaking/not functioning, runoff					TRUE				Environmental	3	3	Medium	MCC currently undertaking risk assess	Somewhat effective	2	3			
R013B		Social				TRUE					TRUE		People	4	3	High			3	3			
R013C		Economic			TRUE								Financial	4	3	High			3	3			
R014A	Foreshore development	Environment	Projections for future growth within coastal localities	Projections for future growth within coastal localities					TRUE				Environmental	3	2	Medium	Neutral or beneficial effect applied to r	Somewhat effective	2	3			
R014B		Social				TRUE							People	2	2	Low	DCPs in former GTCC						
R014C		Economic			TRUE								Financial	2	2	Low							
R015A	Pests and diseases	Environment	Introduced plants, animals and diseases are present throughout the catchment and estuary, incl. deer, pigs, European fox, Indian mynah, gambusia, goldfish	Introduced species predating, competing, displacing native species, altering ecosystems					TRUE				Environmental	4	4	High	MCC biosecurity (weeds) program for high priority weeds Control progra		3	4	High		
R015B		Social				TRUE							People	3	3	Medium		Somewhat effective	3	3	Medium		
R015C		Economic			TRUE								Financial	3	2	Medium			3	2	Medium		
R016A	Water pollution on environmental values - litter, solid waste, marine debris and microplastics	Environment	Physical waste and pollutants including litter, solid waste, marine debris and microplastics	Potential sources of contaminants, include urban areas, tourism sites, agriculture etc					TRUE				Environmental	3	3	Medium	Some gross pollutant traps in Taree Cle	Somewhat effective	2	3	Medium		
R016B		Social				TRUE							People	3	4	High			3	3	Medium		
R016C		Economic											Financial	3	3	Medium			3	3	Medium		
R017A	Commercial fishing - estuary prawn haul, estuary general	Environment							TRUE				Environmental	3	4	High	DPI regulations: risk to stocks managed with controls/regulations in place	Somewhat effective	3	3	Medium		
R017B		Social				TRUE							People	3	4	High			3	4	High		
R017C		Economic			TRUE								Financial	3	4	High			3	4	High		
R018A	Recreational fishing - shore and boat based line and trap fishing, hand gathering	Environment		Illegal or excessive take Inadequate/adequate regulation Limited/lack of access Infrastructure leading to Inappropriate access, environmental degradation Water and other pollution Impacting environmental values (litter, solid waste, marine debris) Boat wash erosion Impacting sections of river and estuary, eg Lansdowne					TRUE				Environmental	4	2	Medium	Manning River estuary designated as a Recreational Fishing Haven, o		4	2	Medium		
R018B		Social				TRUE							People	3	2	Medium			3	2	Medium		
R018C		Economic			TRUE								Financial	3	2	Medium			3	2	Medium		
R019A	Oyster aquaculture (in estuaries	Environment	Oyster leases, infrastructure, operations	Infrastructure past, present and future in shallow areas of estuary and on land base Land-based impacts from occupancy of waterfront land for farming operations & storage of cultivation Infrastructure and associated equipment Disturbance of sediments through deep water oyster harvesting Fuel or oil spills Wash from oyster punts travelling					TRUE				Environmental	3	2	Medium	Environmental Management System for Manning River Oyster Farmer		3	2	Medium		
R019B		Social				TRUE							People	2	2	Low			2	2	Low		
R019C		Economic			TRUE								Financial	2	2	Low			2	2	Low		
R020A	Shipping -small commercial vessels	Environment	Small commercial vessels, limited in estuary	Fuel/oil spills, boat wash, wildlife interactions/strikes					TRUE				Environmental	3	1	Low	RMS regulations	Effective	3	1	Low		
R020B		Social				TRUE							People	2	2	Low			1	2	Low		
R020C		Economic			TRUE								Financial	2	1	Low			2	1	Low		
R021A	Oil, gas, minerals, sand, aggregate, coal mining	Environment	Coal mining, sand mining	Coal mining and proposed mining in middle and upper catchment, risk assessed through local studies					TRUE				Environmental	3	2	Medium	EPA regulations, EIS		3	2	Medium		
R021B		Social				TRUE							People	2	2	Low			2	2	Low		
R021C		Economic			TRUE								Financial	2	1	Low			2	1	Low		
R022A	Pipelines, cables, trenches and boring	Environment							TRUE				Environmental	2	2	Low			2	2	Low		
R022B		Social				TRUE							People	1	1	Low			1	1	Low		
R022C		Economic			TRUE								Financial	1	1	Low			1	1	Low		

Risk No.	Project Component	Risk name	Risk description	Causes of risk	Financial	People	Servi	Comp	Environme	Reputation	Project B	Project Tin	Highest Risk	Inherent Conse	Inherent Likelihoo	INHERENT R	Existing key controls	Control effectiveness	Residual Conse	Residual Likelih	RESIDUAL Ri	Proposed risk treatment	Responsible Offi
Allocate a number to each risk	You may group your risks in line with project components, such as Project Management; Funding; Approvals; Procurement; Contractors; etc This is optional.	What could happen to impact your ability to successfully achieve your project objectives? Example: Poor overall project management	What are the consequences of the risk occurring? Example: Poor overall project management leads to errors, omissions, delays, missed opportunities, poor outcomes, substandard construction, additional costs, damage to reputation	How could the risk to occur? Example: Lack of staff resources; inadequate staff accountability; insufficient staff skill for project type This list is not expected to be exhaustive.	*Risks that have a financial impact on the organisation (revenue, expenses, assets, liabilities, reserves)* *(Tick applicable risk consequences - refer attached Risk Assessment Criteria - click on paperclip to left of row)*	*Risks that impact the safety and wellbeing of staff and the community*	*Risks that impact the ability to deliver internal / external services and/or the expected level of service delivery*	*Risks that impact compliance with legislation and regulatory requirements*	*Risks that impact the natural environment*	*Risks that impact Council's reputation with the community, media & government*	*Risks that impact the ability to deliver project outcomes within budget*	*Risks that impact the ability to deliver project outcomes within timeframe*	1. From the drop down list, select the consequence which has the highest rating for the risk being assessed 2. Rate the risk in the next columns using Council's attached Risk Assessment Criteria	Rate the highest risk consequence - before controls are in place: 1 = Insignificant 2 = Minor 3 = Moderate 4 = Major 5 = Catastrophic	Rate the risk likelihood - before controls are in place: 1 = Rare 2 = Unlikely 3 = Possible 4 = Likely 5 = Almost Certain	Do not type in this field. The risk rating will automatically calculate	List processes, systems, plans, etc. currently in place to reduce the risk. Type one control per row (insert rows as required)	1. Using the attached Risk Assessment Criteria, select from the drop down list how effective the existing controls are (on a whole) at reducing the risk. 2. Re-rate the risk in the next columns with consideration of control effectiveness	Re-rate the highest risk consequence - after controls are in place: 1 = Insignificant 2 = Minor 3 = Moderate 4 = Major 5 = Catastrophic	Re-rate the risk likelihood - after controls are in place: 1 = Rare 2 = Unlikely 3 = Possible 4 = Likely 5 = Almost Certain	Do not type in this field. The risk rating will automatically calculate	What controls do you need to implement or improve to reduce the risk? Type one risk treatment per row (insert rows as required)	Who will be responsible to implement / monitor the proposed risk treatment?
R023A	Wildlife interactions (eg, shark bite, boat strikes, jellyfish)	Environment											Environmental	2	2	Low			2	2	Low		
R023B		Social				TRUE			TRUE				People	2	2	Low			2	2	Low		
R023C		Economic			TRUE								Financial	1	2	Low			1	2	Low		
R024A	Population growth	Environment	Increased pressure - system functions and the possible localised and downstream impacts of reduced flow and declining water quality in modifying system functions and associated aquatic communities										Environmental	3	4	High	DCP in former GTCC		3	4	High		
R024B		Social											People	2	3	Medium			2	3	Medium		
R024C		Economic											Financial	2	3	Medium			2	3	Medium		
R025A	Excessive or illegal extraction	Environment							TRUE				Environmental	3	2	Medium			3	2	Medium		
R025B		Social				TRUE							People	1	2	Low			1	2	Low		
R025C		Economic			TRUE								Financial	1	2	Low			1	2	Low		
R026A	Entrance modifications, including dredging, permanent entrance training	Environment	Ecological impacts of permanently opening the entrance of the estuary and the change in the salt wedge	Permanent entrance opening, sand dredging					TRUE				Environmental	4	5	Extreme	Farquhar entrance opening plan, REFs		4	4	High		
R026B		Social				TRUE							People	2	3	Medium			2	3	Medium		
R026C		Economic			TRUE								Financial	2	3	Medium			2	3	Medium		

iii. MCC Risk Assessment Criteria

MIDCOAST council

RISK ASSESSMENT CRITERIA

This is the Risk Assessment Criteria included in Council's draft Risk Management Framework as at 02/07/18. The Criteria is to be used for the assessment of organisational and operational risks until such time as the Framework is adopted, at which time the Criteria will be updated to reflect any required amendments.

Contact Council's Manager Governance for further assistance.

Table 1: Risk Consequence Rating (Water Services to refer to Table 1a for operational risk assessments)

Risk Categories What could be the consequences if the risk occurs?			Consequence Rating				
			Insignificant	Minor	Moderate	Major	Severe
			1	2	3	4	5
ORGANISATIONAL & OPERATIONAL *(except refer Table 1a for Water Services Operational risk consequence rating criteria)*	Financial	Risks that have a financial impact on the organisation (revenue, expenses, assets, liabilities, reserve)	Negligible financial loss < $10,000	Minor financial loss $10,000 - $100,000	Substantial financial loss $100,000 - $500,000	Significant financial loss $500,000 - $3million	Major financial loss >$3million
	Worker health & wellbeing	Risks that impact the health and safety of staff, as well as contractors & volunteers	Insignificant injury; no first aid required; no impact on staff morale / performance	Minor injury; first aid required; minor impact on individual staff morale / performance	Injury or illness requiring medical attention; several days leave; short term impact on staff morale / performance	Long term illness or injury; extensive medical attention and leave required; medium term impact on staff morale/ performance within multiple business areas	Fatality; permanent disability, illness or disease; long term impact on staff morale/performance across organisation
	Public health & wellbeing	Risks that impact the health and safety of the community	Insignificant injury; no medical treatment required	Short term isolated incidents of illness or injury; first aid required	Medium term illness or injury; medical attention required; health impacts in single Council locality	Long term illness or injury; long term medical attention required; health impacts in multiple Council localities	Fatality; permanent disability; illness or disease; widespread health impacts across LGA
	Service delivery & infrastructure	Risks that impact the ability to deliver internal and external services (includes assets and technology)	Isolated, insignificant impact on service delivery; minimal inconvenience to customers	Short term minor impact on service delivery; some inconvenience & customer dissatisfaction	Medium term disruption to delivery of several services; moderate inconvenience & increased customer dissatisfaction	Long term disruption to delivery of several services, incl. some key services; significant inconvenience & high level customer dissatisfaction	Ongoing inability to deliver key services; widespread customer dissatisfaction; threat to viability of organisation
	Compliance	Risks that impact compliance with legislation and regulatory requirements	Isolated non-compliance of minimal significance; minor fine; internal staff warning	Minor breach of legal obligations; improvement notice; minor fine / penalty	Substantial breach of legal obligations; adverse finding; substantial fine / penalty	Significant breach of legal obligations; adverse finding with long term significance; significant fine / penalty	Major breach of legal obligations; adverse findings against Council and / or individuals; major fines or penalties (>$mil); possible imprisonment; dismissal of Council
	Environment	Risks that impact the natural environment	Insignificant, immediately reversible impacts on the environment	Limited short to medium term, quickly reversible impacts on the environment	Potentially significant medium term reversible impacts on the environment	Severe, medium to long term potentially irreversible impacts on the environment	Critical, long term irreversible impacts on the environment
	Reputation	Risks that impact Council's reputation in the community and media, as well as with the government	Isolated complaints from members of the community; one off insignificant enquiries from local media and/or on social media	Minor unfavourable local and/or social media attention; heightened concern and criticism from narrow group/s within the community	Short-term adverse local and / or social media attention; moderate community dissatisfaction; potential government agency concern	Significant adverse local / state media attention; public outcry and community dissatisfaction across multiple Council localities; potential government agency enquiry	Sustained adverse local, state and/or national media attention; severe widespread dissatisfaction and loss of community trust; potential loss of Government support and adverse intervention
PROJECT	Project Budget	Risks that impact the ability to deliver project outcomes within budget	Insignificant impact on budget manageable within allocated budget	Marginal budget over-run; manageable within contingency funding	Substantial budget over-run requiring additional funding and/or resources	Significant budget over-run requiring allocation of significant funding and resources	Critical budget over-run; threat to viability of project
	Project Timeframe	Risks that impact the ability to deliver project outcomes within timeframe	Insignificant impact on project milestones	Marginal impact on project milestones, manageable within resources	Substantial impact on project milestones; potential impact project delivery date	Critical impact on project milestones; requiring review of implementation date	Major over-run affecting many milestones; threat to ability to deliver critical project outcomes on time

Table 1a: Water Services - Risk Consequence Rating (to be used for Water Services operational risk assessments)

	Risk Categories What could be the consequences if the risk occurs?		Consequence Rating				
			Insignificant	Minor	Moderate	Major	Severe
			1	2	3	4	5
WATER SERVICES - OPERATIONAL RISK ASSESSMENTS	Financial	Risks that have a financial impact on the organisation (revenue, expenses, assets, liabilities, reserve)	Negligible financial loss < $10,000	Minor financial loss $10,000 - $100,000	Substantial financial loss $100,000 - $500,000	Significant financial loss $500,000 - $3million	Major financial loss >$3million
	Worker health & wellbeing	Risks that impact the health and safety of staff, as well as contractors & volunteers	Insignificant injury; no first aid required; no impact on staff morale / performance	Minor injury; first aid required; minor impact on individual staff morale / performance	Injury or illness requiring medical attention; several days leave; short term impact on staff morale / performance	Long term illness or injury; extensive medical attention and leave required; medium term impact on staff morale/ performance within multiple business areas	Fatality; permanent disability, illness or disease; long term impact on staff morale/performance across organisation
	Public health & wellbeing	Risks that impact the health and safety of the community	Results indicating poor performance leading to non-conformance. No effect on public health	Some customers (neighbouring households) exposed to contaminated drinking water	Customers in multiple streets within a suburb/town exposed to contaminated drinking water or sewage	Illness affecting customers in many streets within a suburb/ town attributable to drinking water contamination or sewage exposure	One or more fatalities and/or a widespread illness (multiple suburbs/towns) attributable to drinking water contamination or sewage exposure
	Service delivery & infrastructure (Services & Supply)	Risks that impact the ability to deliver internal and external services / supply (includes assets and technology)	Continuity Supply: disruption to an individual customer for 4 hours: OR Continuity of operations: insignificant and/or short term (days) effects on an element of operations	Continuity Supply: disruption to multiple customers (approx. 20 neighbouring households) for 4 hours; OR Continuity of operations: minor and/or short term (days) effects on an element of operations	Continuity Supply: disruption to multiple of customers (many streets) for 4 hours; OR Continuity of operations: moderate and/or short-medium term (weeks/months) effects on an element of operations	Continuity Supply: disruption to <5% of customers for 4 hours; OR Continuity of operations: major and/or medium term (weeks) effects on an element of operations	Continuity Supply: disruption to >5% of customers for 4 hours; OR Continuity of operations: Long term (months) effects on an element of operations
	Compliance	Risks that impact compliance with legislation and regulatory requirements	Isolated non-compliance of minimal significance; minor fine; internal staff warning	Minor breach of legal obligations; improvement notice; minor fine / penalty	Substantial breach of legal obligations; adverse finding; substantial fine / penalty	Significant breach of legal obligations; adverse finding with long term significance; significant fine / penalty	Major breach of legal obligations; adverse findings against Council and / or individuals; major fines or penalties (>$mil); possible imprisonment; dismissal of Council
	Environment	Risks that impact the natural environment	Insignificant, immediately reversible impacts on the environment	Limited short to medium term, quickly reversible impacts on the environment	Potentially significant medium term reversible impacts on the environment	Severe, medium to long term potentially irreversible impacts on the environment	Critical, long term irreversible impacts on the environment
	Reputation	Risks that impact Council's reputation in the community and media, as well as with the government	Isolated complaints from members of the community; one off insignificant enquiries from local media and/or on social media	Minor unfavourable local and/or social media attention; heightened concern and criticism from narrow group/s within the community	Short-term adverse local and / or social media attention; moderate community dissatisfaction; potential government agency concern	Significant adverse local / state media attention; public outcry and community dissatisfaction across multiple Council localities; potential government agency enquiry	Sustained adverse local, state and/or national media attention; severe widespread dissatisfaction and loss of community trust; potential loss of Government support and adverse intervention
PROJECT	Project Budget	Risks that impact the ability to deliver project outcomes within budget	Insignificant impact on budget manageable within allocated budget	Marginal budget over-run; manageable within contingency funding	Substantial budget over-run requiring additional funding and/or resources	Significant budget over-run requiring allocation of significant funding and resources	Critical budget over-run; threat to viability of project
	Project Timeframe	Risks that impact the ability to deliver project outcomes within timeframe	Insignificant impact on project milestones	Marginal impact on project milestones, manageable within resources	Substantial impact on project milestones; potential impact project delivery date	Critical impact on project milestones; requiring review of implementation date	Major over-run affecting many milestones; threat to ability to deliver critical project outcomes on time

Table 2: Risk Likelihood Rating

Likelihood Rating		Description	Estimated Probability
Almost Certain	5	The event is expected to occur in most circumstances in the current environment; frequent past event history	>90%
Likely	4	The event will probably occur in most circumstances in the current environment; some recurring past event history	61-90%
Possible	3	The event might occur at some time; some past warning signs or previous event history	21-60%
Unlikely	2	The event could occur at some time, no event history	2-20%
Rare	1	The event may occur but only in exceptional circumstances; no past event history	<2%

Table 3: Control Effectiveness Rating

Effectiveness Rating	Description
Effective	Control is mostly reliable, efficient and effective; will significantly reduce the risk likelihood and/or consequences; fully documented processes and well communicated.
Somewhat effective	Control is somewhat effective; will have some effect on reducing risk likelihood and/or consequences; additional action required to improve existing controls and/or possibly implement some additional controls; improved documentation and/or communication of controls required.
Ineffective	Control is not reliable, efficient or effective; will not reduce the risk likelihood and/or consequence; reliable, effective and efficient controls to be developed and implemented; controls need to be documented and communicated.

Table 4: Risk Rating Matrix

Risk Rating = Likelihood Rating x Consequence Rating

		Risk Consequence Rating				
Risk Likelihood Rating		Insignificant	Minor	Moderate	Major	Severe
		1	2	3	4	5
Almost Certain	5	Medium (5)	High (10)	High (15)	Extreme (20)	Extreme (25)
Likely	4	Medium (4)	Medium (8)	High (12)	High (16)	Extreme (20)
Possible	3	Low (3)	Medium (6)	Medium (9)	High (12)	High (15)
Unlikely	2	Low (2)	Low (4)	Medium (6)	Medium (8)	High (10)
Rare	1	Low (1)	Low (2)	Low (3)	Medium (4)	Medium (5)

Table 5: Preferred Risk Treatment Options (including ALARP)

Residual Risk Rating	Preferred Risk Treatment Options	Minimum reporting / escalation level for decision to cease activity, continue activity or take other necessary actions
Extreme	**Preferred treatment options: Avoid** → Cease activity, process or task until further directed. → Requires immediate escalation and active management through additional and effective treatment measures to reduce risk before proceeding. → Detailed planning required in consultation with the Director (and/or MANEX/GM) to prepare a risk management plan.	**Director** (escalate MANEX / GM as deemed necessary)
High	**Preferred Treatment Options: Avoid, Transfer or Mitigate** → Subject to discussions with Manager (and/or Director), consider ceasing activity, process or task temporarily to consider alternative options or review risk treatment strategies to enhance adequacy and effectiveness. → Consider implementation of additional or improved controls to reduce the risk to ALARP. → Continue to monitor control effectiveness.	**Manager** (escalate to Director as deemed necessary)
Medium	**Preferred Treatment Options: Mitigate or Accept** → Subject to discussions with Supervisor, Co-ordinator or Team Leader (and/or Manager), review risk treatment strategies to determine their adequacy and effectiveness. → Consider implementation of additional or improved controls to reduce the risk to ALARP. → Continue to monitor control effectiveness.	**Supervisor, Co-ordinator or Team Leader** (escalate to Manager as deemed necessary)
Low	**Preferred Treatment Options: Accept and identify corrective action** → Manage by existing routing procedures and work practices. → Continue to monitor control effectiveness.	**Responsible staff** (escalate as deemed necessary)

ALARP - As Low As Reasonably Practicable

ALARP involves weighing the benefits and opportunities to be gained from managing the risk and continuing with the proposed activity against the effort, time and resources needed to control the risk.

When determining if additional treatment options should be implemented, consideration should be given to the level of risk that would remain if additional controls were implemented.

- **Unacceptable** - where the cost or resource required to implement further risk treatment is grossly disproportionate to the risk control improvement gained, a decision should be made to cease the activity altogether or find an alternative course of action (except in cases where overriding factors mean there is no choice but to implement the identified additional control measures).
- **Acceptable** - **ALARP** - *aim for this level of risk treatment* - where the cost, resources and effort required to implement additional risk treatment is acceptable and worthwhile given the risk control improvement gained and resulting benefits achieved from continuing with the activity, operation or project being assessed.

iv. Spatial Risk Assessment: Limitations and Scientific Rigour

Where possible, the model outcomes have been tested with independent data. Figure 19 provides an example of this independent data testing. The independent data were sourced from more recent monitoring of estuaries in NSW, undertaken by the Estuaries and Catchments Team of OEH, and/or modelled data from independent modelling supplied by some Councils (and their contractors).

It is important to note that only relative spatial trends should be inferred from the maps given that the models underpinning the maps were intentionally developed to allow a first pass assessment only.

OEH has a scientific rigour policy, which requires that all published works are reviewed by independent subject matter experts. To ensure that requirements are met, the following were reviews were conducted:

- Method for developing and using 1D-Branched Models was independently reviewed by a subject matter expert at OEH
- Method for developing and using catchment export coefficient models has been published (and hence reviewed) in a conference paper and an OEH report (Roper *et al*., 2011)
- NSW Estuary Health Monitoring, including indicators for estuary health, has been reviewed in an international journal (Hallett *et al*., 2016)
- Method for the risk analysis is consistent with other risk analyses undertaken for the state's waterways (Healey *et al*., 2012), and independently reviewed by subject matter experts in the Department of Primary Industries – Water (now Department of Industry – Crown Lands and Water) and the Victorian Environment Protection Authority.

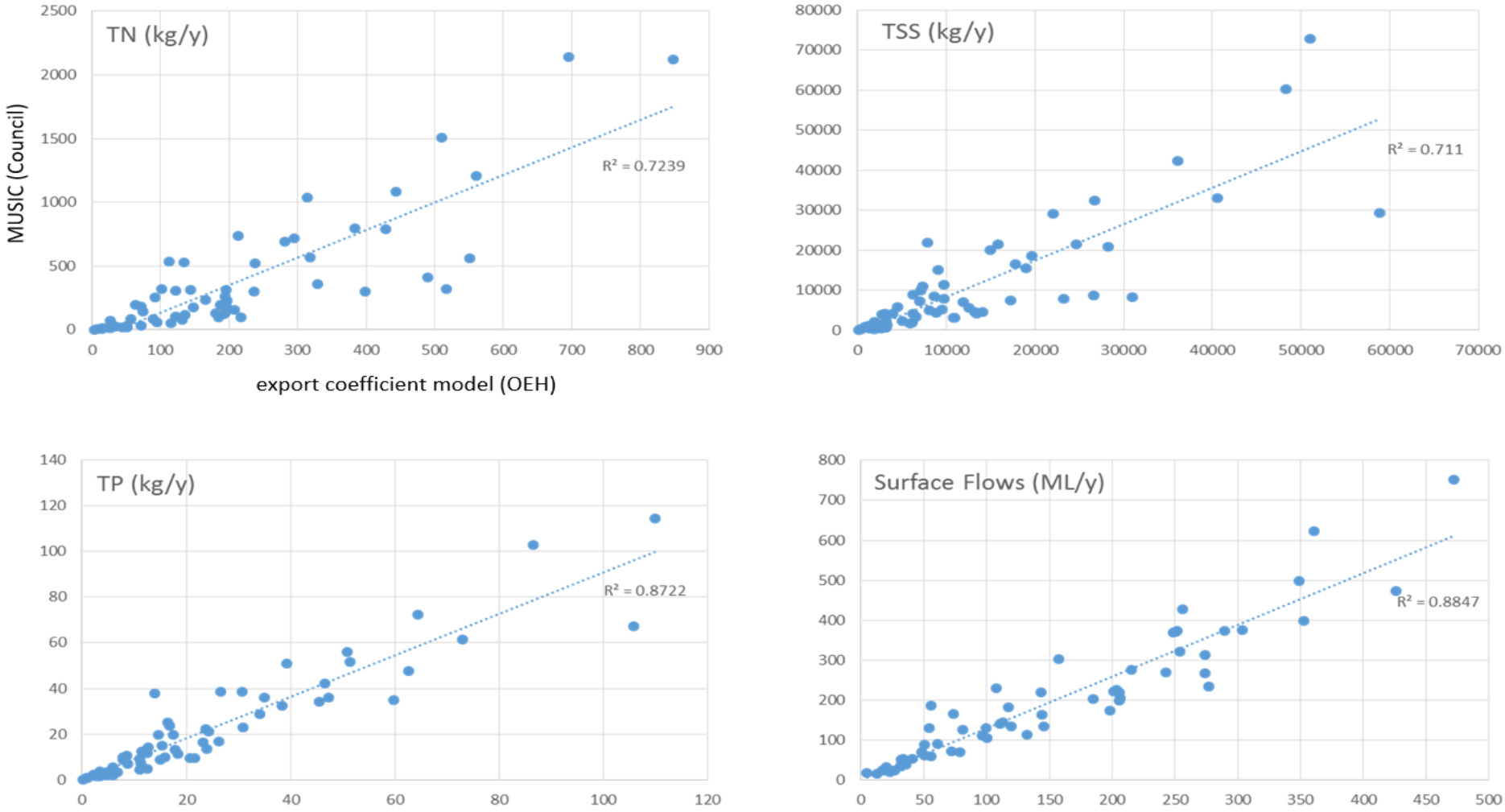
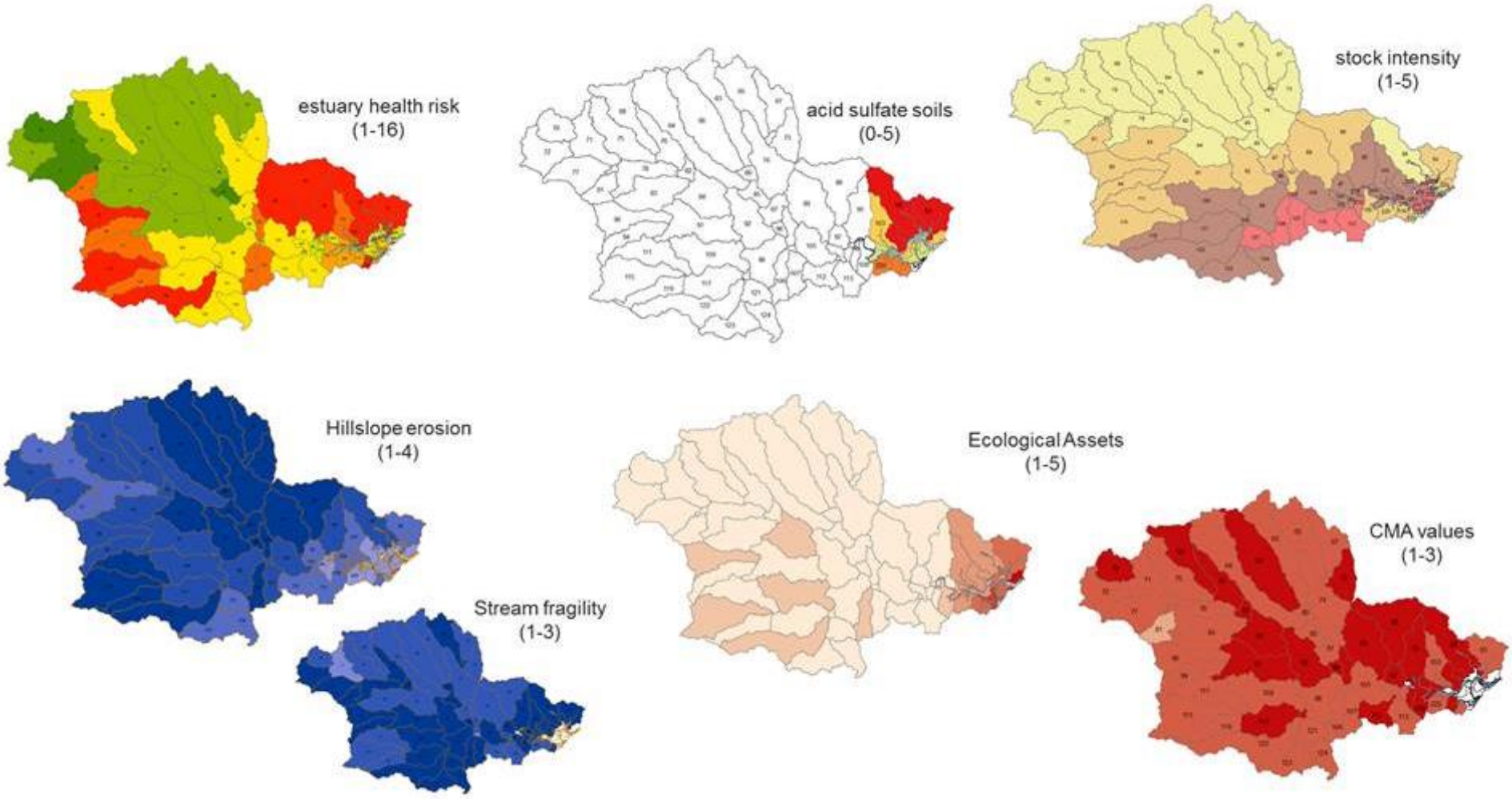


Figure 19: Plots compared modelled annual average TN, TP, TSS loads and surface flows for an upland catchment.

The blue circles in each plot represent one subcatchment, and axes in each plot represent the loads and/or flows modelled using OEH export coefficient model (x axis) and a MUSIC model developed by the Council (y axis).

v. Example Layers for Integration into the Risk Model: Stage 2



vi. Scoping Study Components

Table 11: Location of Scoping Study Components

Components of Scoping Study required by NSW Coastal Management Manual	Location in Scoping Study for Manning River Estuary CMP
Strategic Context	3. The Manning
Purpose, Vision, Objectives	2. Purpose and Scope
Current Management	6. Gap Analysis 7. Forward Program
Roles and Responsibilities	Engagement Strategy (separate document: Appendices 8i.)
First-pass Risk Assessment	4. Values 5. Spatial Risk Assessment 6. Gap Analysis 8 Appendices ii., iii, iv.
Stakeholder and Community Engagement Strategy	Engagement Strategy (separate document: Appendices 8i.)
Preliminary Business Case	1. The Case for Change
Forward Plan	7. Forward Program

vii. Bibliography – Gap Analysis and Literature Review

NB: Key subjects from reference are highlighted in bold.

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