alluvium

FINAL REPORT:

North Creek Coastal Management Program – Stage 1 scoping study

Dec 2019

ballina shire council

Document history

Revision:

Revision no.	05
Author/s	Alex Sen Misko Ivezich Elisa Zavadil Emily Lazarus Tony Weber Lisa Walpole Joshua Tait Jim Binney
Checked	Misko Ivezich
Approved	Elisa Zavadil

Distribution:

Revision no.	05
Issue date	Dec 2019
Issued to	Suzanne Acret (Ballina Shire Council)
Description:	Draft for comment
Revision no.	04
Issue date	May 2019
Issued to	Suzanne Acret (Ballina Shire Council)
Description:	Draft for comment
Revision no.	03
Issue date	January 2019
Issued to	Suzanne Acret (Ballina Shire Council)
Description:	Draft for comment
Revision no.	02
Issue date	September 2018
Issued to	Suzanne Acret (Ballina Shire Council)
Description:	Draft for comment
Revision no.	01
Issue date	June 2018
Issued to	Suzanne Acret (Ballina Shire Council)
Description:	Draft for comment

Citation:
Please cite as: Alluvium (2019) North Creek Coastal Management Program – Stage 1 Scoping Study. Report by Alluvium to Ballina Shire Council.

Acknowledgements:
The project team acknowledges the peoples of the Bundjalung Country that comprises the North Creek catchment. We pay respect to their Elders past, present and emerging, and acknowledge and respect their continuing culture and the contribution they make to the life and protection of this region.

The project team would also like to acknowledge and thank all stakeholders who provided input and feedback on the scoping study.

Executive summary

Ballina Shire Council has commenced the development of a Coastal Management Program (CMP) for the North Creek catchment. This report outlines the Stage 1 scoping study of the CMP development process, and sets the forward program for Stages 2 – 5 (of the 5 stage process).

The North Creek catchment extends north from the confluence with the Richmond River in Ballina. North Creek includes an extensive estuary system, and over two thirds of the catchment is tidally influenced.

The North Creek CMP is one of the first CMPs for a catchment-estuary system (no direct open coastline). The approach to the North Creek CMP development has an integrated focus on catchment and coastal processes, with a vision for:

"A healthy estuary, resilient ecosystems, and a sustainable, productive catchment."

Management objectives are associated with enhancing estuary and wetland health, promoting sustainable industries and liveable communities.

The Bundjalung people are the traditional custodians of the land, having cared for and lived off the land for thousands of years. In the past century the North Creek catchment has undergone rapid changes since European settlement. The vast swampy floodplain and wetlands into which the small coastal catchment creeks flowed have been extensively drained to allow for agricultural and urban development. Now, over half the catchment area is used for agriculture including grazing and sugarcane cultivation and just over 10 % of the catchment urbanised for residential development.

The catchment has a recent history of management challenges related to poor water quality and drainage, with adverse impacts on estuary health as well as agricultural and fisheries industries. Key knowledge gaps are linked to complex surface water, ground water and tidal dynamics.

Priority management issues for the North Creek catchment have been identified through a synthesis of previous work and research (Section 3), stakeholder and community engagement process (Section 3.14), and a first past risk assessment (Section 5). The priority issues for the North Creek CMP are:

1. Catchment runoff
    - This includes - agricultural diffuse runoff, diffuse urban stormwater and acid sulfate soils runoff. For the purposes of the scoping study, these stressors are combined and referred to collectively as catchment runoff.

2. Altered hydrology
    - This includes – changing patterns of surface and groundwater interactions, and altered drainage patters across the catchment.

3. Climate change
    - This focuses on the implications of climate change on sea level rise and increasing tidal inundation across the catchment.

4. Sand mining and dredging
    - This includes sand mining activities in the catchment, and dredging in the lower estuary reaches.

Recommended studies for including into the Stage 2 CMP work program include:

- Collection of high-resolution topographic data to 0.1 m vertical resolution of the entire catchment

- Bathymetric survey of all key drains and the estuary channel

- Development of a hydrodynamic model of the catchment to assess flow dynamics and drainage pathways and impacts on existing land uses. A coupled catchment-coastal model including tidal and storm tide inundation.

- Implementation of a North Creek Water Quality Monitoring Program (WQMP) which will include ambient and event-based monitoring for over 18 months across different areas of the catchment

- Development of a Source Catchment model of surface and groundwater pathways using outputs from the hydrodynamic model and WQMP to assess pollutant pathways through the catchment.

A range of additional studies of benefit to the health of the catchment and estuary have also been identified, which can be delivered as part of the Stage 2 CMP development, or later stages / as part of the CMP program implementation (or linked into other relevant strategies).

The proposed forward work program for Stages 2 – 5 of the CMP development runs over Jan 2020 to Dec 2021. The nominated program budget, including priority studies for Stage 2, is in the order of $600,000 - $700,000.

The preliminary economic assessment for the CMP scoping study has indicated that there is a strong case for investing in the CMP priority studies and CMP development for North Creek. This is based on consideration of the potential implications of tidal inundation impacts on agriculture alone being in the order of up to $14 million (loss) by 2050. The ecosystem services value of natural assets in the catchment (that may be impacted by known issues) is also in the order of up to $1 million per annum. Actions through the CMP will assist to mitigate losses and facilitate adaptation.

Strong stakeholder partnerships exist to support the CMP development and implementation, including an Agency Reference Group who have collaborated to inform the vision, objectives and direction of the CMP developed during the scoping study. There is also strong community support and interest in the CMP development.

The North Creek CMP will enable a holistic and collaborative approach to the management of key issues impacting on the health and resilience of the catchment and estuary ecosystems, while supporting sustainable and productive industries and liveable communities.

North Creek estuarine reach

Contents

Figures

Tables

1 Introduction

1.1 Scoping study purpose

Ballina Shire Council has commenced the development of a Coastal Management Program (CMP) for the coastal catchment of North Creek. The scoping study is the first stage in the process of preparing a CMP. The scoping study assists council to (OEH 2018b):

- Identify the community and stakeholders and prepare an engagement strategy
- Determine the strategic context of coastal management
- Establish the purpose, vision and objectives
- Determine the key coastal management issues and the spatial extent of management areas
- Review current coastal management arrangements
- Establish roles, responsibilities and governance
- Determine where action is required through a first-pass risk assessment
- Identify knowledge gaps and information needs
- Prepare a preliminary business case
- Determine whether a planning proposal will be prepared to amend coastal management area maps and the Local Environmental Plan
- Develop a forward program for subsequent stages of the coastal management program, including a fast-tracking pathway (if applicable).

This document sets out the scoping study for the North Creek catchment CMP. The scoping study establishes the program of work to be completed for the CMP and is completed in accordance with the requirements of the NSW Government Coastal Management Manual (OEH 2018), and with regard to the Coastal Management Act 2016 and Coastal Management State Environmental Protection Policy (SEPP) 2016.

North Creek estuarine reach

1.2 The study area

Ballina Shire

Ballina Shire is located in the Northern Rivers of the Far North Coast of New South Wales (Figure 1). The Shire covers an area of 485km^2, with over 32 km^2 of coastline including sandy beaches, rocky headlands, and the major estuary system and coastal floodplains of the Richmond River system.

Ballina Shire Council have undertaken several investigations in recent years in relation to the management of the open coast environment, including the development of a Coastal Zone Management Plan (CZMP) focused on managing beach erosion, shoreline recession and coastal inundation (Ballina Shire Council and GeoLink 2016). Prior to this, the Ballina Shire Coastline Management Study and Management Plan (2003) was also completed, looking at values of the coast and management options. A CZMP has also been completed for the Richmond River Estuary (Hydrosphere 2011) outlining action to address management issues affecting the estuary, along with a recent study on governance arrangements to enhance delivery of coordinated management efforts (Ballina Shire Council 2018).

North Creek is a tributary of the Richmond River estuary, and has not been the subject of a CZMP or similar detailed planning investigations to date. The catchment has a history of management challenges related to poor water quality and drainage, with adverse impacts on estuary health as well as agricultural and fisheries industries. Setting a forward program for integrated catchment management in the North Creek coastal catchment is a current priority for Ballina Shire Council. Therefore, the North Creek catchment is the focus area for this first CMP to be completed by Ballina Shire under the new legislation.

North Creek catchment

The North Creek catchment extends north from the confluence with the Richmond River in Ballina (Figure 1). The catchment is situated parallel to the coastline, and is bordered by the Alstonville plateau to the north west and the coastal dunes and headlands to the east near Lennox Head. The total catchment area is in the order of 122 km^2, and North Creek itself flows south for approximately 28 km, with an extensive estuarine reach in the lower catchment area.

The intertidal flats of lower North Creek and the Richmond River provide a sheltered environment for recreation, threatened migratory shorebirds, juvenile fish and other fauna. The mid to lower zones of North Creek are highly valued by tourists and locals for swimming, boating and fishing. A designated recreational fishing haven is situated within the lower estuary, except for the commercial mullet fishery at its mouth which is operated seasonally. Commercial oyster culture occurs in North Creek and within the Richmond River in Mobbs Bay.

The upper catchment supports agriculture such as sugarcane, macadamia plantations and livestock where tidal influence is limited. A complex network of drainage infrastructure has been installed to allow these agricultural developments. The Ballina Nature Reserve occupies a large area of the mid-section of North Creek and provides habitat for flora and fauna, including threatened species. Ongoing urban development is occurring within the catchment on the fringes of both Ballina and Lennox Head.

Figure 1. *The North Creek catchment to the north of Ballina*

1.3 Report structure

This North Creek catchment CMP scoping study is structured as follows, reflecting the scope of the CMP as defined previously in Section 1.1.

- **Section 2 – Program context:** An overview of the strategic and legislative context to the NSW CMPS, and for the North Creek catchment specifically.
- **Section 3 – Strategic context of coastal management:** A literature and data review - supplemented with new targeted desktop analysis and field assessments - on the relevant context and management challenges for the North Creek catchment. Including: environmental context, social and economic context, legal and planning context, review of Coastal Management Areas extents, current coastal management arrangements (existing plans), and potential barriers and enablers for effective management.
- **Section 4 – Purpose, vision and objectives:** Clarification of the purpose, and a preliminary vision and objectives of the North Creek catchment CMP.
- **Section 5 – Scope of the CMP – key management issues and areas:** First pass risk assessment on priority issues, and recommendations to address key knowledge gaps.
- **Section 6 – Preliminary business case and forward program:** A business case for the CMP including activities across CMP stages 2 – 3, costs, roles and responsibilities – lead applicant and established partnerships, as well as timeframes and any requirements for an amended planning proposal.
- **Attachment A –** A Community and Stakeholder Engagement Plan (C&SEP) prepared as a document that is part of this scoping study and can also be a stand-alone document for ease of reference throughout the CMP process.
- **Attachment B –** EPBC report
- **Attachment C –** First ARG meeting minutes
- **Attachment D –** North Creek CMP survey responses
- **Attachment E –** Relevant policy summaries
- **Attachment F –** Water Quality Monitoring Program

North Creek catchment - rural landscape

2 Program context

2.1 NSW Coastal Management Framework

Overview

Recent coastal management reform led by the Office for Environment and Heritage and the Department of Planning and Environment has involved the release of several key pieces of legislation, policies and guidance material over the last six years (**Error! Not a valid bookmark self-reference.**). These changes have been developed under the supervision of the responsible ministers and the Coastal Expert Panel with the aim to manage the coastal environment in a manner consistent with the principles of Ecologically Sustainable Development (ESD), i.e. for the 'social, cultural and economic wellbeing of the people of the State'.

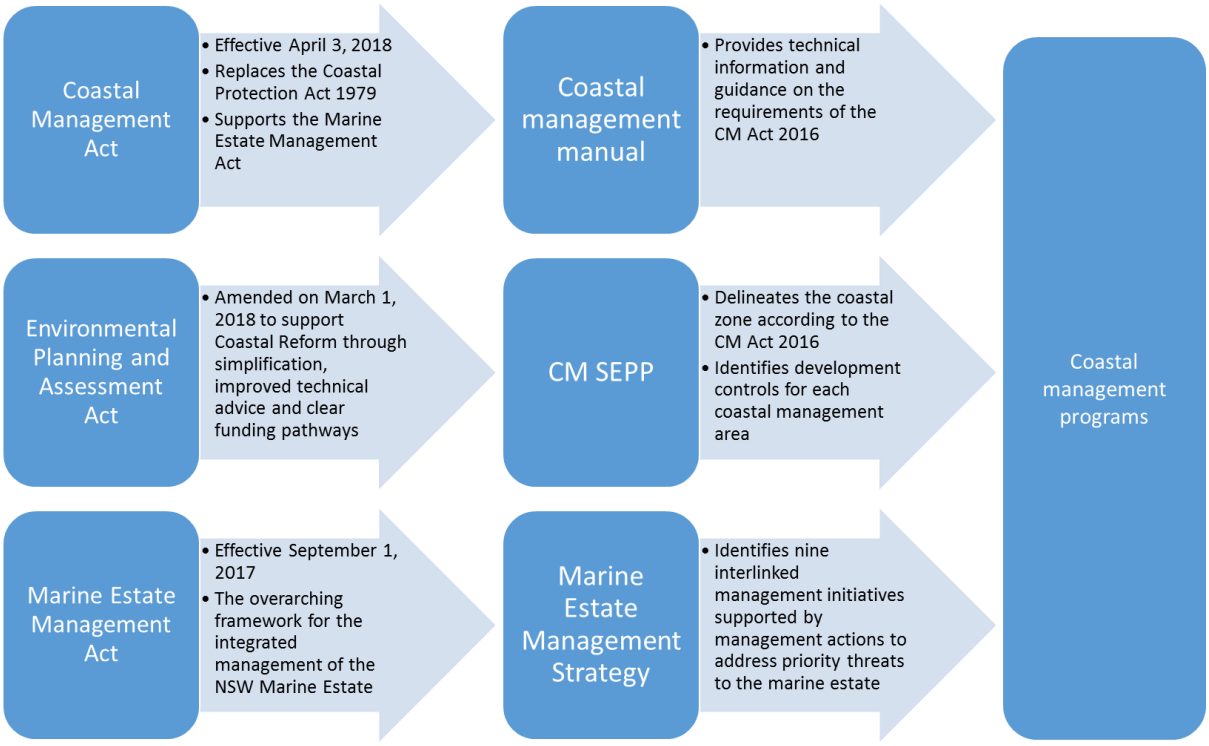


Figure 2. *An overview of the legislation, policies and guiding material involved in NSW coastal management reform*

Four key component documents / programs that provide direct influence / guidance for the Coastal Management Program are summarised further in Figure 3.

North Creek main channel – mid-catchment (rural)

Coastal Management Act 2016	•This Act divides the coastal zone into four management areas which are to be used by local councils to achieve the objectives of the Act through the implementation of their respective Coastal Management Programs. The guidance for this process is provided for by the Coastal Management Manual (OEH 2018a) through a five-stage approach (see Table 1 below).
State Environmental Planning Policy (Coastal Management) 2018	•Updated in 2018, the Coastal Management State Environmental Planning Policy (Coastal Management) 2018 (CM SEPP) supports the Coastal Management (CM) Act 2016 through provision of the development controls specific to each of these coastal management areas. These controls are supported by the Environmental Planning and Assessment (EP&A) Act 1979.
Marine Estate Management Act 2014	•A key objective of the Marine Estate Management (MEM) Act 2014 is improved co-ordination by public authorities in relation to their responsibilities to the Marine Estate. This integration, critical to the delivery of outcomes for both the Marine Estate Management Strategy (MEMS) 2018 and the Coastal Management Program, is supported by the Coastal Management Act, which 'support(s) the objects of the MEM Act 2016'.
Coast and Estuary Grants Program	•Funding support for local councils has been made available by the State government for this reform process through the Coastal and Estuary Grants Program, which is part of a greater $83.6 million funding package for coastal management in NSW from 2016-to 2021. In developing the CMP, councils are required to clearly identify and balance competing interests and priorities within the coastal zone (OEH 2018).

Figure 3. *Summary of several key documents / programs that have influenced the CMP process*

2.2 Coastal Management Programs

The five recommended stages to preparing a CMP as set out in the Coastal Management Manual (OEH 2018a) are shown in Figure 4 and Table 1. When progressing through this approach, Councils are required to report on progress, outcomes and achievements in line with reporting requirements under the Integrated Planning and Reporting (IP&R) framework (OEH 2018a).

Completion of the Stage 1 scoping study involves a review of the existing understanding of the catchment, examining progress on the management of coastal issues, developing a shared understanding amongst stakeholders of the issues at hand, identifying the key knowledge gaps and risk, and developing recommendations for future studies/investigations and a forward program of work to complete the CMP.

Figure 4. *Five stages to preparing a CMP (OEH 2018a)*

Table 1. An overview of the five-stage process of a Coastal Management Program (OEH 2018a)

CMP stage	Key steps	Key outputs
	• Identify key stakeholders and prepare an engagement strategy • Determine the strategic context of coastal management • Establish the purpose vision and objectives • Identify key coastal management issues and review coastal management arrangements • Determine where action is required through a first pass risk assessment	• Identification of the key knowledge gaps and how to bridge them • Established roles responsibilities and governance • Determination on whether a planning proposal will be prepared to amend coastal management areas and the Local Env Plan • A forward program for the Stage 2 and Stage 3 of the coastal management program • A preliminary business case for recommended studies
	• Define the socioeconomic characteristics such as demographics, coast dependent economic activity, land use patterns and future development scenarios • Improve the understanding of the complexity of the issues and community perspectives • Ensure different perspectives are incorporated in the analysis of consequences and likelihood • Understand the range of potential future scenarios and the local community's attitude to risk	• Quantification of the nature and the extent of threats to public and private assets (both natural and built). • Context and data to support the identification and evaluation of management options in Stage 3. • Identification of opportunities to reduce risks and enhance the environmental, social and economic values. • The detailed information necessary for a planning proposal to amend the mapping of the coastal management areas
	• Confirm the strategic direction for the catchment • Identify potential options for integrated management of all coastal management areas. • Evaluate the feasibility, viability and acceptability of management actions • Engage public authorities about implications for their assets and responsibilities • Evaluate mapped coastal areas and implications if a planning proposal is prepared	• Identify pathways and timing of actions • A business plan for implementation
	• Prepare a Coastal Management Program (CMP) • Submit the draft CMP to the Minister for certification • Review and adopt the draft CMP	• Exhibition of the draft CMP and any related planning proposal • Publishing of the certified CMP in the Gazette
	• Implement actions in the published CMP through the IP & R framework and land use planning system • Implement actions in partnership with adjoining councils and public authorities where relevant • Implement an effective monitoring, evaluation and reporting program • Monitor indicators, trigger points and thresholds	• Amendments, a review of and updates to the CMP • A report to stakeholders and the community on progress and outcomes through the IP&R framework

2.3 Towards the North Creek CMP

The final North Creek catchment CMP will provide a framework for the future management of the catchment and coastal areas

Management challenges at a glance – the need for a CMP
Over time, the ability of the North Creek catchment to support a functioning ecosystem has been significantly compromised to the extent that several environmental, social, legal and planning issues now exist. Some of the key management challenges facing the North Creek catchment centre around the following:

- Altered hydrology
- Impacts of climate change
- Catchment runoff and the impacts on water quality
- Weeds and pests
- Governance
- Ongoing urbanisation
- Sand mining

North Creek has experienced significant historical changes to land use and hydrology as a result of European settlement. The change is ongoing, with urban development continuing on both sides of the mid-catchment. As development increases and agricultural practices change, complex governance arrangements add to the complexity of managing legacy issues associated with altered hydrology and water quality.

The low relief of the majority of the catchment also exposes agricultural and urban areas (including Ballina) to the risk of tidal inundation from projected sea-level rise. Despite relatively minor community concern, this ingress has the potential to significantly impact catchment and community values in the next 20, 50 and 100 years. As the population continues to grow and land use pressures increase, there is a need to quantify the threats and risks to the local communities.

With the new coastal management framework, the appropriate legislation is now in place to provide councils with the support to deal with complex issues associated with management of coastlines and coastal catchments. It is envisaged that the final North Creek catchment CMP will provide a framework for the future management of the catchment and coastal areas. Bridging key knowledge gaps on the social, environmental and economic impacts of altered hydrology, poor water quality and tidal inundation in the catchment are key to the success of the CMP, and concurrently, gaining support for the adoption of the CMP from stakeholders and the community is essential.

Policy context
The statutory framework supporting the management of the North Creek catchment is complex. In addition to the regulatory and policy documents discussed as part of the coastal reform (Figure 3.), several other federal, state and local legislation, policies and management plans and guidance material complete the policy and planning context for the North Creek catchment. This is illustrated and summarised in Figure 5.

Further details of how objectives from local, regional and state policy and planning documents relate to the key management issues facing the North Creek catchment are discussed later in this document.

Figure 5. *Relevant federal, state and local legislation, policies and management plans and guidance material which comprise the statutory landscape for the North Creek CMP*

3 Strategic context of coastal management

The following section provides a review of the background information relating to the existing management practices and studies that have been conducted in the North Creek catchment and Ballina Shire. This includes a literature review and summary narratives that incorporate the following elements:

Landscape context and physical processes shaping the landcape

Climate

Values and threats (environmental, social, economic).

3.1 Setting, geology and soil-landscapes

Key points

- Much of the catchment is of very low elevation representing formerly freshwater and estuarine wetland locations in a back-barrier environment.
- Over 50 % of the North Creek catchment has been identified as at risk from acid sulfate soils (potential or known)

Landscape setting

The North Creek catchment consists of a mosaic of landscapes which have been sculpted over time by the interplay of coastal and terrestrial geomorphic processes. The dominant topography of the catchment comprises of weathered basaltic flows known as the Alstonville Plateau, Skennars Head and Lennox Head. Over time, sediments shed off these flows, plus those delivered from the coastal margin, have deposited in a series of intercalated marine and terrestrial sequences within the adjacent low-lying areas. Once heavily forested, these low-lying coastal swamps and intertidal wetlands have now been extensively modified for agriculture.

The main stem of North Creek runs along a series of agricultural drains which are gated to restrict tidal ingress which can now extend up to two thirds of this modified catchment (Ryder et al. 2015). A considerable portion of highly modified tidal wetland remains along the lower half of the creek (Ballina Nature Reserve) before it widens to a broader estuary system. Lower North Creek flows through the urban areas of Ballina and Ballina East and has high recreational value for the local community.

Coastal processes

The adjacent coastline outside the North Creek Catchment boundary extends from Ballina to the north past Broken Head. The coast is situated within one main sediment compartment, with predominantly sandy shores interspersed with hard rock shores around the several headlands (NCCARF 2018). Erosion (storm bite) and long-term recession with sea level rise are ongoing processes along the open coast areas, and may put increased pressure on development in the North Creek catchment as the future development focus may shift inland.

For North Creek catchment itself, tidal inundation is the main coastal process impacting on the catchment form and function. Predicted sea level rise with climate change is expected to substantially increase the extent

of tidal ingress up into the North Creek catchment area by 2050 and 2100 (NCCARF 2018), bring increased management challenges for the catchment in relation to agricultural productivity, drainage and water quality, and ecosystem dynamics (discussed in later sections).

Geology context

The geologic setting for North Creek is one in which the coastal fringe meets the tertiary basalts of the Alstonville Plateau in a dynamic environment. Much of the catchment is of very low elevation representing formerly freshwater and estuarine wetland locations in a back-barrier environment. Around Broken Head lie metamorphosed sediments forming the north-eastern catchment boundary. The north-western and western catchment divide consists of the Lismore Basalts, which also form outliers at Skennars Head and around East Ballina in the vicinity of the Missingham Bridge.

Originally the catchment consisted of both estuarine and aeolian sediments behind coastal dunes. This would have been a freshwater environment transitioning to a brackish one with intermittent openings to the estuarine waters at very high tides and during storm events. Different climates have also contributed to the development of the sediments and soils on which North Creek lies today. It is likely that the low-lying areas of the catchment were inundated by estuarine waters altogether during the Holocene 'sea-level high stand' some 2000 to 2500 years ago, with the presence of coastal sands deposited inland indicating that the local sea level was approximately 1 to 1.5 m higher at that time (Lewis et al. 2013).

A snapshot of the underlying geology of the catchment demonstrates the complex nature of its coastal landscape location (Figure 6).

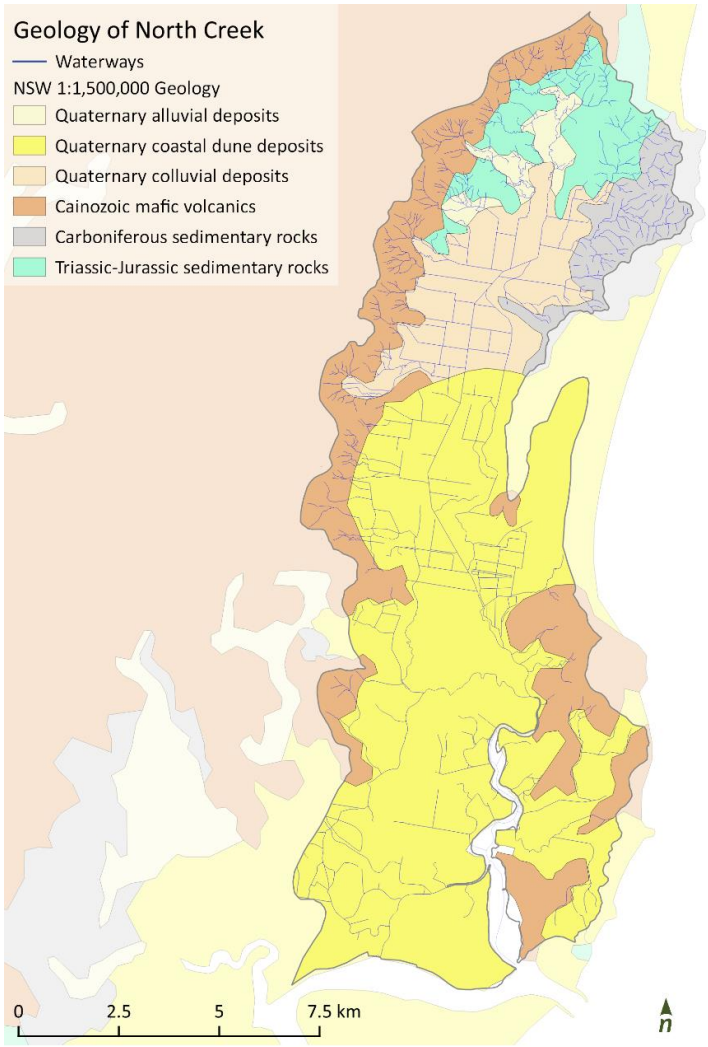
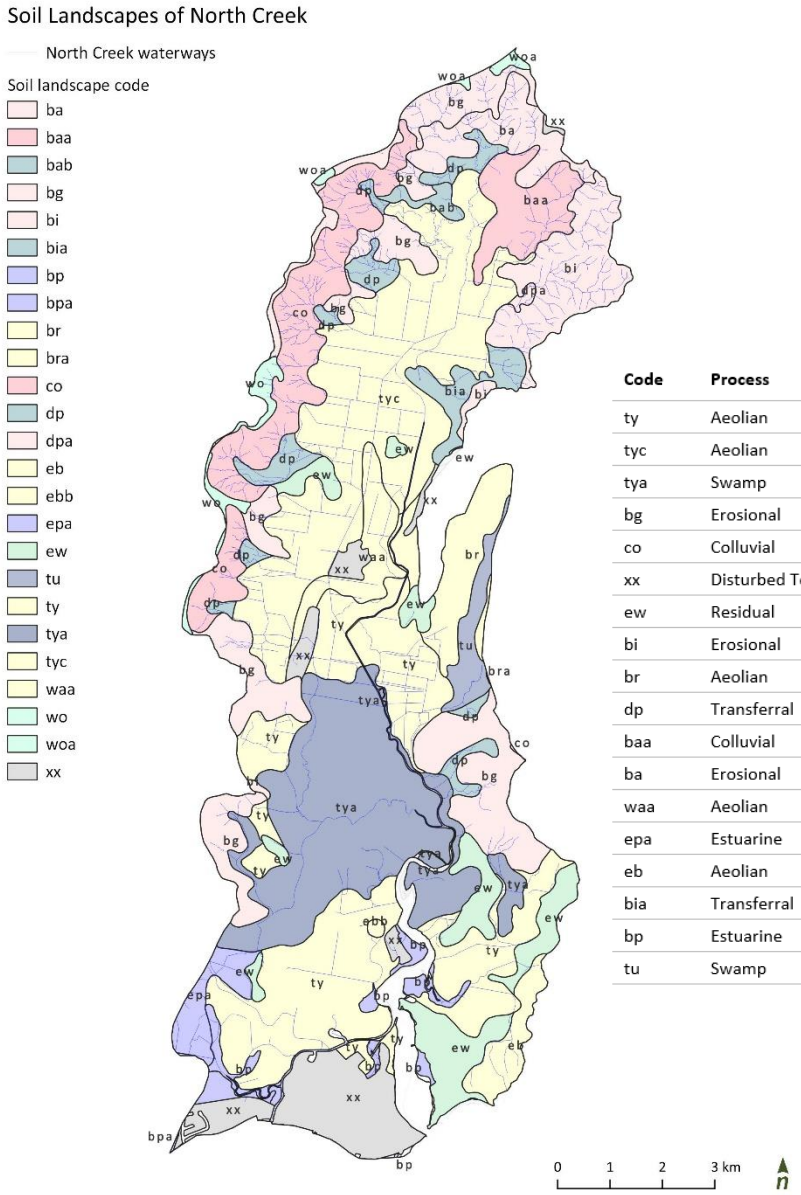


Figure 6. *The surface geology of the North Creek catchment (DPE 2015)*

Soil landscapes

The 'soil-landscapes' mapping by the state government provides an integration of soil and topographic factors to assist with identifying potential limitations for urban and rural development. The soil-landscapes within the North Creek catchment are shown in Figure 7.



Code	Process	Name	% Total area
ty	Aeolian	Tyagarah	16%
tyc	Aeolian	Tyagarah variant c	15%
tya	Swamp	Tyagarah variant a	13%
bg	Erosional	Bangalow	10%
co	Colluvial	Coolamon	7%
xx	Disturbed Terrain	Disturbed Terrain	6%
ew	Residual	Ewingsdale	5%
bi	Erosional	Billinudgel	4%
br	Aeolian	Black Rock	3%
dp	Transferral	Disputed Plain	3%
baa	Colluvial	Bagotville variant a	3%
ba	Erosional	Bagotville	2%
waa	Aeolian	Wardell variant a	2%
epa	Estuarine	Empire Vale variant a	2%
eb	Aeolian	East Ballina	1%
bia	Transferral	Billinudgel variant a	1%
bp	Estuarine	Burns Point	1%
tu	Swamp	Tuckean	1%

Figure 7. *The soil landscapes of North Creek (OEH 2017b)*

DPIE Environment, Energy and Science (EES) utilises soil landscapes mapping to provide an integration of soil, topography, aspect and other geomorphic processes. A soil landscape can be defined as an area of land that has "recognisable and specifiable topographies and soils...and that can be described by concise statements" (Northcote, 1978). Soil profiles are not necessarily uniform within the landscape.

Soil classification

There are other methods of describing soils, such as the Australian Soil Classification (CSIRO).The Australian Soil Classification classifies the soils as they occur in situ which has a relationship to the parent material and geomorphic processes acting upon them, whereas the Soil Landscapes describe those processes and the types

of soils that you find within them. A map of corresponding soil types as described under the Australian Soil Classification is provided in Figure 8.

Together, both classification approaches (soil types and soil landscapes) provide a catchment wide appreciation of both the soils *in situ* and how they have developed. There is an observable relationship between soil types and acid sulfate soil risk (Figure 8).

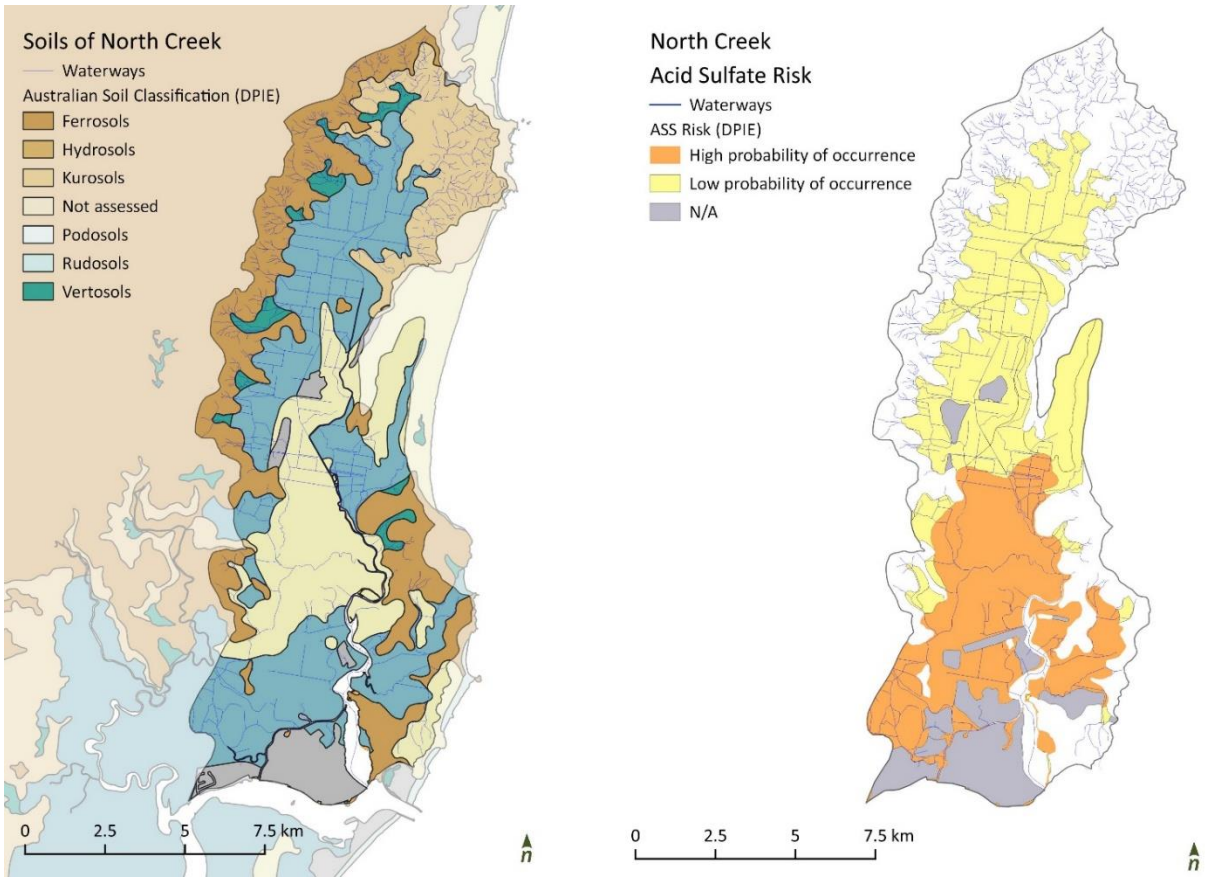


Figure 8. *The soils and acid sulfate risk of the North Creek catchment - note that mining operations and drainage works have confirmed the existence of acid sulfate soils within the low probability zone.*

With regard to acid sulfate soil risk, Morand (1994) notes that acid sulfate soil material was identified near the vicinity of the original course of Deadmans Creek. Studies investigating quarry remediation on the upper North Creek floodplain have found that even sediments identified as Low Risk for acid sulfate soil, such as those in water held in former quarries - are discharging low pH (acid) water. It is unclear whether this is due to the acid nature of the Tyagarah soils or acid sulfate soil material. Morand (1994) also notes very localised acid sulfate soils in old estuarine areas which may be contributing.

A summary of soil types and implications for management in the North Creek catchment are provided in Table 2. Over 50 % of the catchment is likely to be at risk from acid sulfate soils (potential or known).

Table 2. Soil types and associated management issues within the North Creek catchment, including potential acid sulfate soils (PASS) and known/expected acid sulfate soils (ASS).

Soil Type	Description	Management issues to consider	Catchment percentage	Catchment location	Approximate elevation (m)
Hydrosol	Waterlogged soils of varied compositions. High levels of organic matter. PASS	Disturbance likely to oxidise iron sulphides. PASS	35 %	Permanently inundated areas	0-2
Ferrosol	Well structured, deep, Fe rich and well-draining. A high value agricultural soil.	Development pressures on high quality agricultural soil	23 %	Slopes and ridges	10-100
Podosol	B horizon dominated by the accumulation of organic matter, aluminium and/or iron	Metal toxicity in the event of acute acid discharge, PASS	21 %	Flood plain areas and foot slopes	1-10
Kurosol	Texture contrast soils. Sandy surface and clay sub-surface.	Dispersive varieties have high erosion risk	12 %	Slopes and ridges	10-90
Not assessed	Soils predominantly overlain by development	High probability of PASS or ASS	6 %	6 %	1-10
Vertosol	Swelling clays can cracks >5mm when dry Often have dispersive subsoils	Minimise sub-soil exposure	3 %	3 %	1-15

North Creek – mid-catchment swampy areas: potential acid sulfate risk for inundated and floodplain areas

3.2 Climate

Key points

- The climate of the North Creek catchment is regulated by its proximity to the sea
- A relatively short record of temperature and rainfall is available for the Ballina Shire
- The catchment has experienced a number of significant flooding events in recent history
- Sea level rise is likely to have an increasing impact across the catchment

The North Coast region of NSW generally experiences a sub-tropical climate. The main atmospheric factors affecting the climate are the slow, easterly-moving high-pressure systems, low pressures systems associate with cold fronts and the occasional tropical cyclone which drifts south (DECCW 2010). North Creek's climate is regulated by its proximity to the sea, which moderates the extremes in temperature experienced further inland.

Temperature and rainfall

Mean summer highs are approximately 28°C from December through to February and average winter lows reach approximately 9°C in June and July (BOM 2018) (Figure 9.). Approximately 1800 mm of rain falls annually, with the majority falling during rapid and intense rain periods in the summer (BOM 2018) (Figure 10).

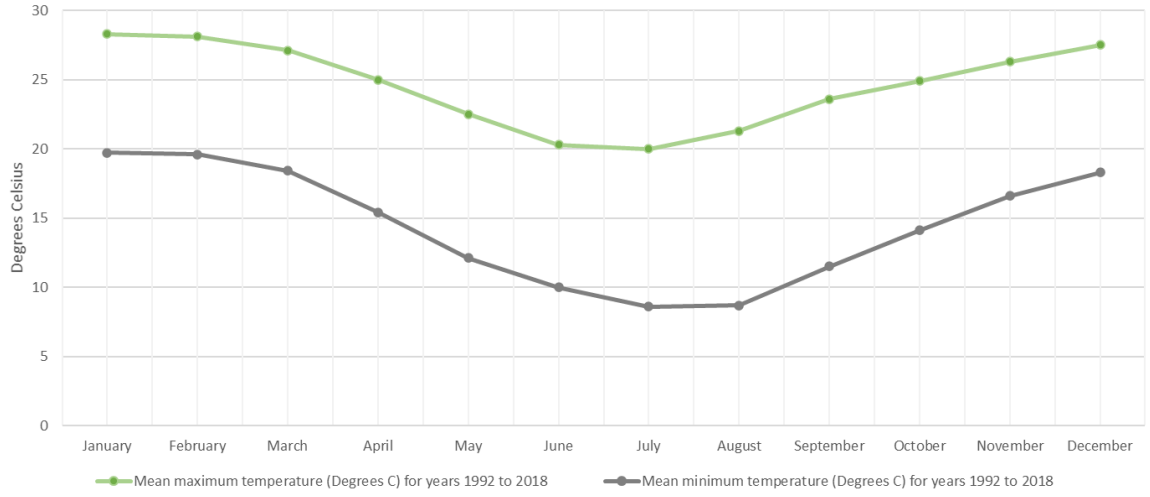


Figure 9. *Mean maximum and minimum temperatures for Ballina airport from 1992 to 2018 (BOM 2018)*

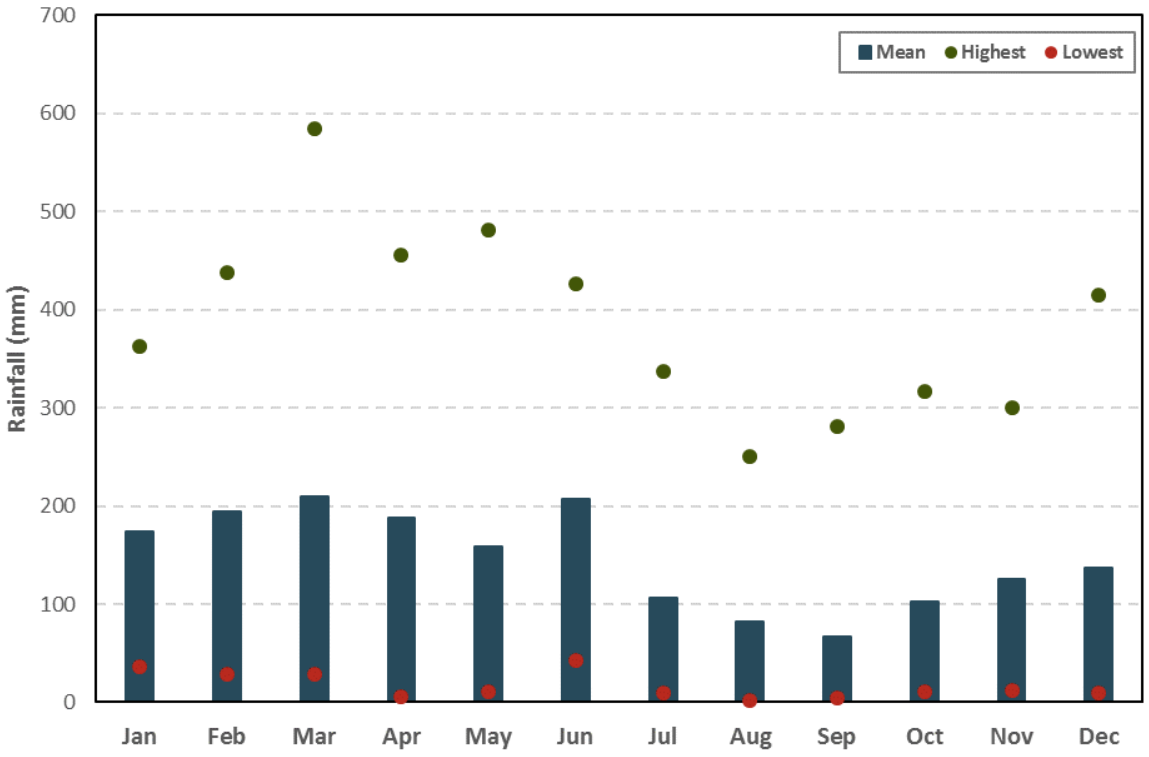


Figure 10. *Highest, lowest and mean monthly rainfall from 1992 – 2018 from Ballina Airport (BOM 2018)*

Significant storm events

The Richmond river catchment has been subject to significant flooding in the past. Since 1900 the largest floods in the catchment were in 1954 and 1974 (WBM 2012). In more recent times significant flooding has occurred in 2001 and 2006 and 2008, all of which were both associated with moderate to major fish kills (Wong et al. 2018). Oyster harvest areas in the Lower Richmond and North Creek were also closed during these times.

A changing climate and implications for Ballina Shire

Climate change is influencing changes in regional sea level, rainfall patterns, and temperature, with a range of implications for coastal management including estuaries and catchments.

Temperature and rainfall

Climate projections for the north coast of NSW depict a warming of 0.7 degrees by 2020-2039 which will reach 2 degrees by 2060-2079. Maximum temperatures also increase with reduction in potential frost risk. Rainfall is projected to increase in autumn in spring and decrease during the winter. Fire weather is also projected to increase in summer and spring, along with severe fire weather days (Mummery 2016).

The CoastAdapt support tool employs eight climate models to predict temperature and rainfall extremes at a Local Government Area level. The projected changes in temperature extremes for the Ballina region are shown in Figure 11. These projected increases in hot day, warm nights and heatwaves have the potential to impact the liveability and productivity of the catchment. These increases could test the climate for which facilities such as retirement homes have been designed. Primary production may also be at risk, particularly those industries sensitive to climatic change. These industries may include intensive horticulture and oyster culture.

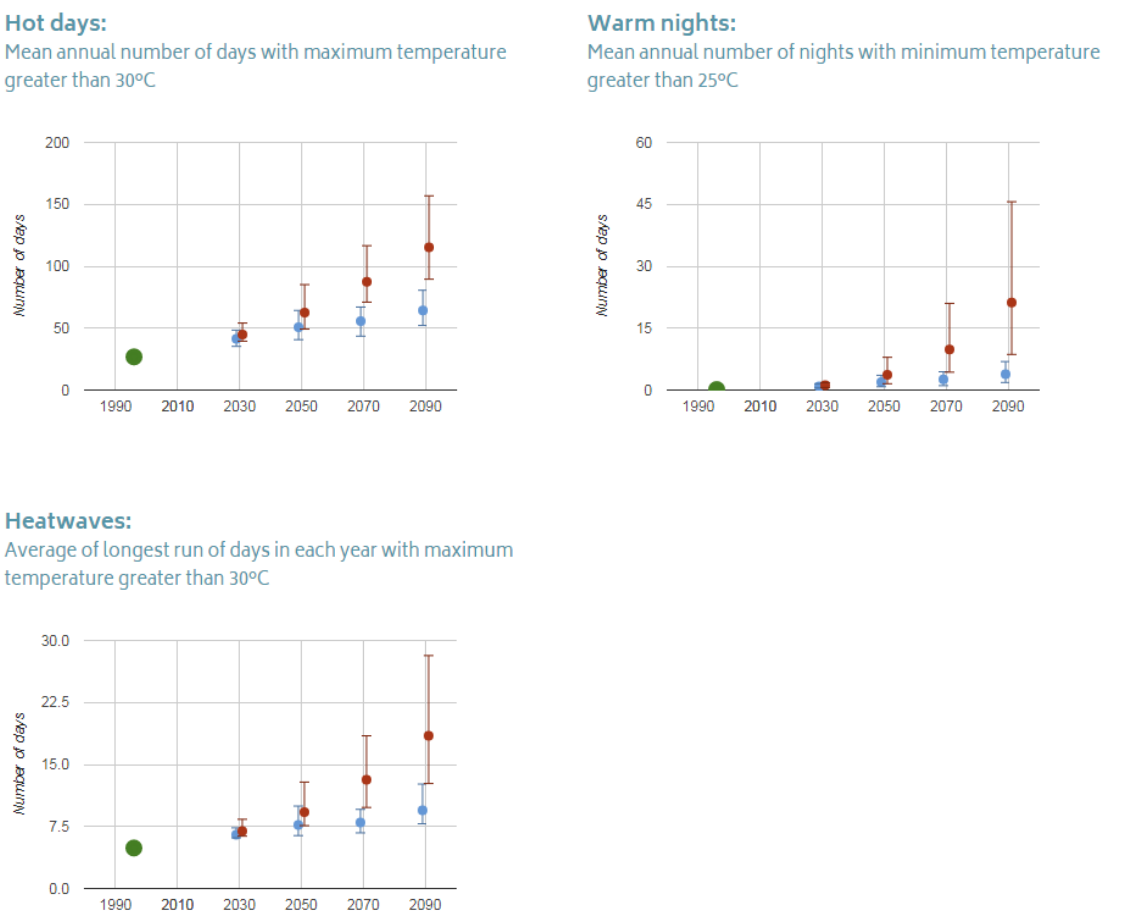


Figure 11. *Temperature extremes plot for the Ballina Region. The green dot represents observed conditions based on 1981-2010 data and the bars indicate future (modelled conditions for four time slices up to 2090. The red dots delineate the highest greenhouse gas scenario (RCP8.5) and blue represent the low (RCP4.5) scenario. The dot is the mean across the eight climate models, the upper end of the bar is the maximum value from the eight models and the lower end of the bar the minimum. (NCCARF 2018).*

The potenital changes in rainfall that could occur as a result of climatic change are presented in Figure 12. These changes indicate a mild reduction of rainfall in the near (2030), mid (2050) and long term (2090). Such changes may impact the viability of marginal primary production, aquifer recharge rates and the resilience of marginal ecosystems within the catchment/region.

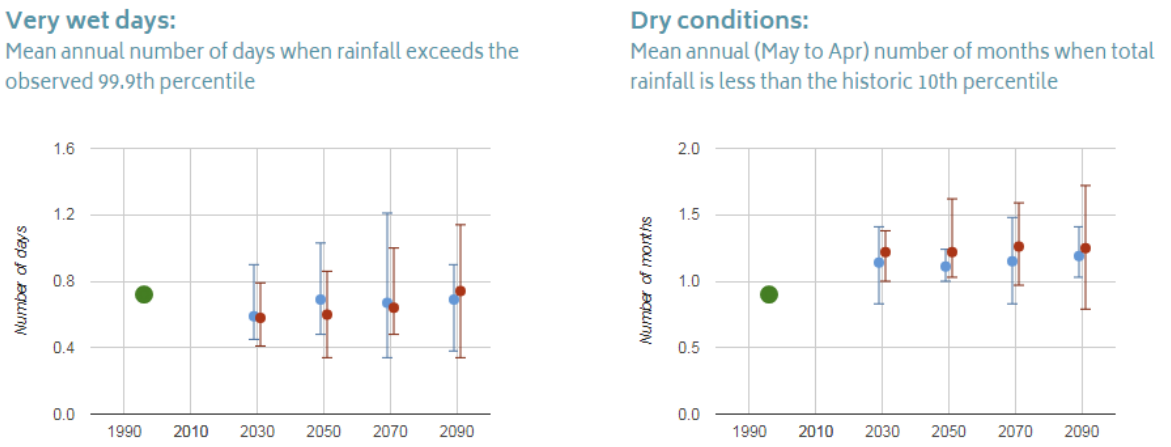


Figure 12. *Extreme rainfall plots for the Ballina Region. Very wet days which are the mean annual number of days when rainfall exceeds the historic 99.9th percentile, and Dry conditions which are the mean annual (May to April) number of months when total rainfall is less than the historic 10th percentile. The green dot represents observed conditions based on 1981-2010 data and the bars indicate future (modelled conditions for four time slices up to 2090. The red dots delineate the highest greenhouse gas scenario (RCP8.5) and blue represent the low (RCP4.5) scenario. The dot is the mean across the eight climate models, the upper end of the bar is the maximum value from the eight models and the lower end of the bar the minimum. (NCCARF 2018).*

Sea level rise and tidal inundation

The NSW government 2009 sea level rise policy statement provided state-wide benchmarks of projected sea level rise to ensure consistent adaptation by coastal councils, namely a 0.9 m increase by 2100. The Ballina Development Control Plan has factored these benchmarks into its flood planning levels (BSC 2012). These benchmarks were also employed in the 2015 WBM Newrybar Swamp drainage and flood mitigation study (discussed further below) which modelled climate change scenarios for the lower and mid catchment.

In the recent NSW coastal legislation reform, the 2009 sea-level rise policy has been adjusted in favour of flexibility for councils to determine their own sea level rise projections. Likely global mean sea-level rise by 2100 has been projected to exceed the 0.9 m benchmark (by 0.08 m) in the highest emissions scenario. The IPCC also suggest the possibility of greater rises should unfavourable conditions prevail, such as ice sheet collapse (OEH 2018d).

The CoastAdapt risk management framework provided by the National Climate change Adaptation Research Facility (NCCARF) has been recently developed as a support tool for local government to assess the risk posed by predicted sea level rise. Four different Representative Concentration Pathways (RCPs) are available to understand how climate change may impact sea levels, as presented in Figure 13. (NCCARF 2018).

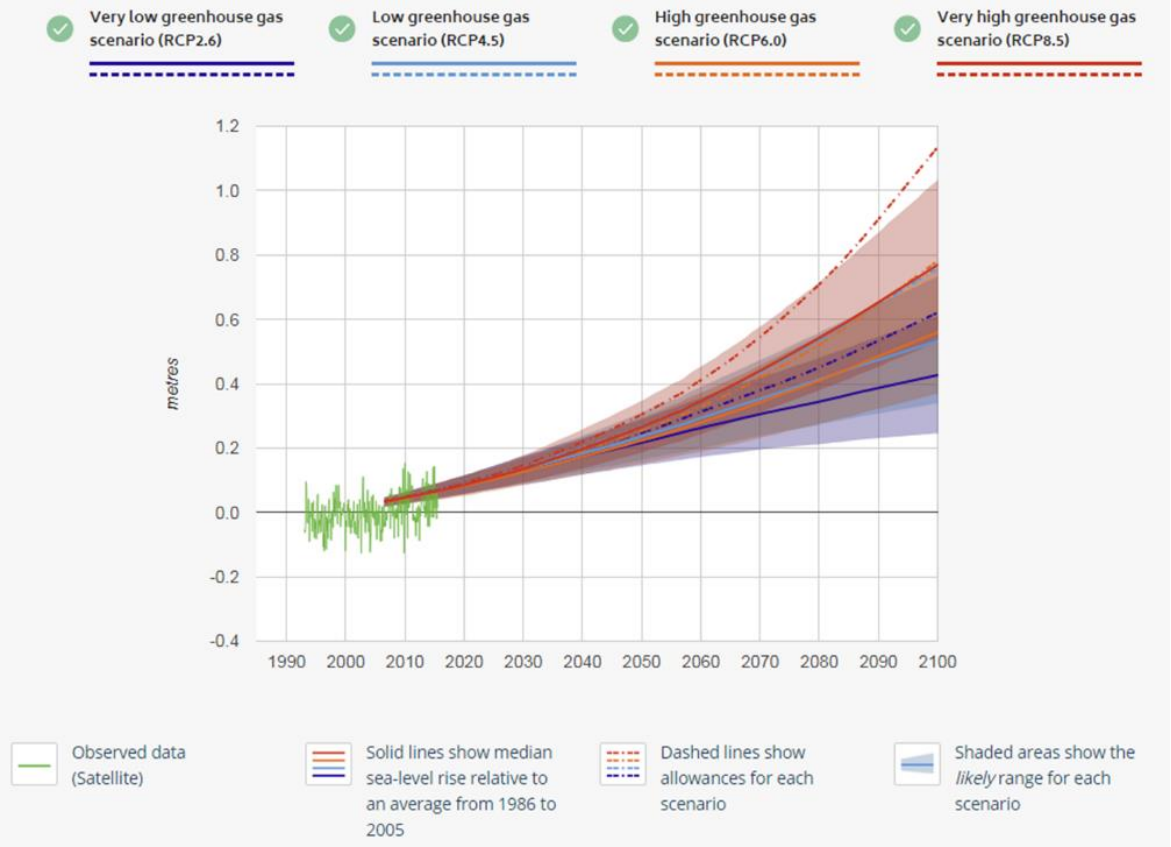


Figure 13. *Predicted sea level rise scenarios under very low to very high greenhouse gas scenarios (NCCARF 2018).*

As current emissions are tracking close to the RCP 8.5 pathway, a high level of adaptation at a high cost is expected (NCCARF 2018). The dashed 'allowance' lines in Figure 13. indicate the corresponding height coastal defences would need to be raised to provide the same level of protection as they do today.

A summary of predicted sea level rise from 2030 to 2090 within the Ballina region and the corresponding allowances required to protect at risk development are provided in Table 3 and Table 4.

Table 3. Predicted sea level rise along the Ballina coastline relative to an average calculated between 1986 and 2005 (NCCARF 2018)

	Greenhouse Gas scenario (RCP)			
Date (unit)	Very Low (RCP 2.6)	Low (RCP 4.5)	High (RCP 6.0)	Very High (RCP 8.5)
2030 (m)	0.09 - 0.18	0.09 - 0.18	0.09 - 0.17	0.09 - 0.18
2050 (m)	0.15 - 0.29	0.17 - 0.32	0.15 - 0.30	0.19 - 0.35
2070 (m)	0.20 - 0.42	0.24 - 0.48	0.23 - 0.46	0.31 - 0.58
2090 (m)	0.23 - 0.55	0.31 - 0.65	0.32 - 0.66	0.46 - 0.88
Rate of change at 2100 (mm/yr)	1.6 - 6.5	3.2 - 8.7	4.7 - 10.5	7.6 - 16.1

Table 4. Corresponding allowances for predicted sea level increase under different RCPs (NCCARF 2018)

	Greenhouse Gas scenario (RCP)			
Date (unit	Very Low (RCP 2.6)	Low (RCP 4.5)	High (RCP 6.0)	Very High (RCP 8.5)
2030 (m)	0.14	0.15	0.14	0.15
2050 (m)	0.25	0.27	0.26	0.31
2070 (m)	0.38	0.44	0.42	0.55
2090 (m)	0.54	0.65	0.65	0.92

The predicted inundation levels for the highest modelled emissions pathway (RCP 8.5) in 2050 and 2100 is illustrated in Figure 14.. This model imposes the predicted sea level rise shown in Figure 13. on the highest astronomical tide (HAT) for the Ballina region. The model uses a simple 'bucket fill', and the result is an approximation only, the model does not consider existing seawalls or barriers, the consequences of erosion, storm surge and wave height. Technical guidance material on the data and methodologies used to produce these maps is available in Church et al. (2016).

Despite the constraints of the model, it provides an indication of the potential increase in tidal inundation expected by the 2100 planning horizon. As such, it supports the first pass risk assessment as part of this scoping study (see Section 5).

The NCCARF model indicates an increase in sea level of approximately 1.2 m by 2100 when compared to baseline 1981-2010 data. This contrasts with the benchmarks currently employed by the BFRMP and the subsequent Development Control Plan (DCP), which employ a 1990 mean sea level as baseline. At the very least, there is a 0.3 m difference in the two 2100 benchmarks which the BFRMP and DCP will need to consider. The tidal extent of North Creek is also susceptible to storm tide inundation. Storm surges and the other factors excluded from the bucket fill model will need to be taken into consideration with future modelling.

Within the North Creek catchment tidal inundation is the main coastal hazard. Large areas of the lower catchment have a low elevation and will be increasingly exposed to tidal inundation associated with sea level rise. Urban and agricultural areas will be increasingly exposed to tidal inundation by 2100.

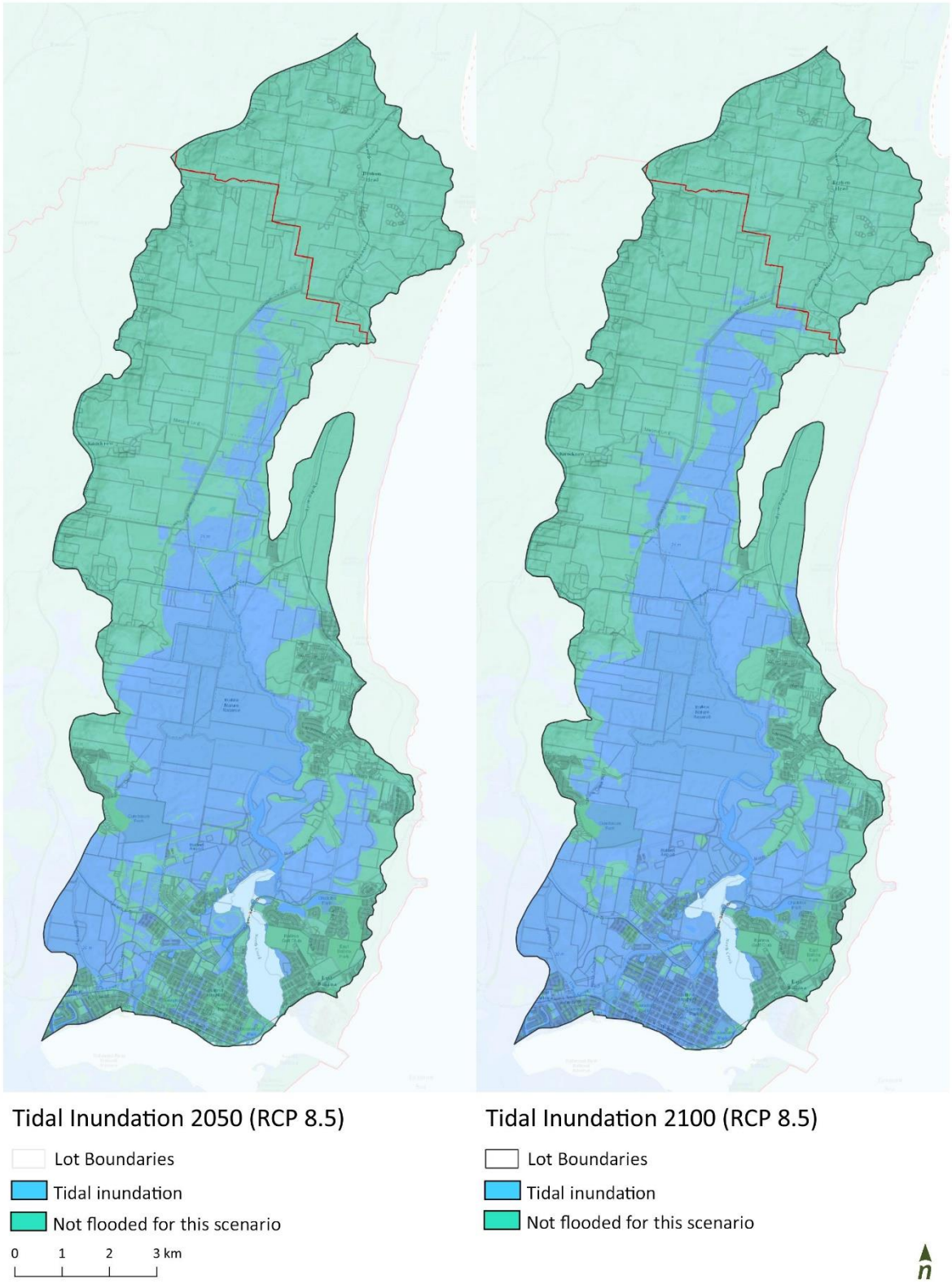


Figure 14. *Modelled tidal inundation extents for North Creek in the highest emissions scenario for 2050 (left) and 2100 (right) (otherwise known as the Representative Concentration Pathway 8.5 or RCP 8.5) (NCCARF 2018).*

The CoastAdapt risk assessment tool provides for the initial screening of climate change hazards and implications. This tool has been applied to the North Creek catchment and considers the climate hazards relevant to the North Creek catchment under a 2100 planning horizon assuming a RCP 8.5 scenario. A summary of the potential climate hazards and implications identified within the catchment are provided in Table 5.

Table 5. Summary table of potential climate hazards in the North Creek catchment within the 2100 timeframe

Potential hazard	Have these occurred in the past?	Likely future direction of the hazard?	Which geographic area/sector/assets/ecosystems can be impacted?
Storm surge inundation	Yes	Increase	All low-lying areas within and adjacent to the tidal 2100 extent of North Creek as depicted in Figure 29.
Entrance instability	Yes	Increase	Any training walls and entrance management (including dredging) which did not take 2100 projected sea level rise (and associated sediment transport impacts) into consideration during construction.
Tidal inundation of estuary and surrounding area	Yes	Increase	All low-lying areas within the catchment which intercept the projected tidal inundation levels for years 2050 and 2100 at RCP 8.5. Refer to Figure 35.
Erosion within estuary	Yes	Increase	All exposed or poorly vegetated banks along North Creek and the estuary as outlined in low lying areas within the catchment at risk of inundation are also at risk of increased erosion.
Saline intrusion in estuary	Yes	Increase	Estuarine macrophytes, especially those at the upper end of the tidal extent, groundwater dependent ecosystems, groundwater dependent industry/agriculture. Low lying green spaces and recreation spaces. Primary industry (macadamias, sugar, grazing etc) through groundwater intrusion.
Prolonged summer heatwave	Yes	Increase	Entire catchment, especially townships (urban heat island effect), young and elderly, Primary industry (macadamias, sugar, grazing etc)
Increased number of hot days and nights	Yes	Increase	Entire catchment, especially townships (urban heat island effect), young and elderly, Primary industry (macadamias, sugar, grazing etc)
Surface water flooding	Yes	Increase	All low-lying areas within the catchment, including Ballina Island and proximal low-lying developed areas. Primary industry (macadamias, sugar, grazing etc)
Drought	Yes	Increase	Entire catchment, Primary industry (Macadamias, sugar, grazing etc), Water sensitive threatened ecological communities (Swamp oak forest and Littoral Rainforest)
Erosion induced by excessive rainfall	Yes	Increase	All areas within the catchment with exposed soil.
Bushfire	Yes	Increase	Well vegetated areas and/or grasslands which are prone to drying out due to seasonality or drought.

Knowledge gaps

A detailed understanding of impacts from climate change, in particular tidal inundation, in the North Creek catchment are largely unknown. While the projected sea level rise reflected in the bathtub model provided through CoastAdapt is a good indication of potential inundation, it is a broad estimate only. The bathtub model does not account for the dynamic estuarine environment and model precision is limited by the resolution of the baseline DEM used in the model.

Key knowledge gaps exist around:

- Tidal inundation extent within the catchment.
- The socio-economic impact of inundation, including vulnerability mapping to inform floodplain and land use planning.
- How coastal wetlands will respond to tidal inundation.
- How groundwater systems will respond to tidal inundation and how this will impact primary industry.
- How projected changes in climate will impact ecosystems, primary industry and liveability within the catchment.

A hydrodynamic model incorporating tidal and storm tide inundation for the present and future time frames (20, 50 and 100 years) would assist to improve understanding of sea level rise impacts across the catchment. This model will need to take into consideration the construction of training walls at the mouth of the Richmond River, the installation of drainage infrastructure, future dredging scenarios and the possibility of subsidence of areas built on reclaimed land, all of which can increase tidal amplitude and influence.

3.3 Historical changes to the catchment

Key points

- The Bundjalung people are the traditional owners of the land
- Extensive drainage works have modified catchment hydrology, surface water, groundwater and tidal interactions

An overview narrative

Prior to European settlement, the North Creek catchment was occupied by traditional owners, the Bundjalung nation. The catchment itself was a seasonal source of food and shelter, affording a rich supply of oysters, fish and traditional medicines.

This pre-European ecosystem comprised of an extensive and diverse array of vegetation communities and flora. Expansive tidal wetlands, sandy shoals and seagrass meadows formed the lower sections of the catchment. Further upstream, these tidal wetlands gave way to increasingly fresh water melaleuca swamp across the lowland flats and coastal heath towards the barrier dunes. The low hillslopes which rose from the swamp bore thickets of subtropical and littoral rainforest and stands of red cedar, which extended to the elevated slopes of the catchment boundary.

Changes since the displacement of the Bundjalung people have been extensive. Floodplain clearing for timber resources paved the way for settlement and agriculture in the 1860s. North Creek itself provided the main means of transport for settlers, who began to install drainage works with Newrybar Swamp as early as 1888 to cultivate the floodplain. Drainage works accelerated in the 1900s to protect agricultural exploits from flooding and tidal inundation (Hydrosphere 2011).

In the late 1970s, the Richmond River County Council constructed a large flood mitigation drain which facilitated widespread floodplain cultivation of sugarcane (WBM 2015). Ad hoc drainage work by landholders has also continued throughout the catchment, leaving behind a complex and poorly understood drainage pattern.

More recently housing developments continue to extend along the hillside fringes of the floodplain north and east of Ballina. Figure 15, Figure **16**. and Figure 17. highlight some of the major changes to the North Creek catchment since the 1967.

North Creek – drainage channel in upper catchment (2018)

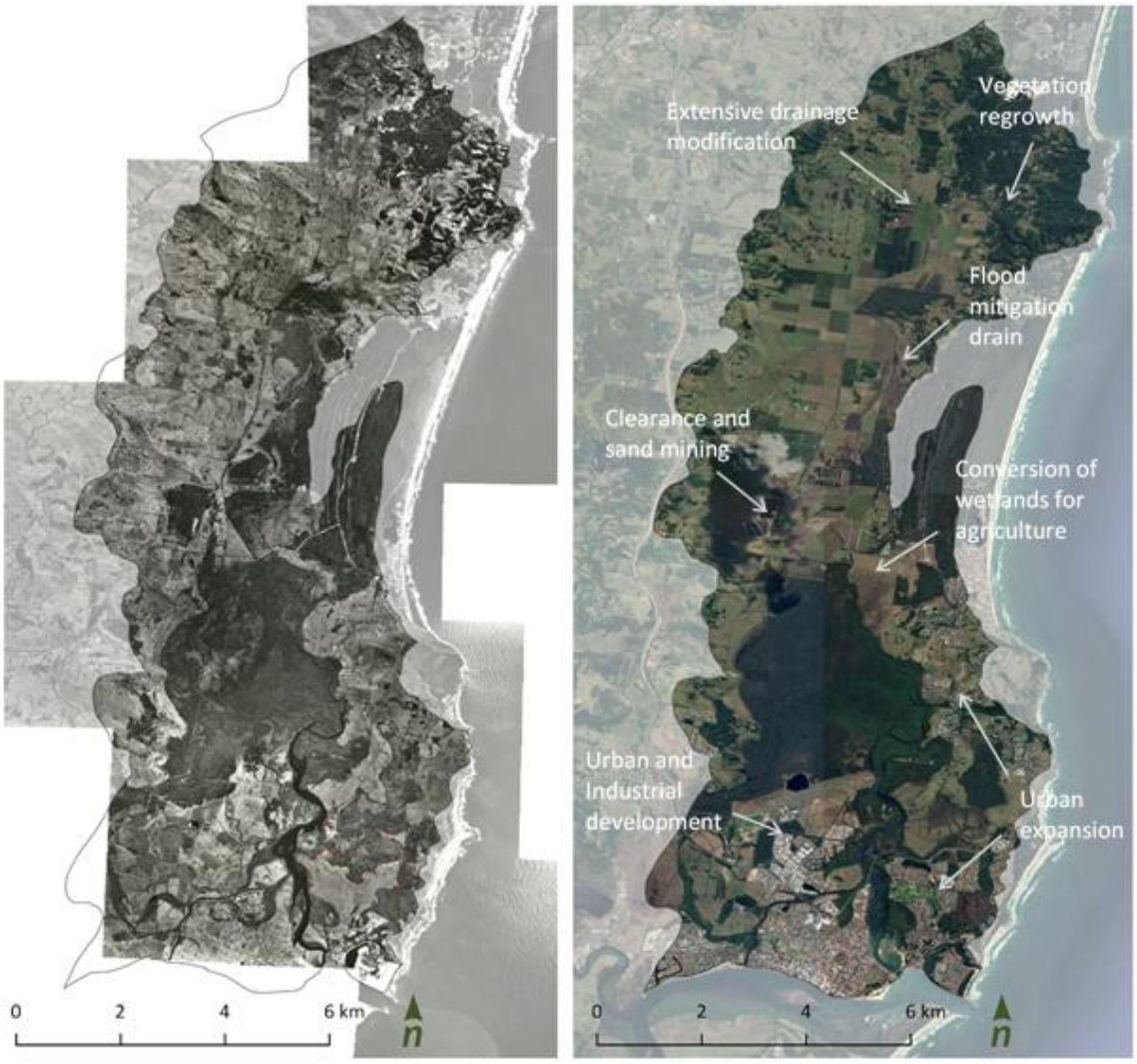


Figure 15. *Historical imagery highlights widespread change to the North Creek catchment between 1967 and 2017*

Figure 16. *Historical imagery reveals the degree of drainage modification within the central section of Newrybar Swamp since 1967. The 1967 imagery shows an array of swampy discontinuous watercourses which have been replaced by linear drains.*

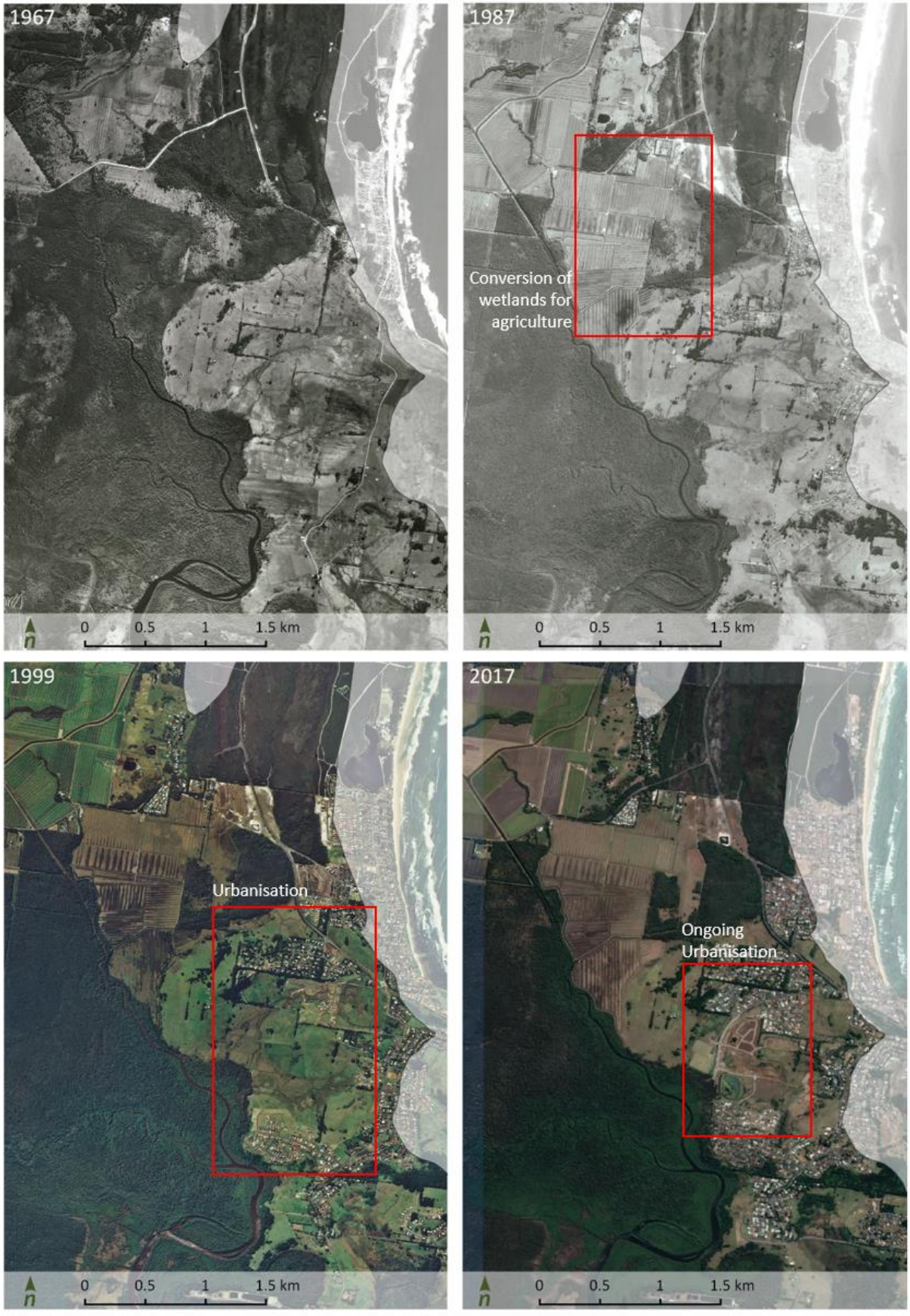


Figure 17. *Historical imagery from 1967, 1979, 1999 and 2017 illustrating land use change near Lennox Head*

3.4 Land use

Key points

- Present day landuse includes rural residential, horticulture and grazing, and increasing macadamia plantations and conservation areas
- Urban growth is increasing incrementally, with around 2 – 5% of the catchment classified as urban release/growth areas

Overview

Land use within the catchment has changed over time following the initial and extensive clearing of vegetation and subsequent drainage works (as discussed previously in Section 3.3).

Today, the slopes of the Alstonville Plateau and surrounding coastal uplands and headlands support rural residential and agricultural (horticulture and grazing) land uses (Figure 18.**Error! Reference source not found.**). The reclaimed floodplains of upper North Creek are primarily agricultural, including sugarcane, grazing and increasing macadamia plantations. Ballina Nature Reserve represents a significant percentage of the catchment (6.1 %). South of the reserve, Ballina airport and light industrial areas fringe the urban development of the Ballina township.

North Creek – linear drain in upper catchment (2018)

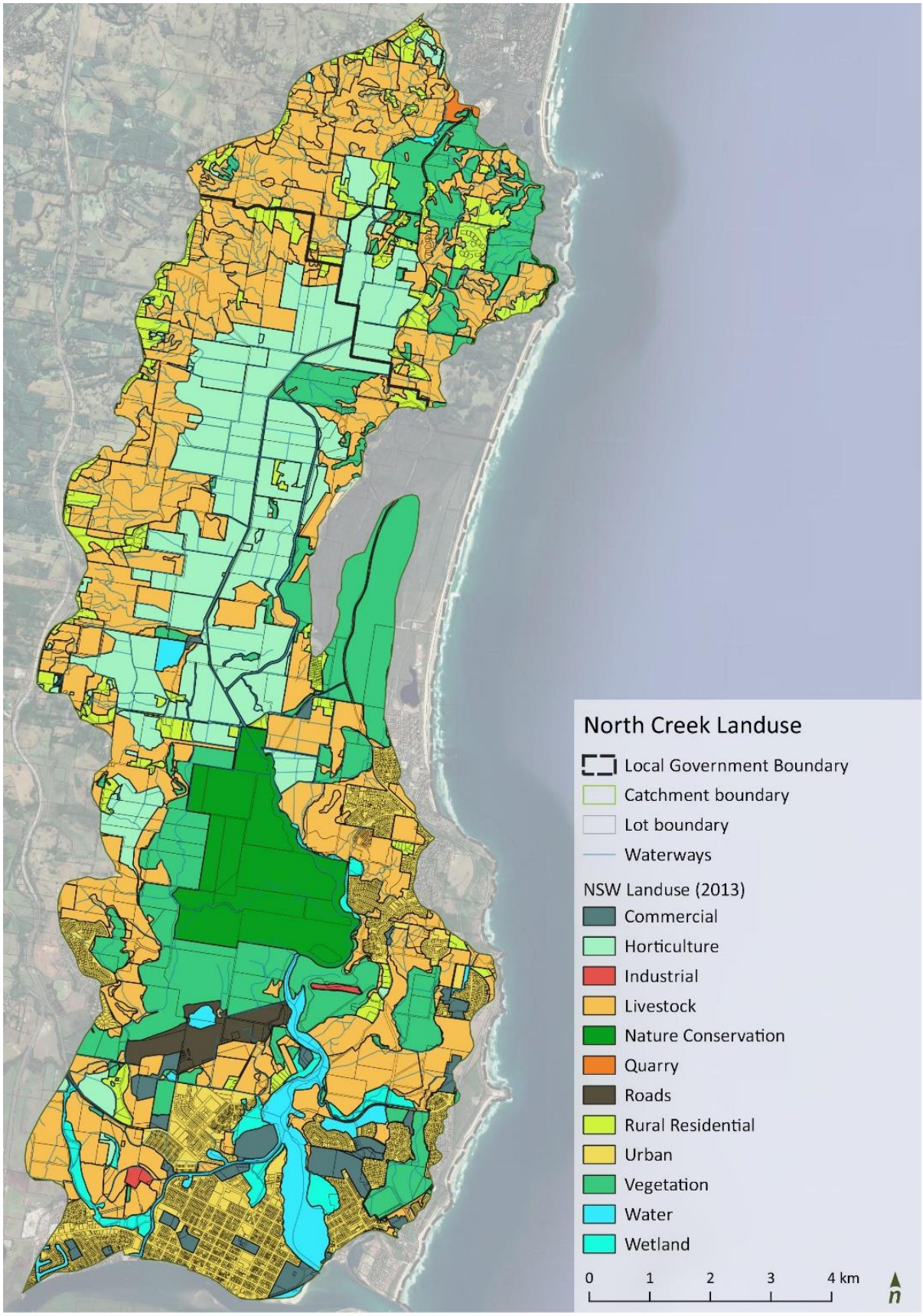


Figure 18. *A summary of simplified land use categories within the North Creek catchment.*

Trends in land use change

Land use data from 2007 (NSW DECC 2007) and 2013 (OEH 2017a) which covers the North Creek catchment was used to identify changes in the landscape which may be of significance to the development of the CMP. Descriptions for each land use type vary as both layers employ different classification schemes. While the difference in classification schemes limits a direct comparison, a summary of the general changes between 2007 and 2013 in the landscape is listed below (and the data is provided in Table 6):

- Urban coverage increased from 16.8 % (2007) to 18 % (2013)
- Total grazing area increased from 32.1 % (2007) to 35.8 % (2013)
- Sugar cane reduced from 17 % (2007) to 12.9 % (2013)
- Tree nut (Macadamias) coverage increased from 0.3 % (2007) to 3.8 % (2013) predominately in the upper catchment

Table 6. Land use data for the North Creek catchment from 2007 and 2013. Percentages displayed as the proportion of total catchment area. Different land use classification schemes were employed for 2007 and 2013, meaning that the percentage difference between the standardised categories used in this table may not be reflective of actual land use change (trend only). Land uses that generally increased in percentage are highlighted with orange text (blue for decrease).

2007 Land use			2013 Land use	
Area (Ha)	%		Area (Ha)	%
3596.8	33.0 %	Livestock ↑	3970.8	36.0 %
2161.1	19.8 %	Horticulture ↓	1929.8	17.5 %
2012.0	18.5 %	Vegetation ↓	1763.7	16.0 %
770.3	7.6 %	Urban ↑	1084.4	10.4 %
700.5	6.4 %	Nature Conservation ↓	681.8	6.2 %
491.1	4.5 %	Rural Residential ↑	597.2	5.4 %
330.8	3.1 %	Commercial ↓	331.1	3.0 %
220.8	2.3 %	Water ↓	219	2.2 %
214.2	2.0 %	Roads ↓	190.7	1.7 %
155.4	1.4 %	Industrial ↓	145.2	1.3 %
106.6	1.0 %	Wetland ↓	18.8	0.2 %
51.3	0.5 %	Quarry ↓	13.3	0.1 %

Urban growth

Assuming the growth rate of urban area from 2007 to 2013 as 0.2 % of the catchment per year (as per the above comparison), it is estimated that the current urban coverage sits at 19 % for 2018.

The 185 ha of Urban Release Areas constitute 1.7 % of the catchment and are provided for by Ballina Local Environment Plan (LEP). A further 588 Ha of Strategic Urban Growth Area (SUGA) contributes another 5.3 % of the catchment available for strategic urban development. The land adjoining these areas comprises of another 855 Ha or 7.8 % of the catchment, some of which overlaps with the Urban Release Areas. Most of these potential development areas fall largely within regionally significant farmland areas on fertile volcanic soils that top the Astonville Plateau, Lennox Head and Skennars Head. Therefore, there may be implications for future development for agricultural productivity in the region.

Future trajectory

With the population of the Ballina Shire growing at a rate of approximately 500 people per year, the North Creek catchment has been identified as an area to help accommodate this growth.

Continued urban development along the plateau and catchment hillslopes may have implications for:

- Some hillslope locations of mapped regionally significant farmland (DIPNR 2005)
- Aquifer recharge, the expression of springs along the basin and the native vegetation communities which depend on them
- Baseline nutrient inputs and surface freshwater flows
- Fauna movements.

Urban coverage increased at a rate of 0.2 % of the total catchment area per year between 2007 and 2013. While growth rates are rarely linear, if the growth rate is assumed constant, the Urban Release Areas and the Strategic Urban Growth Areas (which constitute 7 % of the catchment combined) would accommodate this rate of increase until 2050.

An increasing extent of tidal inundation by 2050 and 2100 is likely to have implications for existing and planned urban areas, farmland and assets and infrastructure within these land uses and tenures (Figure 19).

An initial high-level assessment of the projected increased impact of tidal inundation (HAT plus sea level rise extent) based on the CoastAdapt modelling has been considered for this scoping study (Figure 19, Table 7). Increased areas of agricultural land and urban areas are expected to be impacted by tidal inundation (e.g. up to a 50% increase for agricultural areas from 2050 to 2100, and a substantial increase in urban areas impacted). This overlay assessment is indicative only, based on a simple bucket fill model and broadscale elevation data (NCCARF 2018). A more detailed assessment of tidal inundation potential (hazard areas) would be beneficial for the CMP process. Impacts can be mitigated for these areas through targeted planning in the CMP.

Table 7. Indicative areas impacted by projected tidal areas (based on CoastAdapt modelling)

	Total Area inundated 2050 (ha)	Total Area inundated 2100 (ha)	Change (ha)	% change
Coastal Forest (Ballina Nature reserve)	1440	1535	95	7
Agricultural Land (hort)	521	799	279	54
Agricultural Land (livestock)	875	1021	147	17
Urban Area	156	568	412	265

One of the most significant land use changes within the catchment basin has been the transition from sugarcane to macadamia farming. Between 2007 and 2013, the area of sugar cane reduced by approximately 0.7 % (of the total catchment area) per year while macadamias increased by approximately 0.6 %. If these rates of transition are assumed constant, the total area covered by cane farms could be as low as 2 % of the catchment by 2030.

While there are multiple drivers and limitations to the rate and extent of this transition, the tidal inundation extents and projected variations in climate need to be taken into consideration as land use change continues. It is likely that increases in sea level will threaten the viability of agriculture in low-lying areas through changes in drainage, soil condition and groundwater dynamics. Understanding these impacts on different land use types will be necessary to understand how investments in land use change (e.g. macadamias) should be made in the future.

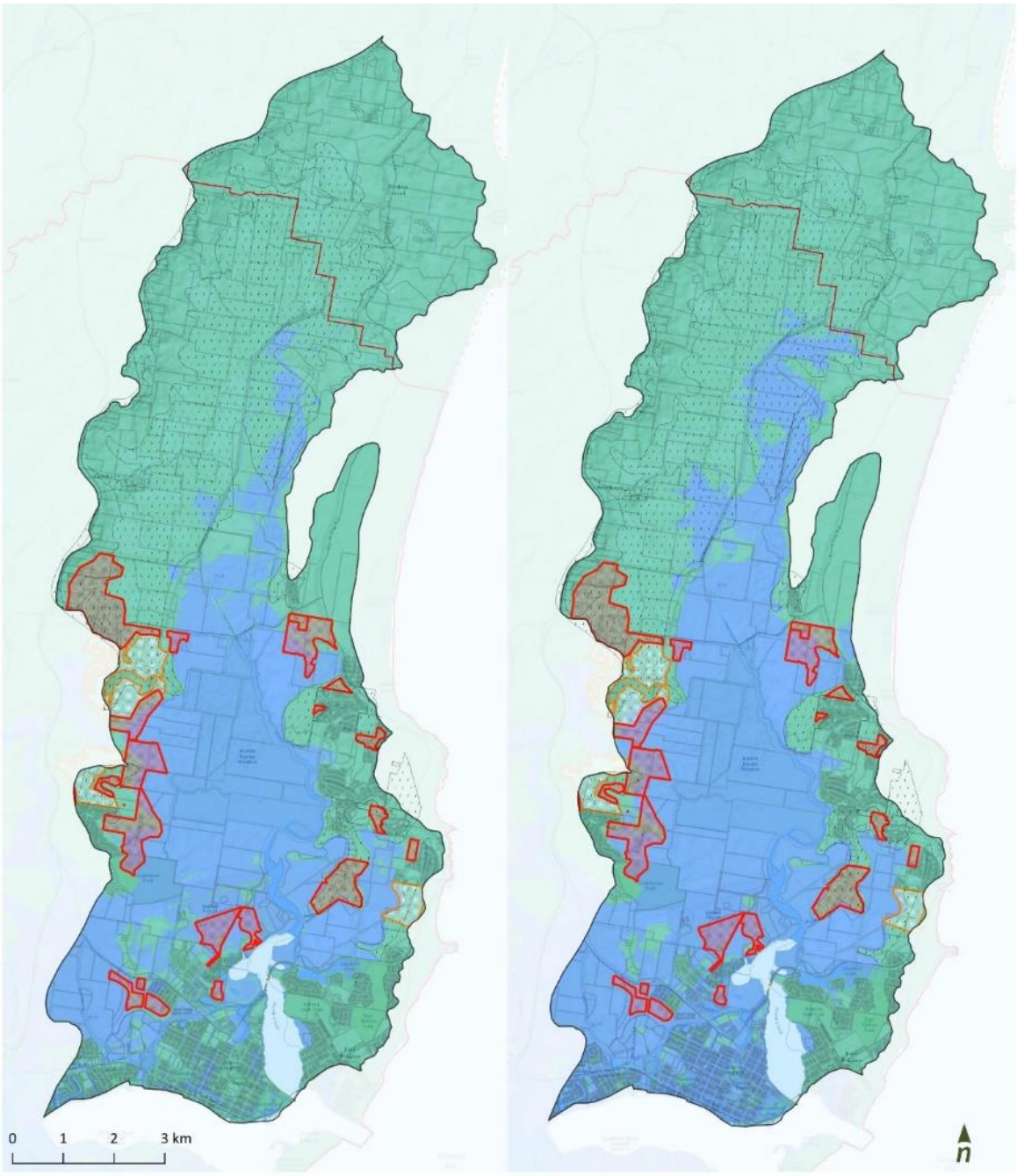


Figure 19. *Projected tidal inundation extents, planned growth areas and regionally significant farmland within the North Creek catchment (NCCARF 2018)*

3.5 Groundwater

Key points

> Groundwater levels are strongly influenced by tidal cycles across the mid and lower catchment

> The complex interaction between groundwater levels, tidal influence, recharge and water quality is a key management challenge for the North Creek catchment

Groundwater dynamics in the North Creek catchment have an important role in:

- Supporting agriculture and groundwater dependent eco-systems (GDEs)
- Regulating acid water discharge from acid sulfate soils (ASS)
- Influencing water quantity and quality as it flows downstream.

Aquifers and recharge
The catchment is host to two aquifers, the unconfined 'Alstonville' within the basalts of the Alstonville Plateau, and the 'Richmond Coastal Sands' within the catchment basin itself. Both are managed and protected by water sharing plans under the Water Act 2000. A radon mass balance study by Southern Cross University concluded that North Creek is groundwater dominated in its upper reaches above Ross Lane. This is linked to the relatively small catchment size, extensive drainage network and permanent spring discharge from the Alstonville Plateau (Atkins et al. 2013).

As noted previously, the catchment experiences a relatively high annual rainfall of ~1800 mm, much of which falls during the summer months (see Figure 10). Along the plateau, rainfall infiltrates through the well-draining soils, into the basalt aquifer beneath, and is expressed as numerous springs at the foot slopes of the escarpment, some of which are permanent.

The high rainfall and relatively small and flat catchment basin contribute to a groundwater level within the coastal sands which is relatively shallow, at around two metres deep. The extensive drainage network which cuts through this shallow aquifer, enables groundwater to flow into the drains (Atkins et al. 2013). Both these factors contribute to a permanent freshwater recharge of the upper reaches of North Creek (before the bifurcation of the Union and Flood Mitigation Drains).

Tidal influence
The penetration of the tidal wedge along the creek also influences groundwater dynamics. The tidal water mixes along the North Creek estuary to just north of Ross Lane, however the overall height of the creek can raise as much as 0.7 m (by tidal influence) a further 6 km north (Atkins et al. 2013).

This fluctuation of the water level across the drain network creates a pumping effect, where the groundwater surrounding the drains is raised and lowered with each tidal cycle. As the tide lowers, groundwater flows back into the drain, drawing with it the chemical characteristics of the surrounding soil water. The drain network therefore receives a chronic discharge of acidic groundwaters sporadically throughout the catchment wherever the acid sulfate soils occur (Atkins et al. 2013). Under flood conditions, this pumping effect is overprinted by the complete saturation of the subsoil, leading to a large pulse of acidic water into the drains and subsequent dilution depending on flood magnitude.

The supporting study for the proposal of McGeary's sand mine (Enviro Solutions 2017) found that groundwater levels upstream of the tidal gates show indications of daily fluctuations in response to the nearby Union and Mitigation Drains. The four-week study, which measured water quality and groundwater levels across six boreholes to asses variation across the proposed site, included the following observations:

- Groundwater levels were typically 1-3 m below ground level and exhibit daily fluctuations in response to the tidal influence within nearby Union and Mitigation Drains.

- Low permeability coffee rock within the coastal dune and beach deposits is largely discontinuous through the soil profile.
- Iron cemented and clay layers within the shallow aquifer (the Richmond Coastal Sands Groundwater Source) act as partial barriers to vertical flow and as such can form perched aquifers.
- Groundwater level response to rainfall is rapid given the porosity of the sandy deposits.
- Groundwater is moderately acidic, with an average pH of 4.2.
- Electrical conductivity (EC) ranges from 56-1,560 µS/cm.
- Concentrations of arsenic, nickel and zinc exceeded one or more national screening levels adopted for the protection of freshwater and marine ecosystems and drinking water.
- Elevated nitrogen levels were found (mostly organic) and metals in groundwater may be related to the addition of fertilisers.

Knowledge gaps

This complex interaction between groundwater levels, tidal influence, recharge and water quality, is not well understood, and will continue to be a key management challenge for the North Creek Catchment, particularly with rising sea levels in the future that will extend the tidal influence further inland.

North Creek – lower estuary

3.6 Ecology

Key points

- Threatened ecological communities within the North Creek catchment include Coastal swamp oak forest, Littoral rainforest and coastal vine thickets, and Lowland rainforest
- There are a number of species and ecological communities that are vulnerable to a changing catchment and coastal processes, land use and climate change impacts

Threatened, protected and migratory species

The 'Protected Matters Search Tool' was employed to identify species protected under the Environment Protection and Biodiversity Conservation Act 1999 within the North Creek catchment.

The search identified a total 87 threatened species and 77 migratory species within the catchment and its immediate surrounds (1 km buffer). The list included six critically endangered birds; the regent honeyeater, curlew sandpiper, the great knot, the swift parrot, the northern Siberian bar tailed godwit and the eastern or far eastern curlew, a critically endangered insect (Australian fritillary) and gastropod (Mitchell's rainforest snail) (DEE 2015).

The NSW 'Bionet' database search tool was also employed to identify the potential threatened and protected species within the catchment (OEH 2018e). The query identified a total of 1739 listed animal and plant species within the catchment and a one-kilometre buffer zone. Of these, 364 were listed as protected, 79 vulnerable & protected and 40 as either endangered or critically endangered. Critically endangered species included birds; the red goshawk and the beach stone curlew, and one critically endangered plant; the coastal fountainea. Other endangered fauna and flora included the: giant barred frog, Davidson's plum, hairy quondong, spider orchid, southern swamp orchid, basket fern, flat fork fern and the small-leaved tamarind. The EPBC Protected Matters report is provided in Attachment B.

Widespread clearing, agriculture and flood mitigation works across the North Creek catchment have contributed to the fragmentation of terrestrial and aquatic ecological communities and habitat, however important remnant and restored areas are present, as discussed below.

Terrestrial ecology

Three threatened ecological communities are located within the catchment. These are the Coastal swamp oak forest of NSW, the Littoral rainforest and Coastal vine thickets of Eastern Australia, and Lowland rainforest of Subtropical Australia (DEE 2017). Areas of Coastal swamp oak lie mainly within the Ballina Nature Reserve (BNR) and the latter two threatened communities are distributed predominantly within sections of 'Littoral rainforest' which are highlighted in red in **Figure** 20**.** It is possible that further detailed mapping of areas listed as 'residual native cover' and areas listed as 'Other' in **Figure** 20 may identify previously unknown pockets of these communities, such as the pockets of coastal littoral rainforest identified within the proposed McGeary's sand quarry (Parker 2017).

The largest contiguous zone of protected native vegetation is contained within the BNR, which makes up six percent of the catchment. The reserve hosts the 'Coastal swamp oak forest' threatened ecological community, as well as mangrove forest wetlands and salt marsh complexes, all of which provide refugia for a variety of native flora and fauna and exotic species. Threatened species recorded in the reserve include Osprey (*Pandion haliaetus*), Mangrove Honeyeater (*Lichenostomus fasciogularis*), Black Flying Fox (*Pteropusalecto*), Grey-headed Flying Fox (*Pteropus poliocephalus*) and Little Bent-wing Bat (*Miniopterus australis*) (NPWS 2003).

The extents of both Coastal Wetlands and Littoral Rainforests within the North Creek catchment under the Coastal Management SEPP have been determined by recent state-level vegetation mapping. Within the North Creek catchment approximately 20 km² is classified as Coastal Wetland. This includes large areas of the North Creek estuary, the Ballina Nature Reserve and Birrung Creek area to the east of Byron Bay Road. Three small areas of Littoral Rainforest areas comprising a total of 0.8 km² are located in the east of the catchment near

Birrung Creek, north of Skennars Head Road and along the upper reaches of Midgen Creek near Broken Head reserve.

The hydrology and ecology of the BNR has been significantly altered since European settlement. Increased catchment runoff, sedimentation, ad-hoc drainage works, disturbance of acid sulfate soils and introduced flora and fauna (pigs) have significantly changed and continue to change the wetland system. As a result of these changes, sections of the BNR, which also contains the threatened ecological community – the Coastal swamp oak forest – has experienced dieback. Weed infestations also continue to proliferate within the largely inaccessible reserve.

The decline of koala populations across north east NSW has been attributed to the reduction of suitable habitat and pest species (e.g. wild dogs). Remnant primary and secondary koala habitat has also been noted in sections of the North Creek catchment (BSC 2017a). While North Creek catchment does not contain a significant number of koalas, the populations that do occur have been identified within proximity to the development areas in the Cumbalum and Ballina East precincts. The proximity of these areas increases the risk of further koala population decline through interaction pest species / domesticated animals. The remaining habitat areas within the catchment are small fragmented patches with restricted opportunities for improved connectivity. While extensive 'potential' habitat exists within low lying areas surrounding Ballina Nature Reserve, their long-term potential may be limited by the impacts of projected sea-level rise.

Seagrass, salt marsh and mangrove communities

The historic modification of the waterways has impacted upon the extent and health of the seagrass, salt marsh and mangrove communities of North Creek. These communities provide several key ecological functions for the estuary, including feeding grounds for fish and habitat for a range of native fauna and flora, some of which are threatened (Hydrosphere 2011). A significant proportion of the salt marsh which exists within the catchment is protected within Ballina Nature Reserve. Elsewhere, salt marshes exist along tributaries where protection is available behind fringing mangrove communities (such as Little Fishery Creek) (**Figure** 20**.** These salt marsh communities, in conjunction with the adjacent estuarine sand shoals, provide key feeding, roosting and nesting areas for 19 species of shorebird, seven of which are threatened (Hydrosphere 2016).

The oyster reef at North Creek immediately downstream of the Prospect Bridge is an important ecological asset. An in-press study has shown that the North Creek oyster reef and seven other remnant Sydney Rock Oyster reefs bear distinct assemblages of macroinvertebrates with 30 % higher densities, five times the biomass and almost five times the productivity of adjacent bare sediments (McLeod et al. 2019)

Seagrass meadow distribution will vary within most estuaries depending on habitat stability and water clarity. The most common species within the Richmond River and North Creek system is the fast growing *Zostera Muelleri* subsp. *Capricorni* (ABER 2008). Three species of marine turtle are known to forage in this type of habitat; the Loggerhead turtle (*Caretta caretta*); Leatherback turtle (*Dermochelys coriacea*) and Green Turtle (*Chelonia mydas*) are also potential visitors to North Creek (Hydrosphere 2016). Historical modifications of the North Creek channel have led to variations in the seagrass communities over time, however mapping suggests that seagrass coverage increased between 1942 and 2000 (ABER 2008). Recent assessments of seagrass health within the North Creek estuary have been limited due to boat access restricted to the Creek's main channels (Ryder et al. 2015). Further mapping of all three communities by DPI Fisheries in 2019 will provide enhanced understanding of macrophyte distributions in the near future.

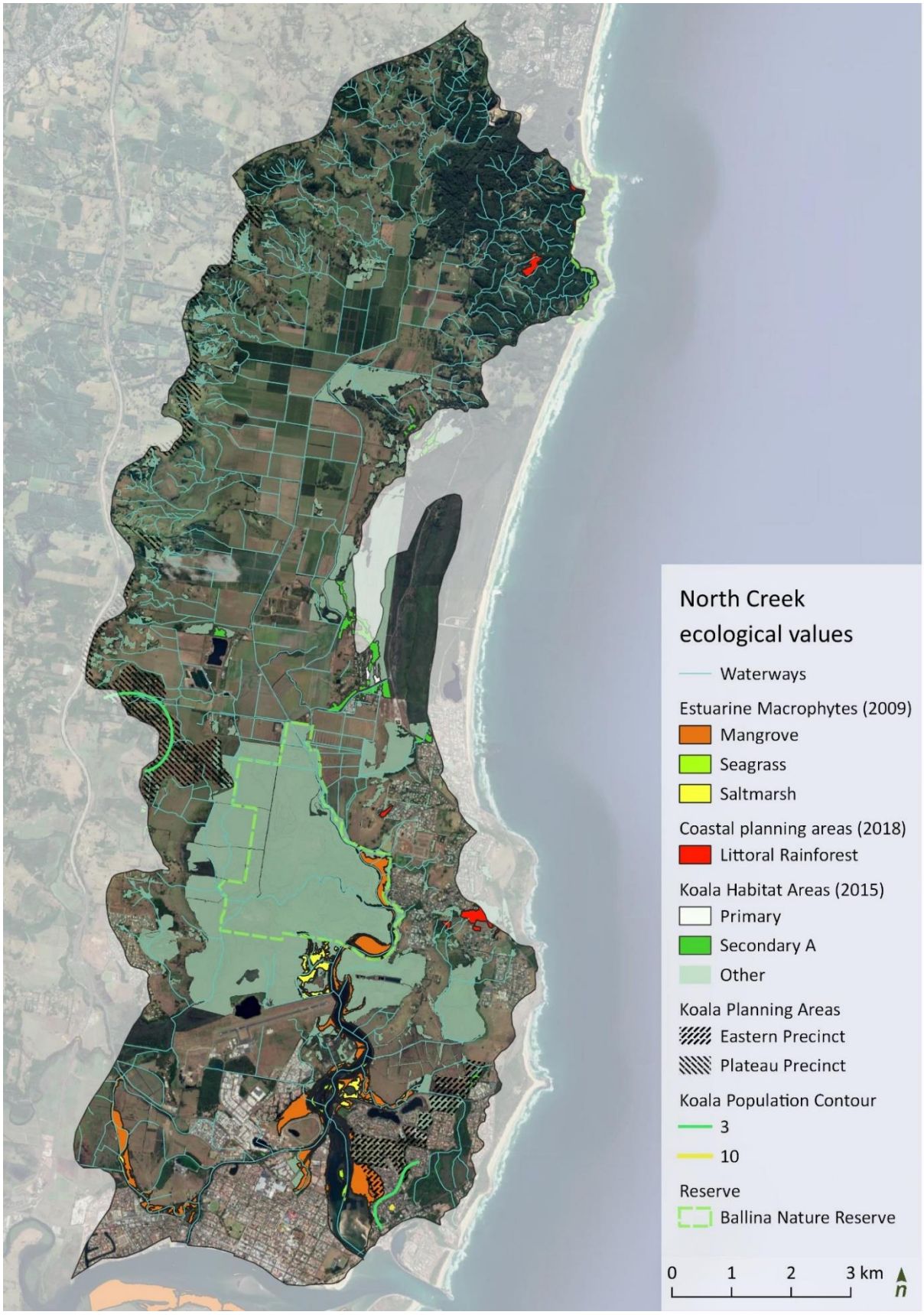


Figure 20**.** *A collage of ecological values within the North Creek catchment (Creese et al. 2009; BSC 2017; DPE 2018)*

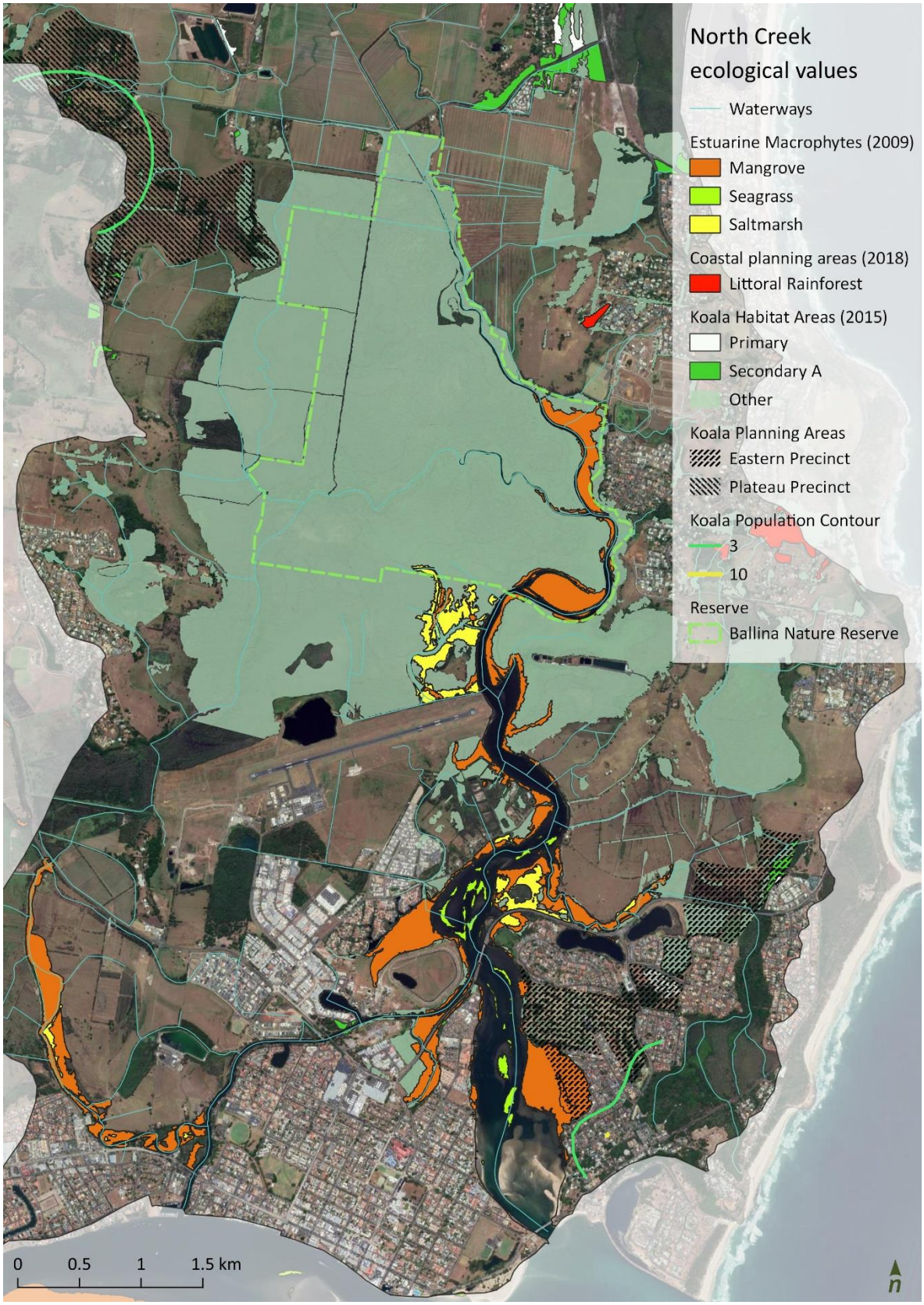


Figure 21. *A closer view of the mapped ecological values in the southern half of the North Creek catchment*

3.7 Catchment runoff and water quality

Key points

- The modified nature of the North Creek catchment and floodplains, including past vegetation clearing, planting of exotic species, and the low gradient drainage network, creates a challenging environment for managing water quality
- Poor water quality through the drainage network has contributed to fish kill events and a decline in the oyster production
- Agricultural runoff is the primary source of diffuse pollutant loads
- There is (modelled) potential for significant pollutant generation from both urban and rural areas during runoff events
- There is a need for, and opportunity to, enhance water quality monitoring across the catchment to better inform future management activities and priorities.

Modified catchment setting

The heavily modified nature of the North Creek catchment creates a physical and hydrological environment which lends itself to poor water quality.

The widespread clearing of floodplain vegetation has removed flood adapted species which would typically withstand periods of inundation. Native species have been replaced by poorly adapted exotic species which are more likely to die (due to inundation), and subsequent plant decomposition and accumulation in the drain network contributes to lower dissolved oxygen levels (Hydrosphere 2011).

The drainage process from the floodplain is slow due to the low gradient of the topography and vegetation, often taking many days following an event (Enviro Solutions 2017).

Blackwater events

Under flood conditions, the extensive drain network facilitates the outflow of these drain waters, which can deliver masses of decomposing and deoxygenating material all at once to produce what is otherwise known as blackwater. In conjunction with antecedent conditions which were particularly dry, blackwater events were a major contributor to the fish kills of 2001 and 2008 within the greater Richmond River system, including North Creek (Wong et al. 2010, 2018). Anecdotal reports by local fishermen indicate an observed reduction in fish numbers within the North Creek estuary in recent times. Reductions in water quality impact fish and other aquatic fauna, causing death, disease, limiting survivorship of juveniles and act as a behavioural barrier.

Persistent poor water quality

Frequent episodes of poor water quality will persist in the lower reaches of North Creek following rainfall. The exact reason for this is unclear, however it is likely to be a combination of several issues. Water flow through the extensive drain network is restricted by the low gradient on the floodplain. This leads to stagnation under drier conditions and an increased opportunity for the accumulation of pollutants from the adjacent agricultural land (ABER 2008; Hydrosphere 2011). Conversely, under wetter conditions, the drain network can also facilitate the export of nutrients and sediment into the main channel.

Chronic discharge of acid water also reduces the pH of these waters, this is in part due to the groundwater dominance of the catchment as described earlier. The pH typically decreases progressively upstream (ABER 2008). The drains which cut though larges sections of acid sulfate soils facilitate the expression of acidic groundwater as it passes through oxidised acid sulfate soils (ABER 2008; Atkins et al. 2013). Groundwater outflow increases the overall tidal peak within the drains as it intercepts the incoming tide. This temporarily raises groundwater levels, thus increasing the amount of disturbed acid sulfate soils that is drained with each tidal cycle (Atkins et al. 2013). Furthermore, acid sulfate soil runoff affects the upper reaches of the North

Creek estuary during smaller runoff events during the wet season when groundwater levels are relatively high (Hydrosphere 2011).

Mono-sulfidic black ooze

The drains within catchment basin have a high supply of organic matter in both particulate and dissolved forms. The combination of stagnant water, acidic groundwater ingress and organic matter creates a favourable environment for low oxygen environments to develop. In combination with iron and sulfur from acid sulfate soils areas that are also likely to enter drains, these factors would appear to provide ideal conditions to promote the formation of "Mono-sulfidic Black Ooze" (MBO). While MBO production has been well documented in the Tuckean swamp, some 25 km southeast Ballina, the conditions described suggest that its occurrence within the North Creek catchment is possible (Hydrosphere 2011).

If MBO is discharged into the lower estuary during small runoff events (i.e. without sufficient flushing), it can cause severe oxygen depletion which is likely to be a significant stressor on oyster health. While the direct linkage between MBO and QX disease has not been established, anecdotal evidence suggests that there is a relationship between MBO release and QX disease outbreak. Observations noted by oyster famers are that outbreaks typically correlate with the outflow of drain waters after rain events – when outflows are not large enough to flush the entire system but just enough to push the stagnant waters into the estuary.

Nutrients and contaminants

Over the past two decades, oyster leases within the lower North Creek estuary have suffered several harvest closures. Extending for up to 9 months of the year, these closures were primarily due to rainfall exceedances, high levels of nutrients and faecal coliforms associated with catchment runoff during the 2001 and 2008 flood events (Hydrosphere 2011). Ryder et al. (2015) suggests that contaminants were likely sourced from agricultural and urban runoff and the STP, which was replaced by the Ballina recycled water treatment plant in 2016. Wastewater that is not re-used is released by the plant back into the North Creek canal on the ebb tide, having a negligible impact on nutrient and algal biomass (NSW Water Solutions 2009). Faecal coliforms are likely to persist in the creek, given the presence of drains open to grazing cattle and that chronic turbidity inhibits the sterilising effect of sunlight as it penetrates the water-column.

The floodplain drainage patterns have the potential to exacerbate deoxygenation of the estuary by acting as a conduit for water with low dissolved oxygen (DO) (Hydrosphere 2011). It has been shown that DO decreases progressively upstream which is driven by low oxygen swamp and drain inputs. Additionally, humic rich and tannin rich waters of the upper catchment, combined with high temperatures and high TN levels which are not necessarily available for plant uptake are expected drivers for summer algal blooms (ABER 2008). This influences the DO concentrations, along with longer flushing times in the mid to lower estuary (ABER 2008).

Snapshot monitoring

Figure 22. and Figure 23. provide a snapshot into the water quality conditions of the North Creek estuary near the Ballina Airport during the month of June and provide an example of the biochemical dynamics described above. The figures show how a large rainfall event during mid-June caused a shift from saline to fresh conditions within the estuary. During this time pH levels lowered and DO levels dropped to levels around 3-4mg/L, which are potentially hazardous to aquatic life (RCC 2017). If this rainfall event occurred during the warmer months, the likely result would be a greater reduction in DO. Note the small rainfall event on the 30th of June was also associated with a spike reduction of DO to within this hazardous range.

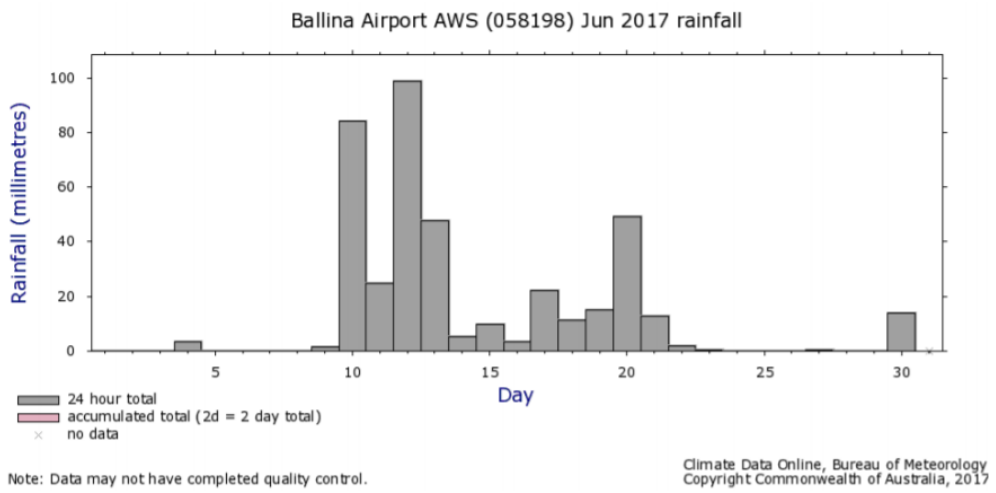


Figure 22. *Rainfall recorded at Ballina Airport over the month of June 2017 (BOM 2018).*

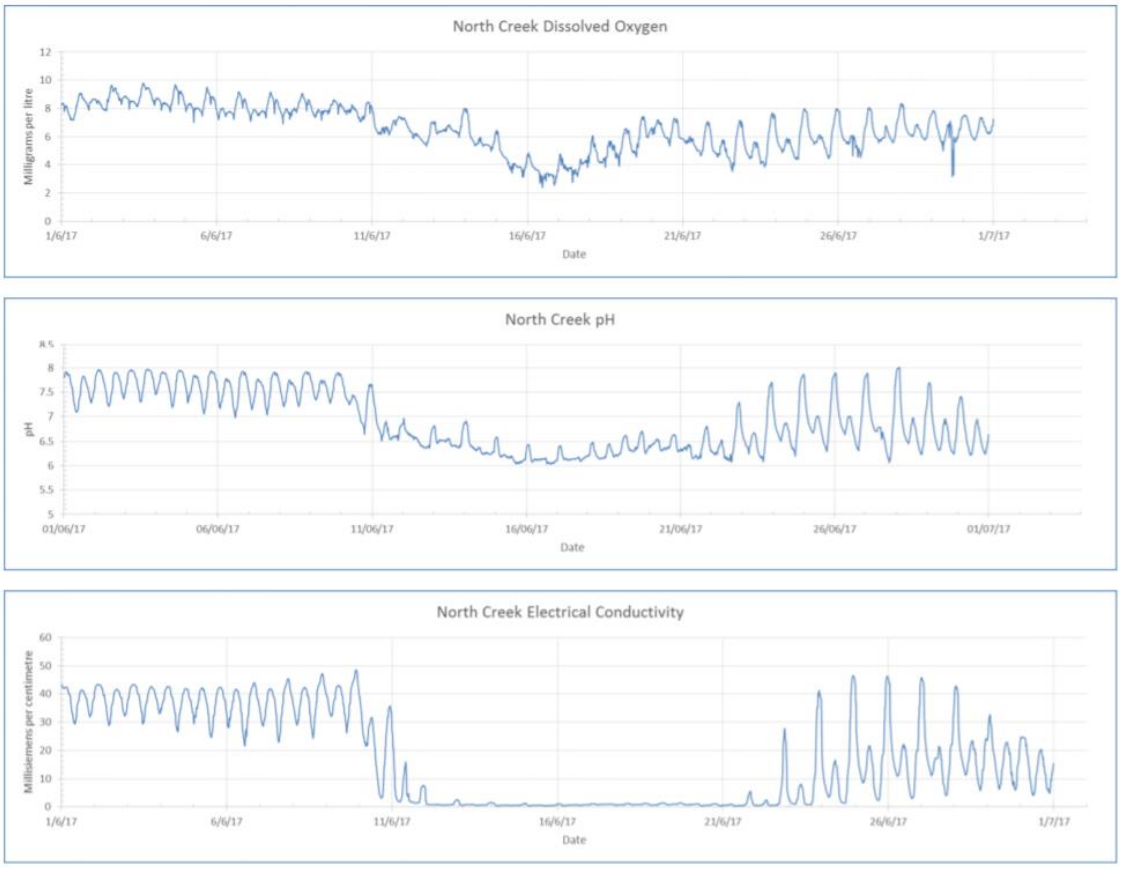


Figure 23. *Rous County Council Data Logger water quality plots for June 2017 (near Ballina airport) (RCC 2017).*

In addition to the Rous County Council water quality data, the Eco-health monitoring program (2014-15) provided the most recent analysis of surface water quality across multiple sample points within North Creek system. Exceedances of ANZECC trigger thresholds were common for all five sample sites in North Creek. The consistently low pH and DO readings likely relate to drainage modification and the presence of acid sulfate soils as previously explained. The monitoring program also observed high levels of suspended solids which remain in suspension for the length of the estuary (Ryder et al. 2015).

Catchment runoff / water quality modelling

There is substantial anecdotal and recorded information that indicates agricultural and urban development, drainage works and disturbance of acid sulfate soils has degraded (and will continue to degrade) water quality within the North Creek estuary. However, to date there has been limited modelling or monitoring that helps determine the catchment drivers of poor water quality (and their spatial and temporal variations). As part of this scoping study, a new Rapid Catchment Assessment (RCAT) model of the North Creek catchment was developed to help identify likely risk areas for generation of four common pollutants.

The model utilises runoff water quality data from different land uses to estimate the contaminants contributed to a waterway based on the proportion of land use types within its catchment. The modelling estimates that substantial pollutant generation (i.e. Total Nitrogen (TN) and *E. coli*) occurs within the agricultural areas upstream of Ross Lane (Figure 24.) and that higher density urban areas also contribute considerable pollutant loads, namely Total Phosphorous (TP) and Total Suspended Solids (TSS). The full results of the RCAT modelling are summarised in the Water Quality Monitoring Plan (Attachment F).

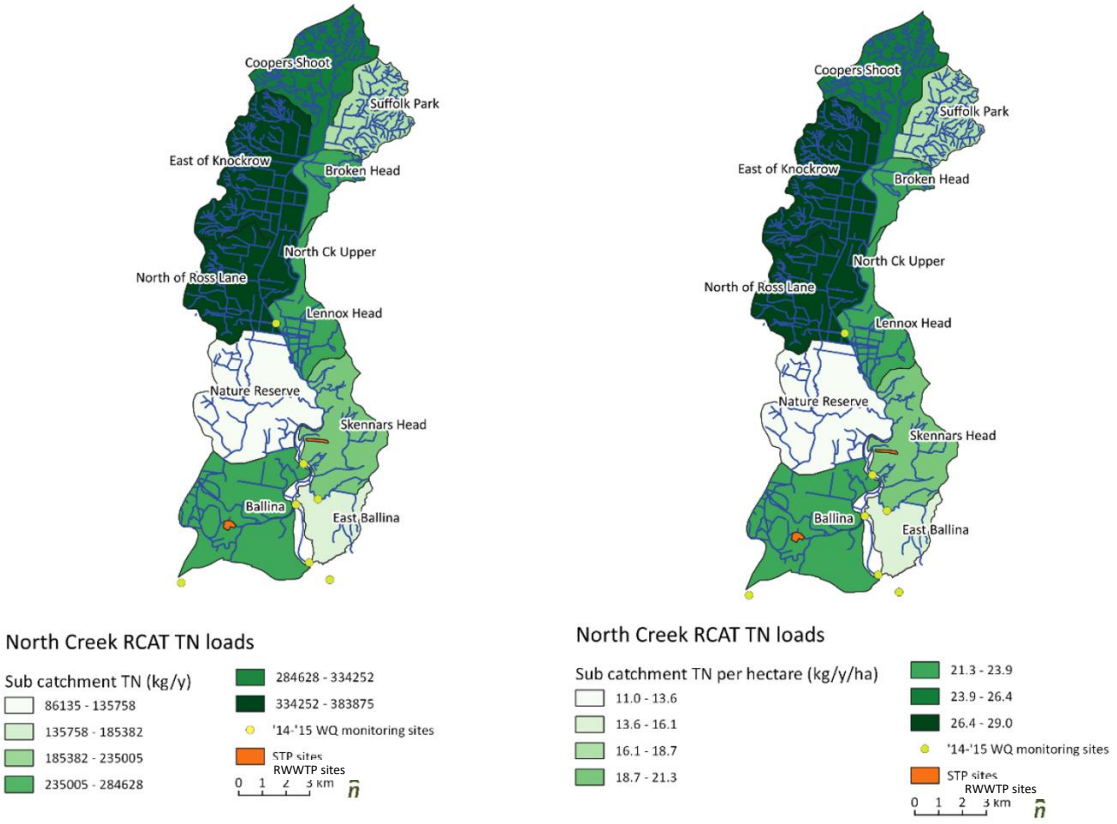


Figure 24. *Estimated TN loads within the North Creek catchment.*

The RCAT modelling highlights the potential for significant pollutant generation during runoff events from both urban and rural areas, though given previous studies have also inferred that groundwater sources are dominant, the relationship between surface runoff and groundwater contributions will need to be better defined in the future.

The extensive drainage work through the catchment has created predominately perennial waterways which interact with groundwater sources rather than just being conduits of surface runoff. This ongoing interaction is different to that which would have occurred under wetland back barrier environmental conditions. The informally planned floodplain drains draw groundwater from surrounding soils and also expose acid sulfate soils (where present) to oxygen, this lowers the pH of groundwater as well as the surface waters into which it flows. Given that the drains have periods of low or no flow but still hold water, these conditions allow for the processing of organic compounds which, in the presence of acidic water, can lead to anoxic or even anaerobic conditions. As noted previously, there is also the possibility of MBO production within the catchment.

Rubbish
The illegal dumping of rubbish is a priority concern for the community. The Ballina Shire recognises pollution (rubbish) as a significant financial, environmental and social problem and incurs significant costs for the investigation, collection and disposal of illegally dumped material.

Household, garden, building and commercial waste introduces chemical and physical pollution into the catchment and its waterways. Green waste can spread exotic weeds and pests, create a fire hazard, while hazardous materials can contaminate waterways, soil and degrade the surrounding environment. Litter and hard rubbish impact on the catchment's scenic amenity, trap and kill local wildlife, some of which are threatened.

Illegal dumping is known to occur along the fringes of Ballina Nature Reserve. As development within catchment progresses and regional population increases the threat posed by illegal dumping is likely to increase.

Summary points
Some specific points noted from the existing literature and data, which relate to water quality challenges in the North Creek catchment include:

- Agricultural land use is a major source of diffuse pollutant loadings (Hydrosphere 2011).
- Extraction of groundwater to a depth of 20 m at the Ballina Shire Council sand quarry south of the Ballina Nature Reserve may impact the hydrological conditions of the reserve as well as exacerbate acid sulfate soil oxidation (NPWS 2003).
- Humic rich and tannin rich waters of the upper catchment combined with high temperatures are expected drivers for summer algal blooms (ABER 2008), and high TN levels which are not necessarily available for plant uptake.
- Floodplain drainage has the potential to exacerbate deoxygenation of the estuary by acting as a conduit for water with low dissolved oxygen (DO) (Hydrosphere 2011).
- Dissolved oxygen also decreases progressively upstream and is driven by low oxygen swamp and drain inputs. DO concentrations are influenced by high dissolved and particulate loads in relation to humic groundwater inputs, leaf litter fall and summertime phytoplankton blooms (ABER 2008).
- Longer flushing times likely enhance hypoxia (oxygen deficiency) in the lower to mid estuary (ABER 2008).
- pH generally decreases progressively upstream. Chronic acid groundwater discharge from the incised drain network is the likely driver (ABER 2008).
- Acid sulfate soil disturbance has resulted in chronic and acute discharges of acid and associated pollutants (ABER 2008).
- Acid sulfate soil runoff affects the upper reaches of North Creek estuary during smaller runoff events in the wet season when groundwater levels are relatively high (Hydrosphere 2011).
- Sections of the drain network coincide with sections of the Tuckean soil-landscape within the North Creek catchment. Some of these drains are suitable environments for the development of monosulfidic lack ooze (MBO), which has the capacity to rapidly deoxygenate water and damage waterway ecology (Hydrosphere 2011).
- Groundwater near McGeary's sand mine is moderately acidic, with an average pH of 4.2 and an EC from 56-1,560 µS/cm (Enviro Solutions 2017).
- Arsenic, nickel and zinc exceeded one or more national screening levels adopted for the protection of freshwater and marine ecosystems in the bores near the mine (Enviro Solutions 2017).

- Elevated nitrogen levels (which are mostly organic) and metals in groundwater may be related to the addition of fertilizers (Enviro Solutions 2017).

Trajectory
Left to persist, the catchment runoff and water quality issues outlined above are likely to contribute to the ecological decline of the system and consequently the social, economic and ecological values. Poor water quality is likely to impact tourism, recreation and biodiversity, particularly in its ability to provide scenic amenity, a clean and safe environment for people and wildlife, its ability to support oyster culture and act as a nursery for the local, pelagic and migratory species. This in turn can impact the opportunity for growth of industries which rely on these benefits, such as development and tourism.

Knowledge gaps
There is limited modelling or monitoring data that help in determining catchment drivers (and their spatial and temporal variations) of pollutant generation. The RCAT modelling undertaken for this study highlights the potential for significant pollutant generation during runoff events from both urban and rural areas, however this is yet to be confirmed with detailed monitoring.

Furthermore, there is a lack of understanding of the interactions with Richmond River estuary. Following rainfall events, pollution generation within North Creek catchment is likely to degrade water quality the North Creek estuary. However, during ambient conditions tidal exchange between the Richmond River and North Creek estuaries may have a significant impact on water quality. The relative role of catchment runoff in North Creek and tidal exchange with the Richmond River estuary on the overall water quality within the North Creek estuary is not fully understood.

A Water Quality Monitoring Program (WQMP) (Attachment F) will be implemented as part of Stage 2 to determine the linkage between catchment processes and poor water quality in the estuary. The WQMP will also monitor oyster health to assess the water quality drivers of impacts on fisheries (such as QX disease in oysters). The WQMP would aim to:

1. Determine the variation in water quality parameters throughout the North Creek catchment to help identify the areas of the catchment where excessive pollutant generation is occurring

2. Determine the relevant impact of ambient conditions (i.e. anoxic conditions developing in pooled water within drains from groundwater ingress) or runoff events on water quality

3. Identify the water quality parameters in the estuary which increase the susceptibility of oysters to QX disease

Monitoring is to be undertaken for a minimum of 18 months but ideally up to three years to help understand seasonal variations. If there are budget constraints less frequent monitoring can be undertaken (i.e. bimonthly) across more sites (i.e. including either representative sub catchments or all sub catchments) as opposed to more frequent monitoring along the main stem of North Creek only. Sampling within the sub catchments can help identify the source of water quality issues. Sampling in North Creek alone would still provide insight however tidal processes are likely to mean identifying the sources of water quality issues will be more difficult.

The WQMP can help identify where excessive pollutant generation is occurring within the catchment. The outcomes can help improve the risk assessment in Stage 2 and identify priority sub-catchments for water quality improvement works (to be developed as part of Stage 3).

Development of Source Catchment model of surface and groundwater pathways using outputs from a hydrodynamic model and WQMP data would ultimately provide the best approach to asses pollutant pathways through the catchment.

3.8 Dredging and sand mining

Key points

- Sand shoals in the lower estuary have been extensively dredged to allow ship navigation
- The feasibility of dredging in lower North Creek is being considered to provide a sand resource, to improve navigability, and to increase tidal flushing and improve water quality in North Creek
- Sand mining may exacerbate acid water discharge into North Creek

Shoals

The development of sand shoals within the lower North Creek estuary is a natural process as evidenced by early parish mapping of the Richmond River mouth and the North Creek estuary (Figure 25). These shoals provide important habitat and food for migratory shorebirds and juvenile fish species. Extensive dredging has been undertaken in the past to allow for ship navigation and the economic development of the region. The most recent dredging activity was undertaken in 1990s (Hydrosphere 2016). The subsequent redevelopment of sand shoals in the estuary has raised interest in the possibility of further dredging, with the completion of a scoping study (Hydrosphere 2016) and feasibility study (Hydrosphere 2018).

Figure 25 *The 1887 Ballina parish map overlying recent aerial imagery indicating extensive shoaling.*

Dredging aim, and risks and benefits

The 2016 scoping study outlines the aims, risks and potential benefits related to dredging in the estuary (Hydrosphere 2016). The primary aim of dredging North Creek is to provide a sand resource, to improve navigability and to increase tidal flushing and hence improve water quality in North Creek (Hydrosphere 2016). The subsequent feasibility study (Hydrosphere 2018) found that areas A, B and D will yield suitable material for development fill, as per Figure 26. The key risks from dredging activities include:

- The targeted sediment volume for dredging is up to twice the annual littoral sediment transport rate along the Ballina coastline, which will influence coastal sediment dynamics.
- Potential risk to key roost areas and foraging grounds for several species of shorebirds which are favoured by a range of stakeholders.
- Limited flexibility in the selection of a dewatering location, which will require agreements to be made with landholders adjacent to the Southern Cross Industrial Estate.
- The presence of acid sulfate soils in the majority of proposed dredging areas, which will require an acid sulfate soil management plan under the NSW ASSMAC Acid Sulfate Soils Assessment Guidelines (1998).

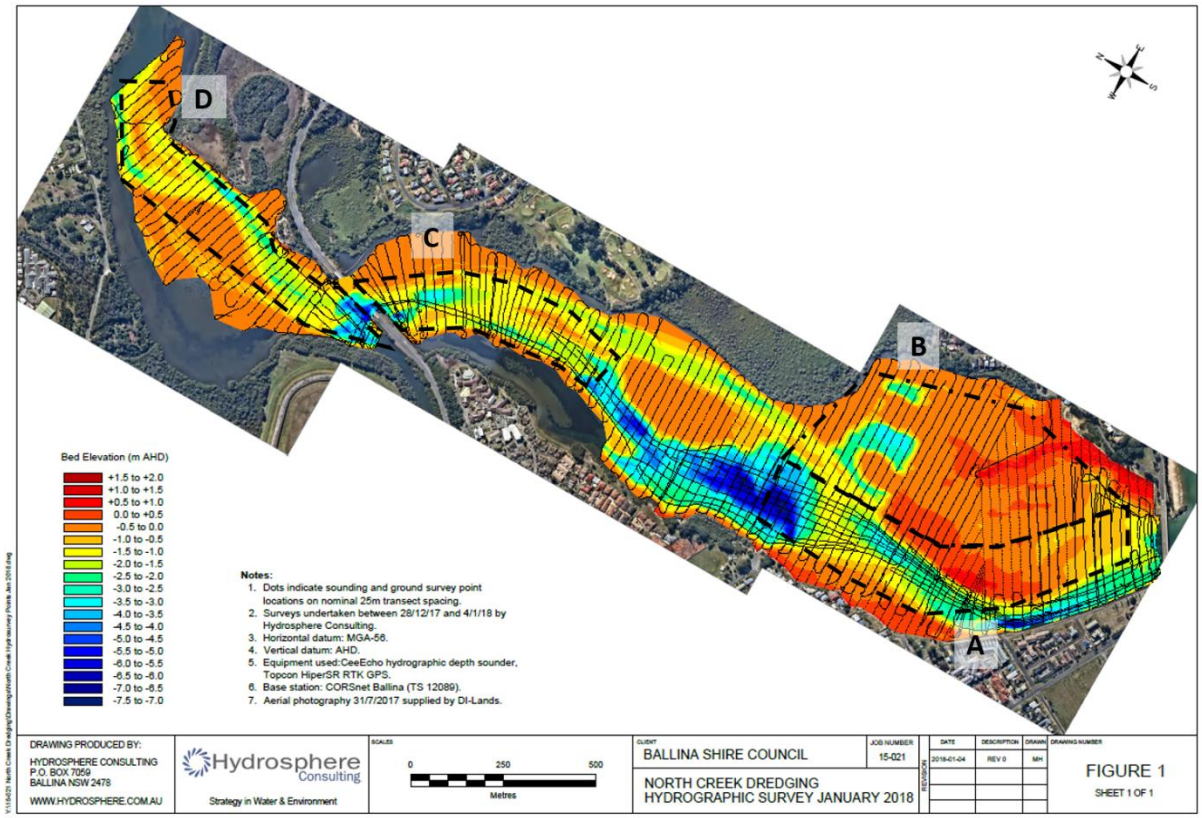


Figure 26. *The bed elevation of lower North Creek was surveyed in relation to the proposed dredging areas A-D as part of the Dredging Sedimentation Investigation Report (Hydrosphere 2018).*

The completed dredging scoping study and feasibility study anticipates water quality improvements from the proposed dredging work. The dredging of the channel is expected to facilitate (Hydrosphere 2016, 2018):

- Increased flushing with low turbidity, low nutrient and low pathogen oceanic water
- Conveyance of flood waters through the system
- Reductions in the residence time of poor-quality water following catchment rainfall events
- Reductions in suspended fine material, which can smother marine flora and fauna.

Modelling has not yet been undertaken to support these anticipated outcomes.

While it is possible for dredging works to achieve environmental outcomes such as those proposed, such a proposal needs to be informed by further investigations, clear goals and an adaptive management approach. The 2016 scoping study recommends the following be undertaken as part of further planning and assessment of the project:

- Liaise with North Creek oyster lease operators to better understand poor water quality events
- Undertake integrated hydrodynamic modelling (tidal prism, residence times) to assess anticipated tidal exchange characteristics
- Evaluate the potential for poor water quality during works and determine appropriate mitigation strategies
- Determine the ecological impact of dewatering.

Assessment of the anticipated increases to the tidal prism as a consequence of the proposed dredging will need to take into account the groundwater dynamics in the catchment. As over two thirds of North Creek is tidal, any increase to the tidal amplitude may increase the volume of acidic groundwater released into North Creek on the ebb tide. Dredging approval would be subject to the completion of an environmental impact assessment.

Shoaling is perceived to be play a causal role in the water quality issues facing the estuary. The Serpentine Sand flats and adjacent areas are also very popular recreational areas. For some members of the community the shoaling diminishes these recreational values (i.e. loss of deep water).

Sand mining

Given the shallow water table and prevalence of acid sulfate soils and potential acid sulfate soils across the catchment basin, current sand mining activities may exacerbate acid water discharge into North Creek. Such discharge would occur through the generation of acid runoff from oxidation of mined sulfide bearing sands (Enviro Solutions 2017). The compliance of dewatering practices is critical to limiting the water quality impacts within the North Creek catchment. As this is a compliance issue, further investigation may go beyond the scope of the CMP process and require actions from the relevant government agency. The proposal for the McGeary's sand mine and future recreation area was withdrawn in 2018 and as a result there is no current proposal for the expansion of sand mining within the catchment.

A rehabilitation plan will be necessary for the historic mine site. An understanding of the remediation approach is necessary to inform the water quality monitoring program. Sample site placement may be influenced by the rehabilitation regime, which could involve activities which may impact downstream water quality. The historic sand mine is also host to vegetation communities that may require protection throughout the rehabilitation process.

The McGeary's sand mine EIS provides valuable information on the hydrology and ecology of the site itself and illustrates the sensitivity of the catchment basin's shallow aquifer to disturbances (Parker 2017). A site visit to the historical sand mine mid 2018 revealed that the quarry lakes are crystal clear and spoil heaps are largely devoid of vegetation, which can be an indicator of the presence of acid sulfate soils.

Continued urban development within the catchment, in conjunction with the minimum fill requirements as provided in the Ballina Development Control Plan mean that there will be an ongoing sand requirement in the region. Cheap and effective sourcing of sandy material within the region to facilitate the projected growth will be required. Given the abundance of sand within the North Creek catchment appropriate consideration will need to be given to the impacts on groundwater, drainage and aquatic and terrestrial ecology for any future extraction proposals, as well as the suitability of the sand for use as fill.

Sand mining within the catchment was identified as a threat during the community stakeholder engagement process for the scoping study.

3.9 Drainage

Key points

> Extensive drainage works have been undertaken over time to mitigate flooding and enable agricultural and urban development

> Changes to the drainage patterns have substantially altered the hydrology, surface and groundwater interactions, which underpins the majority of ongoing management challenges for the catchment

Coastal floodplain context

As outlined previously, North Creek's drainage system has been significantly altered over time to enable the gradual expansion of urban and agricultural development across the catchment's extensive low-lying wetland known as Newrybar swamp. As the catchment topography is dominated by the low relief coastal floodplain, even relatively small structures (levees and constructed drains) and minor alterations to channel and floodplain grades can have a significant impact of drainage, more so than in other landscapes.

The catchment has a history of opportunistic floodplain works, levees, drains and floodgates, installed and modified by landholders to improve property scale operations. However, in several cases these works have had unforeseen adverse impacts for neighbouring properties, the community, the nature reserve and downstream environment. A brief review of the main drainage works is provided below.

Main drainage works

After the introduction of the Union Drain north of Ross Lane in the early 1900's, further drainage works were considered necessary to mitigate flooding in the east. The Richmond River County Council's 1975 investigation into Newrybar Swamp drainage yielded key observations of drainage behaviour prior to the installation of the mitigation drain (Barlow 1975). Namely that:

- The area now known as the Ballina Nature Reserve consisted of mainly mangroves and tea-tree swamp, with much of it either permanently flooded either by runoff or tidal water.
- During flood events, large volumes of overland flow were discharged across Ross Lane into the Ballina Nature Reserve.
- Flood outflow from above Ross Lane via the main drain was considerably influenced by the level of the storage formed in the Ballina Nature Reserve.
- Discharge of floodwaters in Ballina Nature Reserve occurred through Deadman's Creek.
- Calculated water levels of the swamp prior to the mitigation drain estimated no significant change in the natural flooding and drainage of the Ballina Nature Reserve area.

By 1979 the Mitigation Drain was built, which allowed for almost complete cultivation of the Newrybar Swamp (WBM 2015). These works aimed to interfere as little as possible with the existing flood pattern around Ballina Nature Reserve (Barlow 1975). Soon after drain construction, levees and tidal flood gates were also constructed by individual landholders to improve yields. However, these works also had adverse impacts on flood behaviour, and reduced the benefit of the Mitigation Drain (and also impacting on landholder relationships). The net result was that considerably more runoff was directed downstream via the Mitigation Drain and North Creek and correspondingly, considerably less runoff overflowed into the Ballina Nature Reserve wetlands (WBM 2015).

In 1984, The water resources commission of New South Wales examined mitigation options to alleviate flood related issues, however, concluded that levee modification was not possible due to lack of landholder cooperation. Attempts at flood mitigation since have been relatively unsuccessful with levees being broken by

floodwaters or removed by landholders (WBM 2015). Anecdotal evidence suggests that some floodgates have not functioned for at least ten years.

Current flow paths and challenges

At present, uncertainty surrounds the hydrology within the Ballina Nature Reserve. This is largely due to the patchwork of drains dug prior to the declaration of the reserve and the reduced inflows from the north. As noted previously, Deadman's Creek used to flow south east into North Creek along its original drainage path as recently as 1975, however now it is understood to flow to the north. The extent of flow along Deadman's Creek within the western half of Ballina Nature Reserve is shown in Figure 27. It is possible that sediments shed off the Ballina Heights district immediately upstream of Robert's and Deadman's Creeks have gradually accreted within the reserve since the late 1970's. Given the extremely flat nature of the terrain, minor changes in the topography are likely to result in the redirection of flow.

There is anecdotal evidence which suggests that the former main drainage line through the Ballina Nature Reserve wetland to North Creek, Deadman's Creek, is now blocked due to sedimentation. This is reducing flow through the wetland and impacting the drainage of rural properties to the west and north of the Ballina Nature Reserve including the area to the north of Ross Lane.

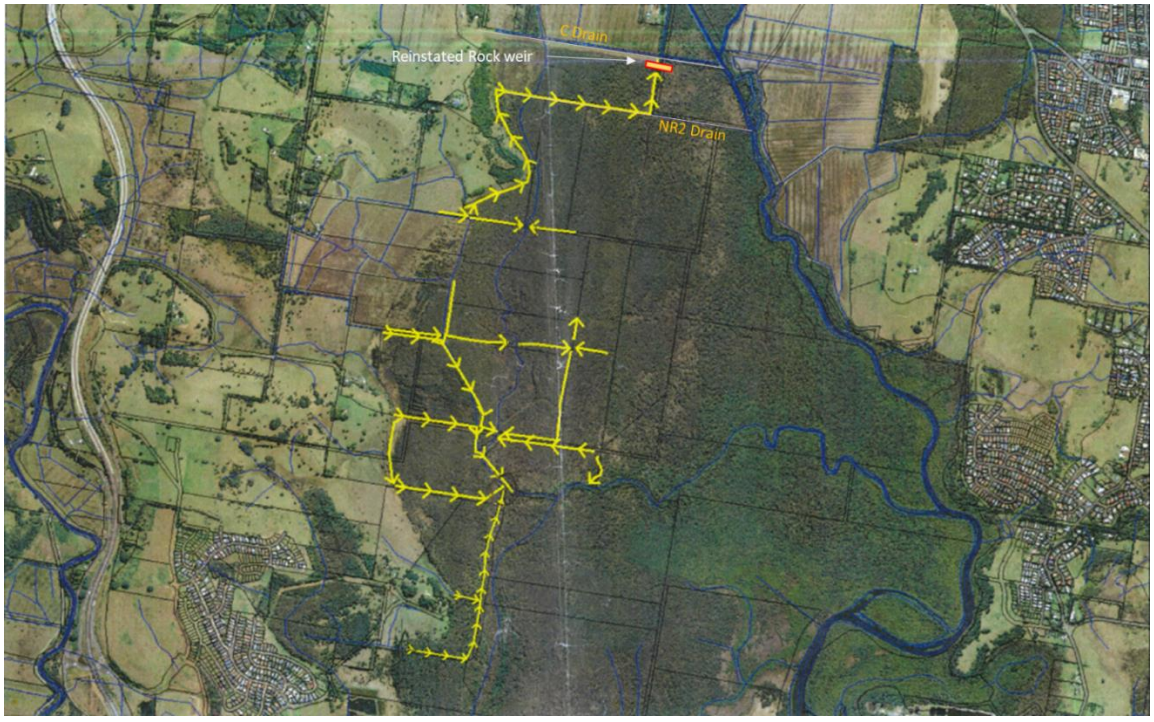


Figure 27. *Anecdotal assessments of flow within the patchwork of drains which have been dug prior to and after the establishment of Ballina Nature Reserve (courtesy of I. Gaskell).*

With further residential development planned within the catchment, stormwater inputs and associated sediment loads are likely to increase. A hydraulic assessment for Precinct B of the Cumbalum Urban Release Area (CURA) by WBM in 2017 addressed potential flood impacts of the development located west of the Ballina Nature Reserve. The report suggested that an extension of the NR1 channel from the reserve would provide adequate drainage for predicted floodwaters despite localised peak flood level impacts on adjoining properties.

The CURA Precinct B hydraulic assessment assumed the removal of a rock weir between the two channels NR2 and C which typically maintained a 0.5 m relative height difference in water levels between the reserve and the adjacent drains. The weir however has been recently rebuilt by persons unknown, possibly to withhold southern floodwaters which flow northwards and inundate sections around Ross Lane for extended periods. Anecdotal reports suggest that the weir holds water back within the reserve and thereby reduces floodwater residence time around Ross Lane.

Continued development in the Ballina Heights region is likely to exacerbate the issues described above. A considered approach will be required in dealing with the associated increase in stormwater and sediment inputs. There are anecdotal reports of a proposal for the routing of storm water from Ballina Heights through part of Roberts Creek and along a channel adjacent to Ballina airport. This option, however, may have other consequences, such as a reduced opportunity for the attenuation of stormwater contaminants.

Predicted changes in sea level and rainfall intensity will influence how water flows through this developing landscape. This added complexity will impact flood risk, which is currently managed through the 2012 Ballina Floodplain Risk Management Plan and its associated development controls. These development controls define minimum flood planning levels, which are based on the future flood level predictions for years 2050 and 2100.

Changing hydrology/drainage patterns

The hydrology and drainage pattern of the catchment continues to change. This is leading to a variety of hydrological issues across the catchment including poor water quality, changes to ecological communities and impacts on landholders. There is no 'silver bullet' for this issue, as each mitigating activity has its own flow on effects. This is demonstrated by the extensive ad-hoc levees across the catchment and ongoing flooding challenges, including those discussed with landholders (see Text Box 1).

Text Box 1 – June 2018 landholder workshop discussion points

On the 25th of June 2018, a landholder workshop was held as part of the scoping study engagement activities, including discussion on the drainage issues facing the catchment. Discussion points included:

- Flows through the Ballina Nature Reserve and Deadman's Creek have changed over time.
- The existing LiDAR dataset through the Ballina Nature Reserve is not detailed enough to model hydrology (as originally raised by Ballina Shire Council).
- The construction and deconstruction of the rock weir between drain lines NR1 and NR2 (of concern to landholders)

Another concern raised was the apparent effect of floodgate infrastructure on floodwater residence time north of Ross Lane, however floodgates can only work where there is no pressure on them opening outwards (due to tidal inundation under downstream flooding or king tide conditions). All floodgates will 'drain' water out at any time where there is no pressure on them opening outwards.

The rock weir in the drain between NR2 and NR1 was of particular focus during the landholder workshop. Participants considered that the weir requires active management by the relevant authority, as its position within the drainage network is perceived to have flood level implications for immediate landholders and the wider landscape. As such, the rock weir may influence the modelling results of stormwater flows relevant to the proposal of the Cumbalum Urban Release Area B. If this is the case, whether the weir is in position or not could have consequences for future stormwater designs. It was also noted that multiple flood gates across the drain network which are either faulty or in disrepair add further complexity to the assumptions upon which flood modelling is based.

Further investigation/validation of flood behaviour observations reported by landholders would assist with future management decisions.

Additional parts of the drainage and management story for North Creek also include:

- The WBM 2015 Newrybar Swamp drainage and flood mitigation study, which provides recommendations for flood and drainage management in the catchment. Recommendations are understood to be in the early stages of implementation. Given that the Ballina Floodplain Risk Management Plan (BFRMP) is due for review, the above mentioned drainage issues within the catchment may be suitably dealt with through a revision which incorporates any further information derived through Stage 2 of the CMP process.

- Changing the hydrology of the Ballina Nature Reserve through reinstating flow through Deadman's Creek may disturb a considerable portion of the reserve, which is classified as coastal wetland and is protected under the Coastal Management Act 2016. Given the recent coastal reform, there are numerous objects and management objectives which can be utilised to support restoration of the hydrologic regime within the Ballina Nature Reserve (if it was deemed necessary). A proposal for the necessary works could be constructed with appropriate legal counsel.

Finding a solution to the drainage issue will require the co-operation between all stakeholders across the catchment. While the current drainage issues regarding Ballina Nature Reserve, and other areas, are of concern, they also need to be considered in relation to the larger scale drainage issues facing the catchment across 50 to 100 year timescales. Projected sea level rise may overprint the flooding issues currently experienced, thus negating any solutions considered in isolation. Developing a shared understanding of the trajectory of the catchment and the tensions between the short- and long-term needs of the catchment community, as part of the CMP, will assist to facilitate progress on the issue.

North Creek (northern rural catchment) – The Union Drain which runs parallel to Newrybar Swamp Road

3.10 Waterways

Key points

- The laterally unconfined streams of the foothills and coastal floodplain have been extensively modified since European settlement
- Discontinuous swampy meadows have been converted to a network of linear drains and levees across the mid-catchment zone
- Tidal ingress up the waterways influences over 70% of waterway length
- The overall geomorphic condition of North Creek is relatively stable, linked to the relatively low gradient across the catchment
- Riparian condition is good where native vegetation remains across the Ballina Reserve area, and moderate to poor in upper and lower parts of the catchment where native vegetation and mangroves have been lost.

Northern catchment

In northern parts of the North Creek catchment, confined and partially confined headwaters flow from the Alstonville plateau (to the north-north west), and to the east, laterally unconfined coastal streams drain coastal swampland. Most of these headwater streams remain in a near natural state.

On the lower (foothill) elevations and transitioning to the coastal floodplain, laterally unconfined coastal streams from the east have been substantially modified since European settlement. Prior to settlement, these streams were largely discontinuous swampy meadows, however, now form a network of linear drains (see Figure 28). As noted previously, this extensive network of channels and levees was constructed to maximise agricultural development. Channelization has also facilitated an increase in tidal ingress which now influences 72 % of North Creek's stream length (Ryder et al. 2015). As noted in the groundwater discussion, flood gates have been installed to manage tidal flow and there is a complex groundwater, tides and surface water relationship.

Mid to southern catchment

Through the mid to lower catchment, the estuarine reaches of North Creek maintain a sinuous planform. The mid reaches upstream of the airport have a relatively natural channel form with mangrove forests established along the banks in many locations. There is also significant instream wood which provides instream habitat. The Ballina Nature Reserve wetland system drains into North Creek from the north of catchment. The hydrology of this wetland has been extensively modified due to drainage works and urbanisation of the surrounding catchment. As it stands, the estuary condition falls short of achieving several objectives within the Marine Estate Management Strategy.

The lower section through Ballina has been extensively modified including the use of rock revetment to reduce bank erosion. Expansive intertidal flats in the shallow lower reach provide important habitat for instream biota which support local fish and seabird populations (Ryder et al. 2015).

Figure 28. *The natural and modified waterways of the North Creek catchment.*

Estuary branches
Four main arms of the North Creek estuary extend within the Ballina urban area, Chickiba Creek, North Creek Canal and Little Fishery Creek (Figure 28).

Winding through East Ballina, Chickiba Creek and its fringing wetlands have been modified for development and consequently experience an altered hydrology. This has led to vegetation dieback, fragmentation and poor water quality (BSC 2006).

The North Creek Canal runs through the heart of the Ballina township and connects to the Richmond River creating an island. The canal follows the route of shallow wetlands which previously occurred in this area. The channel was widened and deepened to facilitate the movement of cane barges to the Broadwater Sugar Mill. The tidal inlet is lined with mangrove vegetation however bare stretches remain exposed to risk of erosion by boat-wash (Hydrosphere 2011). Some rock revetment work has been undertaken through this section.

Sandwiched within urban development, Fishery Creek extends from the North Creek Canal to the west beyond the limits of urban development. Its vegetation is largely intact, and its channel stable, despite some fragmentation of its fringing wetland. The Ballina Recycled Waste Water Treatment Plant discharges into the North Creek canal 1300 m from Richmond River and 2.2 km from North Creek.

Waterway condition
Despite extensive modifications, North Creek's overall geomorphic condition is relatively stable, assisted by the relatively low gradient across the catchment, and residual native vegetation in the mid-catchment area. However, overall, much of the riparian vegetation condition is moderate to poor, given the dominance of invasive exotic species in the freshwater reaches and loss of mangroves in the lower estuarine zone (Ryder et al. 2015). Lateral connectivity is fragmented and the opportunity to extend mangrove communities is restricted by urban development and rock armouring of the intertidal edge in the lower catchment.

Protecting waterways in good condition, improving water quality, and dealing with the impacts of increased tidal influence across the catchment, will continue to be key management challenges for the North Creek catchment waterways and floodplains.

The mid reaches of North Creek which retain good riparian vegetation coverage

3.11 Social context[1]

Key points

- The Bundjalung people are the traditional custodians of the land
- The North Creek catchment is home to an estimated 34,000 people, concentrated within the urban centers of Ballina, East Ballina, West Ballina and the townships of Lennox Head and Skennars Head
- The population of Ballina Shire is predicted to grow by between 20 and 28 % by 2036, with the main growth centres at Ballina North, Lennox Head and Cumbalum

Population

The North Creek catchment lies in the heart of Ballina Shire Local Government Area. It is home to an estimated population in the order of 34,000 people, most of whom are concentrated within the urban centers of Ballina, East Ballina, West Ballina and the townships of Lennox Head and Skennars Head (ABS 2017).

Census data for Ballina provides an indication of the demographics of the region. At the time of the 2016 census, the median age of people in Ballina was 55 years, and:

- Children aged 0-14 years made up 11.7 % of the population compared to the State average of 18.5 %.
- People aged 65 years and over made up 36.3 % of the population compared to the State average of 16.2 %.

Of occupied private dwellings in Ballina:

- 34.7 % were owned outright (compared to State average of 32.2 %)
- 16.5 % were owned with a mortgage (compared to State average of 32.2 %)
- 40.2 % were rented (compared to State average of 31.8 %).

The main population growth areas are Ballina North, Lennox Head (spanning the eastern catchment boarder) and Cumbalum (spaning the western catchment border). Population numbers in these areas are predicted to grow by 20 – 28 % by 2036. Population growth in other smaller settlements is expected to be in the order of up to 5 % by 2036 (ABS 2017).

Settlements

The residential areas in the North Creek catchment include areas of Ballina, followed by several smaller settlements, several of which span the North Creek catchment boundary. Rural residential properties are also scattered across the catchment. The population numbers for the main residential areas in the North Creek catchment at the time of the 2016 census are shown in Figure 29..

[1] Similar social context information is also re-presented in Attachment A as part of the Community and Stakeholder Engagement Plan (CSEP) to enable the CSEP to be a stand-alone document as well.

Figure 29. *Population count from the 2016 census within the residential centres of the North Creek catchment area*

Employment
At the time of the 2016 census, the top employment industry in Ballina was aged care residential services (6.1 % of workers). Other major industries of employment included supermarket and grocery stores 4.1 %, other social assistance services 3.2 %, accommodation 3.2 % and hospitals 3.2 % (ABS 2017).

Similar employment trends hold for surrounding settlements (e.g. Lennox Head, Cumbalum) with major employment industries including hospitals, cafes and restaurants, aged care services, plus primary education (ABS 2017.

The most common occupations in Ballina and surrounding regions included technicians and trades workers 15.7 %, professionals 15.4 %, labourers 14.8 %, community and personal service workers 14.1 %, and sales workers 12.3 % (ABS 2017).

Tourism is also an important part of the Ballina Shire economy with over 1,500,000 international and domestic visitors in 2017/2018 (Tourism Research Australia, 2019). The majority of these visitors are likely to visit within the summer months and school holidays to enjoy the coastal environment and waterways, including parts of the North Creek catchment, particularly Ballina and Lennox Head.

Diversity
The most common ancestries in Ballina at the time of the 2016 census were English 30.9 %, Australian 29.1 %, Irish 9.5 %, Scottish 8.0 % and German 2.8 % (ABS 2017). In addition:

- The percentage of Aboriginal and/or Torres Strait Islander people in the Ballina region was 4.3 %, compared to a State average of 2.9 %.

- The majority of residents, 78.8 %, were born in Australia, compared to the State average of 65.5 %.

Aboriginal cultural heritage
The Ballina Shire, including North Creek catchment area, has important Aboriginal culture and heritage values. An overview of the Shire's Aboriginal and Culture and Heritage is described in Text Box 1.

Text Box 1 – The Shire's Aboriginal Culture and Heritage

Source: https://www.ballina.nsw.gov.au/cp_themes/default/page.asp?p=DOC-ONO-01-56-87

The Bundjalung people are the traditional custodians of the land, having cared for and lived off the land for thousands of years. The many natural features and landforms that make up the Ballina Shire landscape were understood by the Bundjalung people to be the creation of their Dreamtime ancestors.

Bundjalung people tell of how, before the coming of white man, they lived in harmony with the natural environment. Like other Indigenous culture, the Bundjalung people suggest they belong to the land and the land to them. The land provided a wide variety of foods including fish, crustaceans, mammals, birds, reptiles, vegetables and fruits. Shelters were made of timber, bark, branches and palms. Fire was used to cook food and timber, rock and fibres used to make tools and utensils with which to hunt, gather and prepare food. Individuals were part of a complex kin and tribal grouping that frequently moved across different parts of the land in search of food and in response to seasonal change and for ceremony. Bundjalung peoples' culture and traditions evolved over many thousands of years with the passing down of knowledge from previous generations and adapting to environmental change.

Management of Aboriginal Heritage matters in the shire is overseen by JALI Local Aboriginal Land Council and is supported by the National Parks and Wildlife Act (1974) and the NSW Heritage Act (1977) which provide legal protection for Aboriginal sites and relics in NSW, including sites yet to be recorded.

North Creek and its catchment also have specific significance to the Bundjalung people. Gahan (2018) provides a summary of the Bundjalung custodianship of the North Creek catchment before 1840. Key points from this summary include (Gahan 2018):

- Today it is recorded that the Bundjalung people occupied the Creek's catchment from, at least, 4000 BC – that is for over 6000 years.

- A vast kitchen midden once stretched for hundreds of metres along North Creek. The midden predominately consisted of oyster shell provide an indication of the extensive use of North Creek by the Bundjalung peoples over many centuries. Only a remnant of this midden remains intact.

- The Bundjalung peoples viewed the catchment as an integrated, cyclical system and as a result were careful and systematic in what they took from the environment. This knowledge was recorded and passed on through oral traditions of storytelling and song.

- The natural sand shoals in the lower estuary were utilised for permanent fish traps.

- Long wide nets were also used to capture ground dwelling species such as paddy melons and bandicoots.

- Small bands of extended family groups often came together to have much larger gatherings. Early European settlers in the area witnessed and recorded such meetings at Chickiba Lake, when oysters were in abundance.

Jali Local Aboriginal Land Council have been consulted during the development of this document, and in respect to these discussions culturally sensitive information/sites are not included in this report.

European heritage

Gahan (2018) provides a summary the history of European settlement in the North Creek area. Key points from this study include:

- 1828 - Henry John Rous sailed along the east coast. He has been widely celebrated as the first European to explore the Richmond River.

- 1840s – 1850s - A permanent settlement at Ballina by Europeans dates from the early 1840s. Small groups of cedar cutters and their families are recorded to be the earliest to relocate here – this included on land at Prospect on North Creek, and at Shaw's Bay where the North Creek joined the Richmond River. A small stream near Shaw's Bay provided freshwater for the first European settlers.

  Throughout the 1840s cedar cutters and traders were the primary European inhabitants. The Bundjalung people continued to live within the catchment. Bundjalung men were known to also work for the cedar cutters during this period and provided local knowledge. In the 1850s the Native Police rode into Ballina and executed a dawn raid on Bundjalung families camped on the northern side of North Creek, many people were murdered or wounded.

- 1860s - From the early 1860s a new land legislation known as the Robertson Land Acts spurred a further wave of European migration to the Richmond River. The legislation enabled settlers to select land parcels for farming or improvement provided it was occupied. This encouraged farming families to the district. Land located on the North Creek floodplain was amongst the first areas to be farmed in Ballina.

  Early farming practices in the catchment included mixed-cropping, sugar cane production, cattle grazing and dairying. These activities drastically changed the landscape through the clearing of native vegetation. Farming was popular in the North Creek catchment due to the fertile soils.

- 1870s - In 1870 a vehicular ferry was installed across North Creek, along the North Creek Road, to enable the transport of produce and people to and from the farms established along the North Creek.

- 1880s - The establishment of the mill at Broadwater in 1881 saw much of the floodplain areas south of Ballina cleared and cultivated for sugar cane, marking a change in land use that continues to the present day.

- 1890s – By the 1890s, dairy farming also became a dominant landuse in the region. The processing of timbers was also an important industry in the Ballina area throughout the closing decades of the nineteenth century.

  While modest timber houses for many decades dominated both the rural and urban landscape, a number of larger and 'finer' domestic houses from the turn of the century remain in the Ballina area. A number of domestic buildings now form part of the Norton Street Heritage Trail in Ballina, including the restored Ballina Manor. Other historical buildings and community halls are present in the towns and across the rural landscape.

- 1900s onwards - In 1906, the Newrybar Drainage Trust established – under the NSW Water and Drainage Act – 'to drain off the flood waters, and so rendering the land fit for grazing and agriculture'. Water was drained from the swamp into North Creek. This resulted in a major transition in ecosystems as the wetland communities were lost the drainage works and farming.

  Engineering works within the Richmond River and North Creek increased navigability of the waterways which enabled the North Creek to be an important transport corridor between the farms in the catchment and the Ballina community.

  Further drainage works through the 20th Century led to the widespread loss of wetlands and the expansion of agricultural throughout the catchment.

North Creek floodplain – remnant wetland habitat

3.12 Economic context

Key points

- The economy of the Ballina Shire is underpinned by health care, construction and retail trade
- The economy is relatively resilient (diversified)
- Tourism and agriculture, forestry and fishing are also key industries
- Oyster harvesting in the lower estuary is sensitive to environmental factors, including water quality, resulting in annual fluctuations in production and value

Key industries

The North Creek catchment supports diverse economic values. The catchment itself is located within one of the fastest growing parts of regional New South Wales, driven largely by tourism and migration. Residential development within and surrounding the catchment a key driver of increasing economic value (BSC 2017b).

The largest industry sectors for the Ballina Shire in 2018/2019 are shown in Table 8. Health care and social assistance, construction and retail trade are the top three industries underpinning the economy. A large proportion of the land that supports key industry sectors is located within the North Creek catchment, which lends to a relatively higher economic value when compared against the other catchments in the Shire.

Table 8. Key industry sectors (NIEIR 2019)[2] – economic value-add by industry ($m and %) compared to State values (% only).

Industry	Ballina Shire $m	Ballina Shire %	NSW %
Health Care and Social Assistance	202.4	12.9	7.7
Construction	176.1	11.2	8.4
Retail Trade	124.9	8.0	5.1
Rental, Hiring and Real Estate Services	120.6	7.7	4.7
Education and Training	112.4	7.2	5.3
Manufacturing	96.4	6.2	6.3
Professional, Scientific and Technical Services	88.0	5.6	9.7
Public Administration and Safety	80.6	5.2	5.5
Accommodation and Food Services	80.3	5.1	3.2
Financial and Insurance Services	75.0	4.8	14.4
Agriculture, Forestry and Fishing	74.6	4.8	1.4
Administrative and Support Services	54.7	3.5	4.5
Transport, Postal and Warehousing	51.7	3.3	5.8
Electricity, Gas, Water and Waste Services	46.5	3.0	2.4
Mining	44.7	2.9	3.6
Wholesale Trade	43.8	2.8	4.9
Arts and Recreation Services	38.9	2.5	0.9
Other Services	31.9	2.0	2.2
Information Media and Telecommunications	21.9	1.4	4.0
Total Industries	**1,565**	**100.0**	**100.0**

[2] Accessed at <https://economy.id.com.au/ballina/value-add-by-industry> in December 2019.

Based on available economic data for Ballina Shire, the total economic value-added in 2018-2019 was approximately $1.57 billion (value added is a measure of the value generated by business activity by different industry sectors).

The concentration ratio when considering the top four contributing industries in Ballina Shire is 39.9%, compared to 40% for New South Wales. This signals that economic diversity in the Ballina Shire are similarly distributed to that of the state, preliminarily indicating that the shire's economy is expected to be resilient to shocks. However, health care and social assistance, and construction are (by some margin) the two largest contributors to regional value-add and if they were to encounter challenges then the stability of the economy would be tested. Health care is not as prominent at the State level.

Tourism

The topography and proximity of the North Creek catchment acts as gateway to the most widely accessed coastal zone within the Shire, providing access and the scenic amenity that are key to the health of tourism in the Shire.

The value of the tourism industry within the Shire is typically spread across multiple industries, however the total value added by tourism and hospitality in the Ballina Shire in 2018/19 was estimated at $120 million (NIEIR 2019)[3].

While a breakdown of the seasonal fluxes is not available, a significant proportion of the visitors to the Ballina Shire state the main reason for their visit is for holiday or visiting friends and family (NIEIR 2018). Therefore, it is likely that there are peaks in visitor numbers around school holidays and holiday periods such as Christmas and Easter. Tourism is also a very labour-intensive sector, resulting in tourism activity being a major contributor to local employment, particularly for young people that are typically overrepresented in unemployment and underemployment statistical measures.

Agriculture, forestry and fishing

Of the $74.6 million contributed by agriculture, forestry and fishing to the Ballina Shire economy, $4.3 million is attributed to agriculture, forestry and fishing support services and of that $1.3 million is attributed to fishing, hunting and trapping (NIEIR 2019). Anecdotal reports indicate that fishing within North Creek is in decline. The mullet fishery at Misshingham Bridge, located in the Richmond River near North Creek's entrance, was estimated to be worth $500,000 to the local economy in 2004 (DPI 2004).

The upper North Creek catchment is predominately utilised for agricultural activities, namely horticulture (sugar cane, citrus and increasing macadamia) and pastoral use. In 2015/16 macadamia nuts were largest commodity produced in the Shire, contributing 46.3% to Ballina Shire's agricultural output (ABS 2017).

Agriculture within the Ballina LGA is experiencing a relative decline in overall significance to the regional economy. provides the approximate economic values for the three main agricultural activities within the North Creek catchment. These values were calculated utilising 2013 NSW land use classification and 2015/16 ABS economic data as an indication of the proportion of value generated by the catchment in relation to the 2018 NIEIR analysis of ABS economic data for the Ballina and Byron Shires. This method provides an indicative measure only as it assumes that all the land within the LGA is productive as per its classified use. This means that it does not take into consideration the possibility of land use change since 2013 or the time needed for recently established macadamia farms (of which there are some) to mature and produce a commercial crop.

[3] Accessed via <https://economy.id.com.au/ballina/tourism-value> in December 2019.

Table 9. The approximate economic value of the main agricultural activities from within the North Creek catchment (NIEIR 2018)

Agricultural activity	2015/16 North Creek catchment contribution by land use area	2015/16 Value added by the Ballina Shire
Macadamia nuts	$2,710,000	$34, 800,000
Sugarcane	$1,170,000	$6,460,000
Grazing (cattle and calves)	$560,000	$2,440,000

Oysters

Despite the oyster harvest area in North Creek closing in 2006, leases within the estuary can still be utilised for farming of oysters, which only require transportation to Mobbs Bay in the Richmond River for depuration prior to harvest. Given there are less than five oyster operators within the lower Richmond/North Creek estuaries, DPI NSW cannot release the economic production data for this system due to confidentiality concerns.

Consequently, it is difficult to determine the exact economic value contributed by North Creek in terms of oyster production. What can be described is the overall percentage change in value and production of oysters from the area, which are provided in Table 10 and illustrated in Figure 30. The variability of the data highlights the sensitivity of oyster productivity to multiple environmental and demographic factors of which water quality and adequate training are considered to be the most influential (Schrobback 2015).

Table 10. Comparison data for the productivity of and value of the oysters harvested within Mobbs bay in the Lower Richmond river, opposite to the North Creek mouth entrance (DPI 2019).

Summary	Change from previous year	Change from previous year
Period	Quantity (dozens) % change	Value ($) % change
2007/08 to 2008/09	83% increase	110% increase
2008/09 to 2009/10	76% decrease	70% decrease
2009/10 to 2010/2011	85% decrease	88% decrease
2010/2011 to 2011/12	264% increase	304% increase
2011/2012 to 2012/13	116% increase	123% increase
2012/13 to 2013/14	77% increase	83% increase
2013/14 to 2014/15	48% decrease	41% decrease
2014/15 to 2015/16	67% decrease	64% decrease
2015/16 to 2016/17	46% increase	37% increase
2016/17 to 2017/18	17% decrease	2.7% decrease

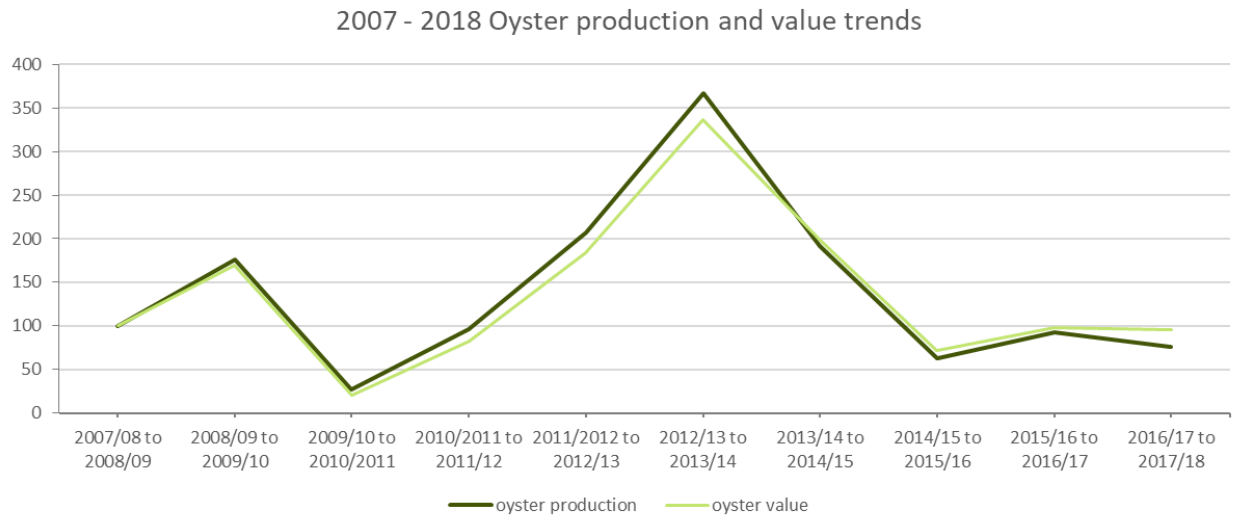


Figure 30. *Oyster production and value trends for the Lower Richmond river and North Creek area. Arbitrary values were assigned to the y axis as only percentage data was provided by DPI NSW.*

North Creek estuary – oyster farming

3.13 Stakeholder and community values

Key points

- A diversity of stakeholders have an interest in the CMP development
- An Agency Reference Group has been established to collaborate during the CMP development
- Key values identified by the community (via survey) included native vegetation, biodiversity, waterbirds, swimming and fishing
- Key threats to values identified by the community (via survey) included rubbish, urbanisation, agriculture, stormwater discharge, loss of riparian vegetation, poor drainage.

Community and Stakeholder Engagement Plan

The Community and Stakeholder Engagement Plan (C&SEP) developed for the North Creek CMP process is provided in the attachments to this document (Attachment A). The C&SEP provides a summary of the key catchment context, engagement objectives, and actions to guide engagement with the community and other stakeholders in the development (and later the implementation) of the CMP.

The C&SEP actions during the scoping phase of the CMP (Phase 1) have included:

- Establishment of an Agency Reference Group, and initial meeting to launch the CMP process
- Identification of stakeholders and key interests
- Phone / email interviews with key stakeholders
- Landholder workshop (25th June 2018)
- Online survey and information stand at two community markets (May - July 2018)
- A focus on gathering community and stakeholder feedback on catchment values and perceived issues/threats.

Agency Reference Group

A key component of the engagement process is the establishment of the Agency Reference Group (ARG) to provide guidance on the study and also latter stages of the CMP. The ARG for the North Creek CMP includes representatives from:

- Ballina Shire Council
- Rous County Council
- DPIE Environment, Energy and Science – Coast and Estuaries
- DPI - Fisheries
- DPIE – Crown Lands
- TfNSW - Maritime
- North Coast Local Land Services NRM
- Jali Local Aboriginal Land Council

The ARG convened early in the scoping study to discuss the desired project outcomes, share knowledge and explore the vision for the North Creek catchment. Discussion included zoning, engagement, water quality and drainage as key elements to include in the CMP process. Minutes from the first ARC meeting are provided in the attachments.

Initial stakeholder interviews

The ARG members provided a list of key stakeholders with interests in the catchment. These stakeholders had a diverse range of interests in the North Creek catchment and included:

- Landholders
- Oz Fish
- Ballina Fisherman's Co-op
- Australian Seabird Rescue
- Steinhardt's Oysters
- Richmond Oysters
- Ballina Environment Society
- Ballina Coast care
- Richmond River Cane Growers Limited
- Australian Macadamia Society
- NSW farmers representation

An attempt to contact each stakeholder by phone and/or email was made early during the development of this scoping study. Key questions were asked including:

- What is your interest/concern in the North Creek catchment?
- Do you know of any data/information which should be included in the scoping study?
- What level of engagement would you like through the CMP process?

An overview of the responses from each stakeholder is provided in the Attachment D.

Community interests

The broader catchment community has been engaged through several avenues during the scoping study.

An information flyer also produced and shared through the BSC website (Figure 31.). The flyer content was designed to inform the community of the recent NSW coastal legislation reform and how they can be involved in shaping the future of management in North Creek through the CMP process.

An information stand was also held at two successive Sunday markets in Ballina in July 2018 where residents could share their knowledge on the history and management of North Creek, values and issues of concern.

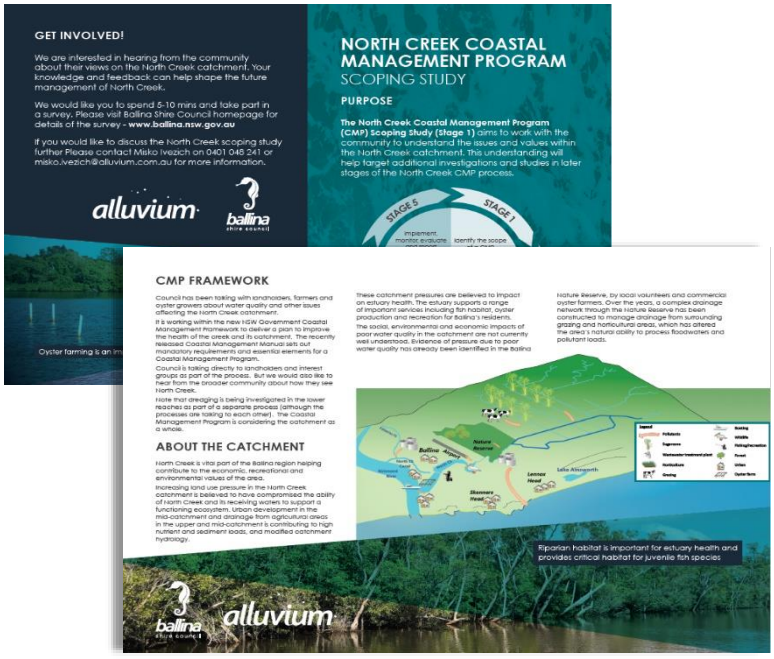


Figure 31. *The information flyer distributed as part of the North Creek scoping study*

An online survey was also made available to the North Creek community via the Ballina Shire Council website and shared through social media platforms. The online survey was designed to draw out the social, economic and environmental values and issues within the catchment, as outlined in the following section.

Online survey

The survey was open to the public over May and July 2018. During this period 150 responses were collected. The survey comprised of 13 questions and took an average of eight minutes to complete. Questions aimed to capture the demographics of the respondents, their values, concerns, interest and observations within the catchment over time. The results from key sections of the survey are provided in . Additional results are provided in Attachment D.

Table 6. Summary of results from the Ballina community survey

CMP theme	Results	Implication/message
Community demographics		
Age 	• More than half (59 %) of respondents were aged over 50	• Age distribution has implications for the future economic and infrastructure development for the Ballina Shire • The community has a strong desire to be engaged with the process of the North Creek CMP development
Occupation 	• 20 % of people surveyed are retired • The greatest proportion of respondents (10 %) are employed in education and training, and library occupations	
Club membership 	• Most respondents (61 %) did not identify as a local activity group member • 15 % were a part of local fishing groups, 14 % community groups and 9 % environmental groups	
Community engagement 	• Nearly half (45 %) of respondents indicated they will check the website for updates • 30 % would attend future information events • 97 % of respondents left their contact details with the wish to be informed in the development of the CMP	

CMP theme	Results	Implication/message
Catchment values		
Areas of Interest 	• Primary areas of interest are: o Overall Catchment Health (37 %) o Urban areas, boat ramps, swimming areas (20 %) o Ross Lane & the Ballina Nature Reserve (12 %)	• These values and initiatives will help inform future management strategies for the coastal area • Strong focus of water management-based positive changes indicates the important value of the North Creek catchment to the community
Important values 	• 76 % of respondents identified Native vegetation as a 'very important' catchment value • Other key values include Biodiversity, Waterbirds, Swimming and Fishing	
Positive Initiatives 	• 20 % of respondents identified initiatives in waterway regulation, riparian restoration or environmental education • Improvements to pathways were suggested by four percent of respondents	
Desired Positive Changes 	• Five main categories were identified for desired positive changes: o Improved environmental protection (24 %) o Dredging of lower estuary to commence (22 %) o Improvements in water quality (22 %) o Drain maintenance (16 %) o Reduced development (9 %)	

CMP theme	Results	Implication/message
Catchment threats		

Community-identified threats 	• The community considers the following to be the top 6 threats to catchment values:
	  ○ Rubbish
	  ○ Urbanisation
	  ○ Agriculture
	  ○ Stormwater discharge
	  ○ Loss of riparian vegetation
	  ○ Poor drainage
	• Only 15 % listed climate change as a top 5 threat
		• Important to gain community feedback to ascertain where there may be ongoing issues as there is a lack of monitoring
		• The community may also have photographs or other information to inform historical changes/threats to the catchment

Factors contributing to threats 	• A significant proportion identified siltation and reduced tidal flushing as the primary threat factor • Others focus on the upstream factors, such as agricultural runoff, acid drainage and urban pollution	• It is apparent that perceived threats are widespread throughout the catchment

3.14 Land tenure

Key points

> North Creek catchment is host to a mosaic of public and private land tenure which is subject to a number of local, regional and state management arrangements

The North Creek catchment is host to a mosaic of public and private land tenure which is subject to a number of local, regional and state management arrangements. These arrangements have changed over time, leading to complexity when attempting to determine responsibilities as land management issues arise. A summary of the existing tenures is noted in Table 11 and Figure 32.. Multiple responsible authorities contribute to the complexities in the existing management arrangements within the Ballina Shire.

Table 11. An overview of the tenure categories found within the catchment and their corresponding responsible authorities

Property type	Responsible authority
National Park	National Parks and Wildlife
Road Reserve	Ballina Shire Council
Agricultural drain	Private landholders
Natural waterway	Crown Land Reserve Manager – Department of Industry (DOI) -Crown Lands and Water Department of Primary Industies (DPI) - Fisheries
Crown land reserve	Crown Land Reserve Manager – Department of Industry (DOI) -Crown Lands and Water
Native Forest	Ballina Shire Council
Freehold	Private landholder

North Creek urban area through Ballina

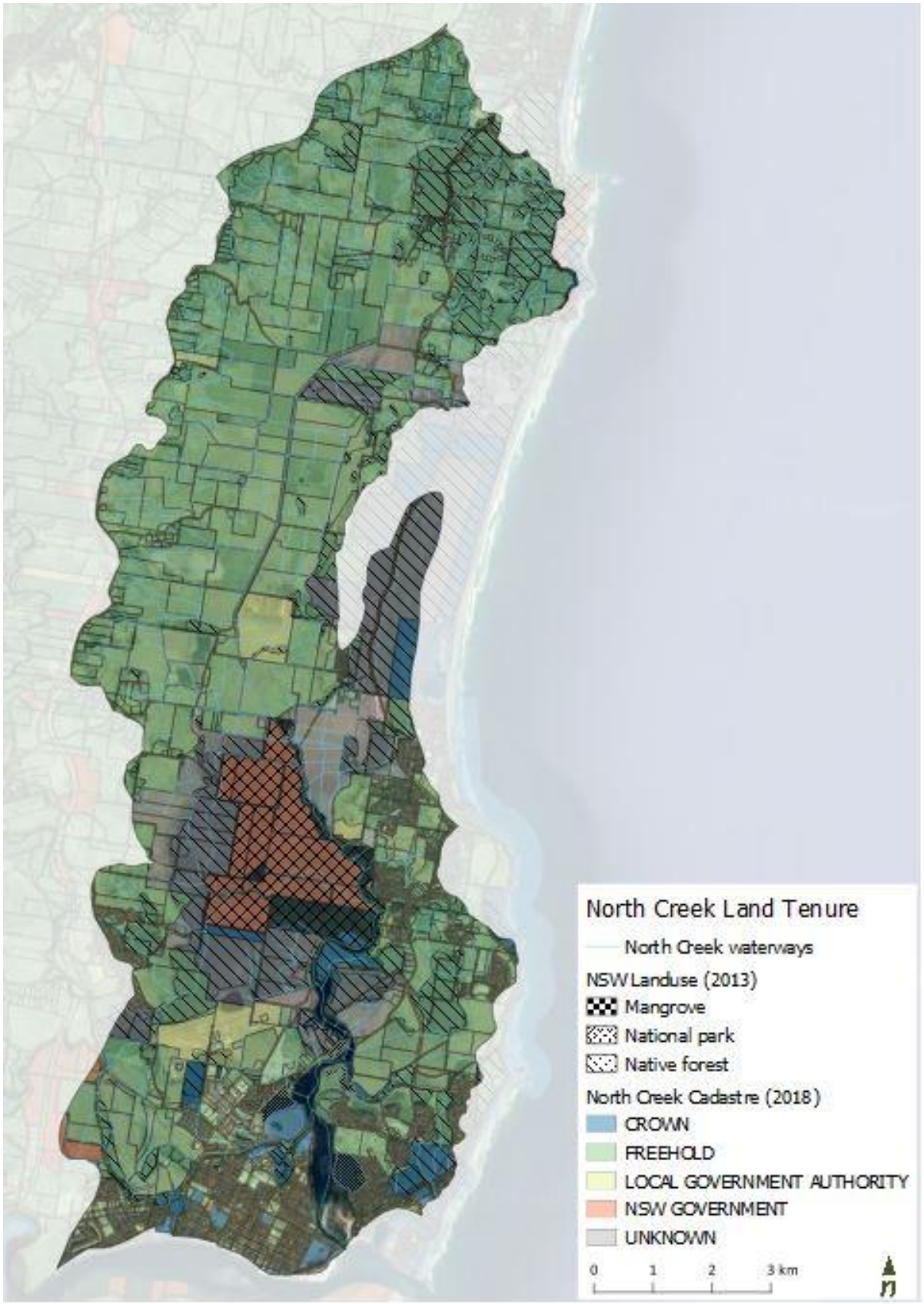


Figure 32. *The varying land tenure of the North Creek catchment*

3.15 Coastal management areas

Key points

- There is some overlap of the coastal management areas with planned urban growth and proximity areas
- Coastal wetlands and littoral rainforests are given the highest priority for management; there is approximately 20 km^2 of coastal wetlands and 0.8 km^2 of littoral rainforests in the North Creek catchment
- It is possible that the boundaries of some coastal management areas will need to be revised as part of the CMP process

SEPP areas

The spatial extent of the coastal zone is comprised of a combination of coastal management areas which are mapped in the recently released Coastal Management State Environmental Planning Policy (SEPP) in accordance with the principles articulated in the CM Act 2016.

The four coastal management areas outlined in the Coastal Management SEPP include Coastal Wetlands and Littoral Rainforest, Coastal Use areas, Coastal Environment areas and Coastal Vulnerability areas. Specific management objectives for each coastal area are provided within with the CM Act 2016. Given that the North Creek catchment spans across the Ballina and the Byron LGA boundary (**Error! Reference source not found.**, Figure 33.), the Byron Shire will also need to be engaged throughout the CMP development process.

Considerable overlap exists between the coastal management areas and planned urban growth and proximity areas (see Figure 33.). If multiple coastal management areas apply to a single parcel of land, the CM Act imposes a hierarchy as to which coastal management objectives apply. The hierarchal order for coastal management areas is presented below (highest priority first):

- Coastal Wetlands and Littoral Rainforest Area
- Coastal Vulnerability Area
- Coastal Environment Area
- Coastal Use Area.

The Coastal Management SEPP, which provides development controls for each coastal management area, will not apply to certain applications for development consent until 3 April 2019 (Hawley, 2018). Further explanation of the intended effects of the Coastal Management SEPP is provided in explanatory notes available on the NSW State Government website. The extents of the coastal management areas provided in the Coastal Management SEPP are based on regional mapping which can change as new information becomes available. The mapped areas act as a starting point for councils in the development of their CMPs.

Changes in the extent to any of the coastal areas by a planning proposal will be subject to government and community consultation under the EP&A Act 1979. The CMP may cover areas outside of the mapped coastal zone if the management of external areas significantly impacts issues within the coastal zone. This is of relevance to North Creek, especially in terms of land use within Newrybar Swamp and its impact on estuarine health. The extent of each coastal management area within the North Creek catchment is discussed in the following section.

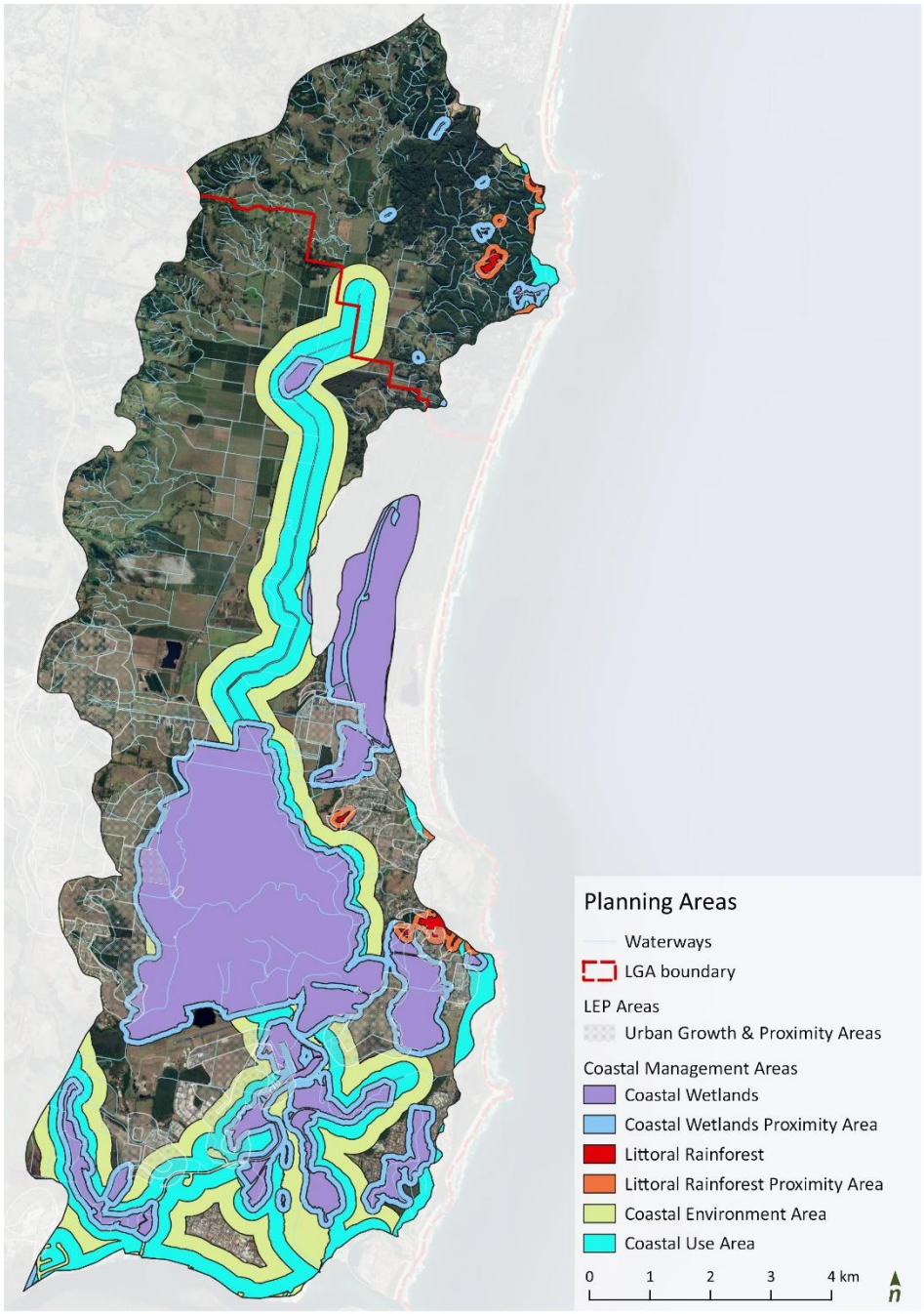


Figure 33. *An overview of the coastal management areas in relation to designated growth areas under the Ballina LEP.*

Coastal Wetlands and Coastal Littoral Rainforests

The extents of both Coastal Wetlands and Littoral Rainforests within the North Creek catchment are shown in Figure 34.. These extents are based on recently improved state-level vegetation mapping.

Within the North Creek catchment approximately 20 km² is classified as Coastal Wetland. This includes large areas of the North Creek estuary, the Ballina Nature Reserve and Birrung Creek area to the east of Byron Bay Road. Three small areas of Littoral Rainforest areas comprising a total of 0.8 km² are located in the east of the catchment near Birrung Creek, north of Skennars Head Road and along the upper reaches of Midgen Creek near Broken Head reserve.

The NSW coastal management objectives for Coastal Wetlands and Littoral Rainforests areas are provided in Table 12.

Table 12. Management objectives for Coastal Wetlands and Littoral Rainforests as described in Section 6(2) of the CM Act

Objective	Description
a	To protect coastal wetlands and littoral rainforests in their natural state, including biological diversity and ecosystem integrity
b	To promote the rehabilitation and restoration of degraded wetlands and littoral rainforests
c	To improve the resilience of coastal wetlands and littoral rainforests to the impacts of climate change, including opportunities for migration
d	To support the social and cultural values of coastal wetlands and littoral rainforests
e	To promote the objectives of State policies and programs for wetlands or littoral rainforests

Current management arrangements for critically endangered Littoral Rainforest areas are provided for by the Saving our Species program which supports the Biodiversity Conservation Act 2016. Littoral Rainforest areas within the catchment span two priority management regions: Newrybar to Cape Byron (Byron LGA) and West of Boulder Beach in Ballina (Ballina LGA). The management objectives for Littoral Rainforests within the Byron and Ballina LGAs is provided in Table 13.

Table 13. Management objectives from the Saving our Species program for Littoral Rainforests across both the Byron and Ballina LGAs

No.	Objective
a	Exclude fire from part/all of the site
b	Minimise impacts of recreational activities
c	Reduce and maintain weed densities at low levels
d	Reduce impacts of tidal/wave activity or storm surges on species habitat
e	Track species abundance/condition over time

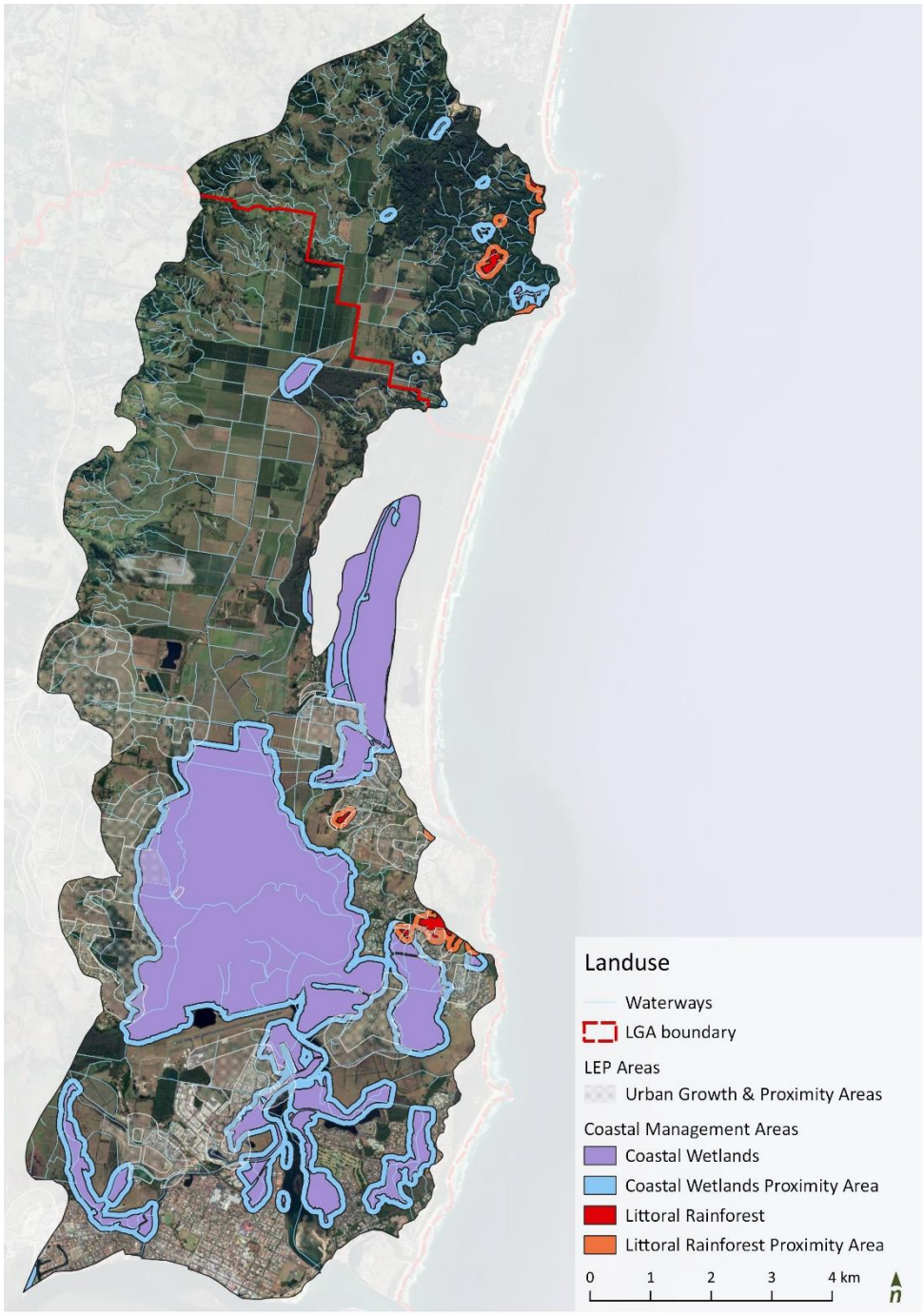


Figure 34. *The extents of Coastal Wetlands and Littoral Rainforests.*

Coastal Use areas

The extent of both Coastal Use and Coastal Environment areas within the North Creek catchment are shown in Figure 36.**Error! Reference source not found.**. Coastal Use areas include areas adjacent to coastal waters, estuaries, coastal lakes and lagoons where the impacts of development on the benefits of these areas need to be considered.

The extent of Coastal Use areas is based on set distances from coastal water bodies and are dependent on factors such as topography, local scenic amenity and the local development approach (OEH 2018b). Coastal use areas within the catchment currently extend approximately 250 m inland from water bodies. Approximately 22 km^2 of the North Creek catchment is classified as a Coastal Use area.

Management objectives for Coastal Use areas are provided in Table 14.

Table 14. Management objectives for Coastal Use Areas (as described in Section 9(2) of the CM Act 2016)

Objective		Description
a		To protect and enhance the scenic, social and cultural values of the coast by ensuring that
	i	The type, bulk, scale and size of development is appropriate for the location and natural scenic quality of the coast
	ii	Adverse impacts of development on cultural and built environment heritage are avoided or mitigated
	iii	Urban design, including water sensitive urban design, is supported and incorporated into development activities
	iv	Adequate public open space is provided, including for recreational activities and associated infrastructure, and
	v	The use of the surf zone is considered
b		To accommodate both urbanised and natural stretches of coastline.

Development controls for land mapped as Coastal Use areas are contained within Division 4 of the Coastal SEPP. Considerations for development within this area support the management objectives, and specifically address the preservation and management of safe public access, physical and visual amenity, Aboriginal cultural heritage, practices, and places, and cultural and built environment heritage. Adverse impacts on these values must be managed accordingly.

Coastal Environment areas

A similar perimeter-based approach is applied to the delineation of Coastal Environment areas. These areas include land and waterbodies which have been identified as ecologically sensitive to impacts from coastal development activity. Perimeter controls vary from 100 m for estuaries/submerged lands and 500 m for coastal lakes and lagoons. As it stands, Coastal Environment areas cover approximately 40 km^2 of the North Creek catchment.

Development controls provide for the consent authority to consider the extent to which the development will meet management objectives and impact upon natural hazards and local cultural, ecological and amenity values. Currently mapped Coastal Use and Coastal Environment areas do not extend along the Union Drain to the same extent as they do along the Flood Mitigation Drain. The CMP may need to consider the modification of the extent of these areas.

Management objectives for Coastal Environment areas are in Table 15.

Table 15. Management objectives for Coastal Environment areas (as described in Section 8(2) of the CM Act 2016)

Objective	Description
a	To protect and enhance the coastal environmental values and natural processes of coastal waters, estuaries, coastal lakes and coastal lagoons, and enhance natural character, scenic value, biological diversity and ecosystem integrity
b	To reduce threats to and improve the resilience of coastal waters, estuaries, coastal lakes and coastal lagoons, including in response to climate change
c	To maintain and improve water quality and estuary health
d	To support the social and cultural values of coastal waters, estuaries, coastal lakes and coastal lagoons
e	To maintain the presence of beaches, dunes and the natural features of foreshores, taking into account the beach system operating at the relevant place
f	To maintain and, where practicable, improve public access, amenity and use of beaches, foreshores, headlands and rock platforms.

Development controls for land mapped as Coastal Environment areas are contained within Division 3 of the Coastal SEPP. Considerations for development within this area support the management objectives, and

specifically address the preservation and management of the integrity and resilience of the biophysical, hydrological, and ecological environment; coastal environmental values and natural coastal processes; water quality of the marine estate; marine vegetation, native vegetation and fauna, undeveloped headlands and rock platforms; existing public open space and access; Aboriginal cultural heritage, practices and places; and the use of the surf zone. Adverse impacts on these values must be managed accordingly.

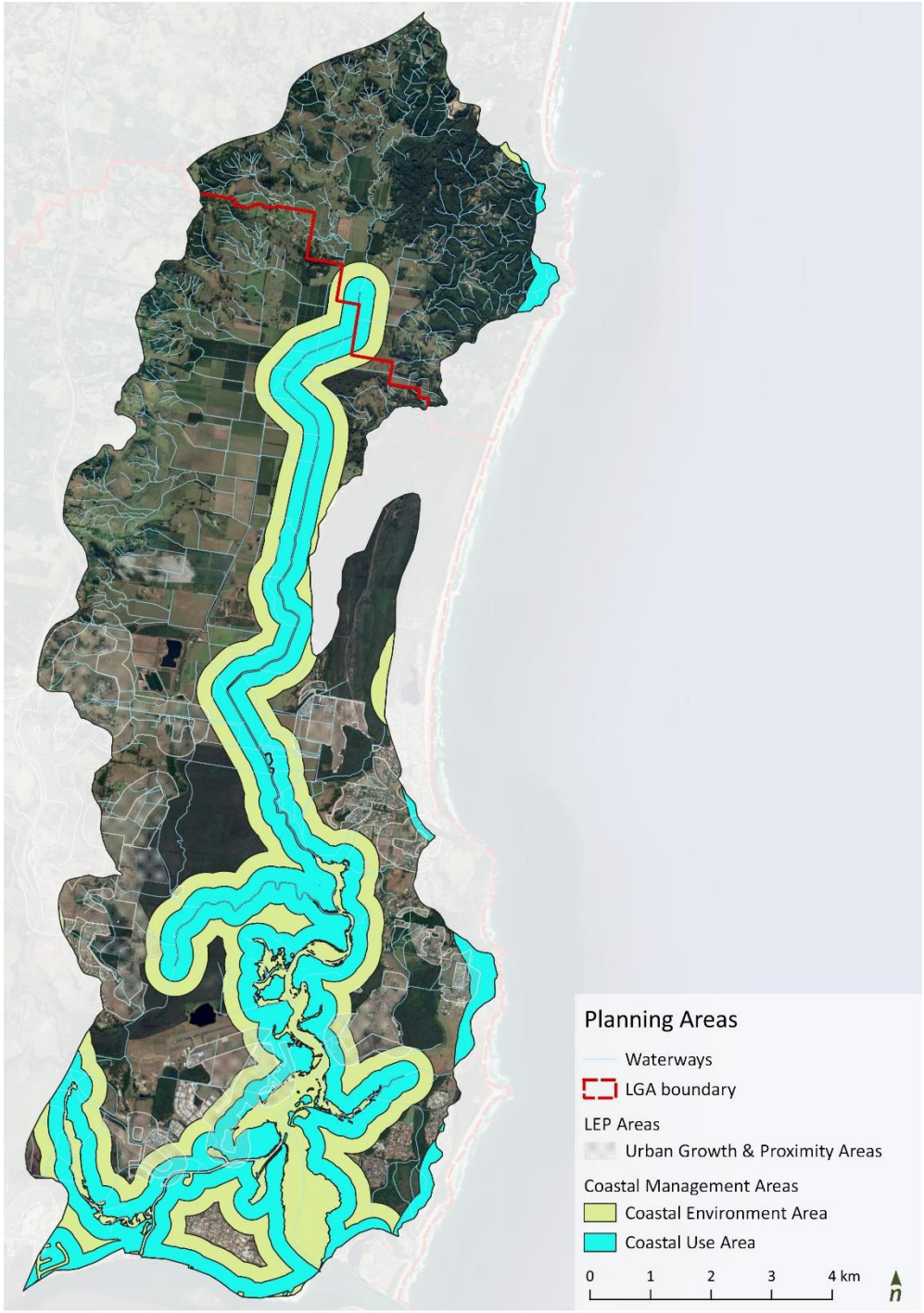


Figure 35. *The current extents of Coastal Use and Coastal Environment areas.*

Coastal Vulnerability areas

No mapped Coastal Vulnerability areas are currently available through the Coastal Management SEPP mapping. Mapped coastal hazards as defined in the LEP and DCP by previous coastal hazard studies may be used to guide the mapping of coastal vulnerability areas for all coastal hazards. Considerations for mapping

include the sensitivity, adaptive capacity and tolerance of the community to coastal hazards. Hazards which are likely to impact areas of North Creek include storm surge and tidal inundation. The issues raised by these hazards and specifically where they are likely to occur will require further clarification in order to determine the extent of Coastal Vulnerability areas within the North Creek catchment.

The 2015 Ballina Floodplain Risk Management Plan accounts for the vulnerability associated with flooding and tidal inundation which is predicted to increase with climate change. The flood extents produced as part of the supporting study are based on state sea level rise benchmarks which are no longer prescribed. This does not mean that the management plan's flood extents are no longer applicable but rather that state government now recommends that local government authorities adopt regionally relevant sea level rise planning levels in planning documents henceforth. This approach provides flexibility for BSC to reconsider local conditions when determining future hazards.

Impacts of projected land use changes
With the growing urbanisation of the catchment, land has been designated to accommodate population growth. An assessment has been conducted to determine the area of land currently designated to coastal environment area and coastal use area that may be impacted by these changes (see Figure 36 for current spatial extents). Based on the land presently designated to urban release area, approximately 15 hectares of this overlaps with coastal land of most of which falls under the classification of coastal use area. An additional 262 hectares of strategic urban growth area intersects with coastal land.

Modification of the spatial extents
Coastal Use and Environment areas as well as Coastal Wetland areas are likely to be the main management areas applicable to the issues that will be the focus of the new CMP. The management of many of the issues facing North Creek will require a catchment wide response. Given the extent of the issues and the potential solutions, it is possible that the boundary of Coastal Use and Coastal Environment areas will need to be revised. Revising these areas so they encompass the broader contributing catchment will help to manage the issues at hand and balance the social, economic and ecological needs of the catchment.

Any proposed amendments to the mapping of these coastal management areas must be identified in the final CMP, including the supporting evidence. The CMP must also identify the information about these amendments which can be used to support the preparation of planning proposals which inform the gateway determination process under section 3.34 of the EP&A Act (CMM 2018).

3.16 Existing management plans review

Key points

- There are five key existing management plans for the North Creek catchment; the Richmond River Estuary CZMP, Ballina Nature Reserve Management Plan, Ballina Floodplain Risk Management Plan, Ballina Local Environmental Plan, and Ballina Development Control Plan
- The majority of recommendations and actions from existing plans are in early stages of implementation
- Limited funding opportunities and administrative challenges have been a barrier to coastal management, as well as challenges with effecting desirable change on privately owned land

The key existing management plans relevant to the North Creek catchment include:

- The Richmond River Estuary CZMP (2012)
- Ballina Nature Reserve Management Plan (BNRMP) (2003)
- Ballina Floodplain Risk Management Plan (BFRMP) (2013)
- Ballina Local Environmental Plan
- Ballina Development Control Plan (2012)

This section provides a review of the intent and objectives of these plans, as well as implementation and outcomes to date (where sufficient information is available to provide comment), and any barriers and learnings noted. Only very limited information / monitoring has been available to inform an audit of these plans, as the majority of actions are in early stages of implementation.

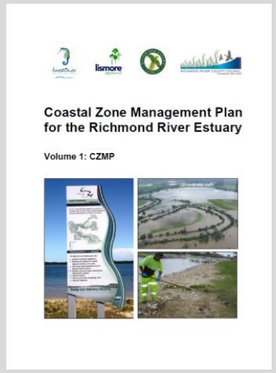
Table 16 provides a summary of the existing management plans and their objectives.

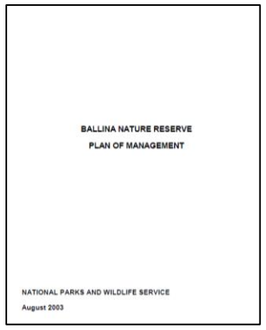
Existing plans
The Richmond River CZMP, BNRMP and BFRMP are generally in accord with the issues / challenges, objectives and management actions. Implementation of the range of recommendations and management actions across the plans is in early days, with limited information / monitoring data available on progress to date. Each of the existing plans has a broader - or more targeted - scope than the North Creek catchment itself. However, these plans align well to provide a platform for the next step of a focused CMP on the North Creek catchment.

The complex governance arrangements, limited funding opportunities and the inability to effect desirable change on privately owned land have been significant barrier to coastal management within the North Creek catchment (and surrounds).The North Creek CMP provides an opportunity to simplify governance arrangements and clearly specify the roles and responsibilities of Council and other agencies, and undertake the integrated technical studies required to address the complex surface, groundwater and tidal dynamics across the catchment. The outcomes of these studies, which will shape the final CMP, as well as the extent of its respective coastal management areas, have the potential to improve integrated land management outcomes across the mosaic of public and private land tenure across the catchment. With adequate funding the North Creek CMP can overcome many of the barriers which have inhibited coastal management arrangements to date.

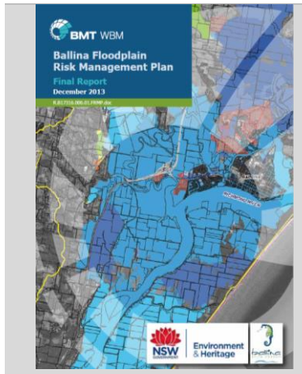
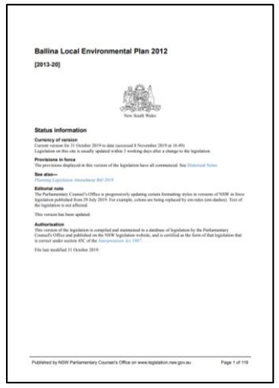
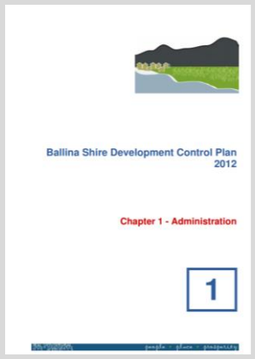
Table 16. Summary of the existing management plans for the Ballina Shire and North Creek catchment

Plan name and date	Summary of the plan	Plan objectives	Key recommendations	Plan progress and other observations

Richmond River Estuary CZMP (2012)
 
	The Coastal Zone Management Plan for the Richmond River Estuary (CZMP) is the current 10-year strategic plan (beginning in 2012) based on the Richmond River Estuary Processes Study (2006) which details the actions needed to achieve the management objectives of the Richmond River estuary, including North Creek (Zone 1).
	
	• 10-year strategic plan based on the Richmond River Estuary Processes Study (2006)
	• Details the actions needed to achieve management objectives for the Richmond River estuary
	• Overall success is defined as continuous improvement towards objectives and application of measures which address the root causes of problems facing the estuary
		1. To encourage economically viable and environmentally sustainable land use practices in the catchment
		2. To ensure strategic planning instruments and programs are consistent with and where applicable, directly address the aims of the CZMP
		3. To ensure efficient and effective management of the estuary through appropriate governance, funding and monitoring
		4. To increase knowledge of the impact of existing practices on estuary values and facilitate continuous improvement
		5. To reduce pollutant loads to the estuary
		6. To protect and enhance the riparian zone
		7. To minimise the frequency and severity of environmental events such as fish kills
		8. To optimise flood mitigation works and flow control structures to improve estuarine water quality
		9. To minimise constraints to estuary adaptation to climate change
		10. To protect and enhance the biodiversity values of the estuary
		11. To provide the increased use of the estuary whilst minimising environmental impact and conflict between users
		12. To protect the cultural heritage values of the estuary
		13. To protect and enhance visual amenity/aesthetic appeal of the estuary
		14. To enhance sustainable commercial return from industries relying on the estuary and the floodplain
		15. To minimise risk to the health and safety of users of the estuary
			Floodplain infrastructure management and farm management were identified in the CZMP as the greatest management challenges. Riparian zone management, bank erosion, floodplain vegetation management, community education, waterway usage, wastewater management and urban runoff are also of concern. Cultural heritage and fishery management were identified as key values of the estuary.
			
			A total of 13 management strategies were developed in response to these issues. The prioritisation of management strategies listed in Table 13 was supported by an options assessment and cost/benefit prioritisation process detailed in volume 2 of the CZMP. Each strategy lists its objectives and is broken down into actions with key details on tasks, desired outcome, lead organisation, supporting resources, priority, cost, timing and KPIs.
			
			Fundamental management strategies include administrative and governance; climate change adaptation; and monitoring, evaluation and review.
			
			High priority management strategies include floodplain infrastructure management and farm management.
			
			Medium and low priority management strategies include the management of the riparian zone, vegetation, education, waterway usage, wastewater, urban runoff, cultural heritage and fisheries.
				• A mid-term review of the plan the following:
				  ○ 5 strategies or actions were 'on target'
				  ○ 13 strategies or actions were 'partially complete'
				  ○ The remaining 9 strategies or actions were still in the early stages of implementation
				
				• Governance and administrative arrangements were the main barriers to implementation
				• Recognises that not all actions may be carried out over its 10-year time frame
				• Broad scope does not provide a direct focus on the issues facing North Creek.
				
				The ABER review of the plan's supporting study (the Estuary Processes study) found that key elements of the system's understanding were missing, particularly an understanding of the biogeochemical interplay with trophic systems which underpin ecological health and water quality. ABER noted that Southern Cross University is a world leader in MBO research and holds knowledge and data of MBO distribution and processes within the Richmond, and by association, the North Creek catchment. Collaboration with the university in the development of the CMP would leverage this knowledge base in the filling of the knowledge gaps identified as part of this scoping study.

Ballina Nature Reserve Management Plan (2003) 	• Provides the scheme operations in accordance with the *National Parks and Wildlife Act 1974* • The desired outcome is an effective hydrological regime, minimal soil disturbance and improved water quality • Fire, introduced species and drainage are listed as the three key threats to reserve values, drainage being the most significant.	1. Preserve the Reserve as part of a regional network of wetland Parks and Reserves 2. Conserve the diversity of habitat types within the Reserve, with particular emphasis on the protection of the wetland habitat 3. Seek to maintain a hydrological regime in the Reserve that maintains Reserve ecosystems 4. Enhance the viability of habitat by encouraging vegetation corridors off the Reserve where possible 5. Conserve the Reserve's diverse native flora and fauna, including vulnerable and endangered species and regionally significant species 6. Protect the native flora and fauna habitats in the Reserve from processes, uses and pest species threatening its integrity 7. Reduce the distribution and/or spread of introduced species in the Reserve 8. Encourage Reserve neighbours in conserving adjoining natural areas	High priority actions include: • A hydrological assessment of the reserve to examine the feasibility of restoring hydrological regimes to a greater part of the Reserve • An examination of the environmental effects of the drains in the reserve • A whole of catchment study if any changes to the current hydrological regime are proposed that may adversely impact the Reserve • For some drains, maintenance works will only be licensed if they constitute an existing interest pursuant to Section 39 of the *NPW Act* and will not be detrimental to the Reserve ecosystems • NPWS will seek the cooperation of relevant government agencies and Ballina Shire Council to monitor quality of water runoff from surrounding residential, industrial, extractive and agricultural land uses	The plan also provides guidance on actions which address issues relating to native flora and fauna, introduced species, fire management, cultural heritage, recreation and education. A flora and fauna study of the Reserve was given high priority to understand the current species diversity. Such a study would assist in determining if vulnerable, endangered and regionally significant species exist and are not further threatened. It is understood these prioritised actions have not been fulfilled, this is partly due to the NSW NPWS being unable to commission a stand-alone study of the hydrology of the Ballina Nature Reserve (to date); and the governance arrangements associated with the maintenance of any legally recognised drains in the Ballina Nature Reserve requires environmental assessment and subsequent mitigation requirements.

Ballina Floodplain Risk Management Plan (2013)	The primary objective of the Ballina Floodplain Risk Management Plan (BFRMP) is to facilitate the mitigation of flood risk within the Ballina LGA) (WBM 2012).
	
	The plan incorporates flood modelling results from a study area which extends as far north as Ross lane within the North Creek catchment. These levels were noted as particularly sensitive to ocean storm surge. The plan also incorporates 2010 sea level rise planning horizons as published by the Department of Planning under the now superseded 2009 Sea level Rise Policy Statement.
			Flood mitigation measures recommended include:
			• Property modification
			  ○ Update development controls
			  ○ Develop voluntary house raising scheme
			  ○ Develop agricultural levee guidance
			• Response modification:
			  ○ Finalise selection of evacuation centres
			  ○ Develop community engagement strategy
			  ○ Update evacuation planning
			  ○ Develop flood intelligence cards
			  ○ Extend gauge network
				• Development controls have been updated as a result of the BFRMP study
				• It is understood that the remaining recommended actions are still in the early stages in implementation
				
				• Flood levels were noted as being particularly sensitive to ocean storm surge
				• The plan incorporates 2010 sea level rise planning horizons

Plan name and date	Summary of the plan	Plan objectives	Key recommendations	Plan progress and other observations
			○ Assess alternative evacuation order methods ○ Investigate flood warning and prediction system options ○ Raise low points on evacuation routes • Flood modification: ○ Implement Gallans Road cycleway floodway ○ Implement structural measures assessed separately from the BFRMS ○ Consider removal or lowering of Deadman's Creek Road	The plan is due for review in 2019 under its implementation schedule. The review will need to take into consideration the legislative reform that has occurred since, especially regarding climate change and associated sea level rise. The updated regional climate modelling projections for NSW (NARCliM) will also need to be considered.
Ballina Local Environmental Plan (2012) 	The Ballina Local Environmental Plan (updated 2012) provides the zoning and development controls which guide the way land can be used. The general aims of the plan are to foster appropriate management, development and conservation of natural and man-made resources, to promote the social and economic welfare of the community and to provide an improved environment.	Separate objectives exist for each of the 17 Land Use Zones specified in the LEP. In an overall sense, however, the aims of the LEP are to: 1. Provide for a sustainable Ballina that recognises and supports community, environmental and economic values through the establishment and maintenance of the following: - a built environment that contributes to health and wellbeing, - a diverse and prosperous economy, - a healthy natural environment, - diverse and balanced land uses, - healthy, resilient and adaptable communities, - responsible and efficient use of resources, 2. Provide for development that is consistent with Council's established strategic planning framework for Ballina 3. Achieve the objectives of the land use zones set out in the LEP 4. Promote the orderly and efficient use of land having regard to the social and environmental characteristics of the land, 5. Provide for the development of public services and infrastructure.	Specific land zone objectives as defined in the plan.	
Ballina Development Control Plan (2012) 	The Ballina Development Control Plan (DCP) is a council policy document that contains the detailed controls applicable to development in the Ballina Shire. Each chapter of the plan provides detailed controls applicable to different aspects of the Council's development control framework.	1. Ensure that applicable considerations are taken into account in the siting and design of development 2. Ensure that development is undertaken in a manner that is compatible with the physical and environmental characteristics of land 3. Ensure that development is undertaken with regard for applicable public health standards 4. Minimise potential for land use conflict 5. Protect the amenity of urban area though the preservation of significant tress and vegetation 6. Provide assessment criteria that will be applied when Council approval is required to remove or otherwise impact on vegetation 7. Conserve trees of ecological, heritage, aesthetic and cultural significance to Ballina Shire 8. Provide holistic approach to managing development on the floodplain 9. Minimise the impact of flooding on individual owners and occupiers of land and public assets 10. Encourage the development and use of land in a manner compatible with the likely flood hazard 11. Maintain the function of flood mitigation measures 12. Minimise the extent to which emergency vehicles and public infrastructure need to be relied upon in terms of evacuation or other flood responses 13. Consider the future projected impacts of sea level rise on the floodplain	Detailed controls as applicable.	Chapter 2 of the plan is most relevant to the North Creek CMP as it covers general and environmental considerations, vegetation management and floodplain management

Coastal emergency response arrangements

The Ballina Shire Council has prepared two documents that are relevant to the response arrangements in relation to coastal emergencies that may arise; the Ballina Shire Local Disaster Plan (DISPLAN) and the Ballina Shire Local Emergency Management Plan August 2016 (BSC 2012; BSLEMC 2016). A Local Emergency Risk Management Study was undertaken by the committee to identify the hazards that have the potential to pose a risk to the Ballina Shire (BSLEMC 2016).

The plans have identified the coastal hazards that may be relevant to the Ballina Shire: cyclone / East Coast low, coastal erosion, flood / storm surge, severe storm, tidal inundation and tsunami (BSC 2012; BSLEMC 2016). The key agency that is responsible for emergency services is the NSW State Emergency Service (SES). Table 17 summarises the responsible agency and the mitigation or prevention strategies that are in place to manage coastal hazards.

Table 17. Summary of the coastal hazards identified in the Local Emergency Risk Management study (adapted from BSC 2012 & BSLEMC 2016)

Coastal hazard	Responsible agency	Mitigation / prevention strategies (BSC 2012)
East Coast low / cyclone	NSW SES, BSC (Local Flood Plan)	• Preparation, ongoing monitoring • Community education • Audible warning system • Road closures and evacuation plan/s • Annual multi-agency exercise • Review existing plans to endure currency
Tidal inundation / storm surge	NSW SES, BSC (Local Flood Plan)	
Storm	NSW SES, BSC (Local Flood Plan)	
Tsunami	NSW SES, NSW State Tsunami Sub-Plan	• Develop tsunami warning plan • Develop education workshop for community and emergency services personnel • Develop a recovery and rehabilitation plan
Coastal erosion	NSW SES	• Ballina Coastline Interim Measures and Actions plan (pending completion of Coastline Management Study and Coastline Management Plan)

The plans also identify that evacuation routes out of the affected areas may become restricted. As a result, specific areas of the catchment where residents may be able to seek shelter are identified. For example, in the event of inundation due to storm surge, flooding or a cyclone, higher ground in East Ballina and the main town area could be used as refuge (BSC 2012).

Updates on coastal hazard areas and risk determined during the CMP process will provide inputs for future updates of coastal emergency response planning.

3.17 Synthesis

Key points

In the past century the North Creek catchment has undergone rapid changes. The vast swampy floodplain and wetlands into which the small coastal catchment creeks flowed have been extensively drained to allow for agricultural and urban development. Now, over half the catchment area is used for agriculture including grazing and sugarcane cultivation and just over 10 % of the catchment urbanised for residential development. With Cumbalum Urban Release Areas A and B due to come online in the short to medium term, development pressures on the catchment are likely to increase.

These changes have already and will continue to fundamentally change the nature of the catchments' hydrology and environment, impacting sensitive terrestrial and estuarine ecosystems, as well as the fisheries and aquaculture industries in the lower estuary. Drainage works have often intercepted acid sulfate soils and increased the connectivity for surface runoff entering the estuary (Enviro Solutions 2017, ABER 2008). These changes have had adverse impacts for waterway and ecosystem health, as well as the oyster industry in the lower catchment (Hydrosphere 2011, Ryder et al., 2015). While the channelization and flood levee works have been beneficial for agricultural development, drainage issues remain a concern for parts of the community, and are a broader challenge for catchment management. Table 18 summarises the key points noted from the information that has been presented across Section 3 of this scoping study.

Table 18. Summary of the background information presented in Section 3 of this report to inform the CMP process

Section	Key points
Geology and soil landscapes	• Much of the catchment is of very low elevation representing formerly freshwater and estuarine wetland locations in a back-barrier environment. • Over 50 % of the North Creek catchment has been identified as at risk from acid sulfate soils (potential or known)
Climate	• The climate of the North Creek catchment is regulated by its proximity to the sea • A relatively short record of temperature and rainfall is available for the Ballina Shire • The catchment has experienced a number of significant flooding events in recent history • Sea level rise is likely to have an increasing impact across the catchment
Historic changes to the catchment	• The Bundjalung people are the traditional owners of the land • Extensive drainage works have modified catchment hydrology, surface water, groundwater and tidal interactions
Landuse	• Present day landuse includes rural residential, horticulture and grazing, and increasing macadamia plantations and conservation areas • Urban growth is increasing incrementally, with around 2 – 5% of the catchment classified as urban release/growth areas
Groundwater	• Groundwater levels are strongly influenced by tidal cycles across the mid and lower catchment • The complex interaction between groundwater levels, tidal influence, recharge and water quality is a key management challenge for the North Creek catchment
Ecology	• Threatened ecological communities within the North Creek catchment include Coastal swamp oak forest, Littoral rainforest and coastal vine thickets, and Lowland rainforest • There are a number of species and ecological communities that are vulnerable to a changing catchment and coastal processes, land use and climate change impacts
Water quality	• The modified nature of the North Creek catchment and floodplains, including past vegetation clearing, planting of exotic species, and the low gradient drainage network, creates a challenging environment for managing water quality • Poor water quality through the drainage network has contributed to fish kill events and a decline in the oyster production • Agricultural runoff is the primary source of diffuse pollutant loads • There is (modelled) potential for significant pollutant generation from both urban and rural areas during runoff events • There is a need for, and opportunity to, enhance water quality monitoring across the catchment to better inform future management activities and priorities.

Section	Key points
Dredging and sand mining	• Sand shoals in the lower estuary have been extensively dredged to allow ship navigation • The feasibility of dredging in lower North Creek is being considered to provide a sand resource, to improve navigability, and to increase tidal flushing and improve water quality in North Creek • Sand mining may exacerbate acid water discharge into North Creek
Drainage	• Extensive drainage works have been undertaken over time to mitigate flooding and enable agricultural and urban development • Changes to the drainage patterns have substantially altered the hydrology, surface and groundwater interactions, which underpins the majority of ongoing management challenges for the catchment
Waterways	• The laterally unconfined streams of the foothills and coastal floodplain have been extensively modified since European settlement • Discontinuous swampy meadows have been converted to a network of linear drains and levees across the mid-catchment zone • Tidal ingress up the waterways influences over 70% of waterway length • The overall geomorphic condition of North Creek is relatively stable, linked to the relatively low gradient across the catchment • Riparian condition is good where native vegetation remains across the Ballina Reserve area, and moderate to poor in upper and lower parts of the catchment where native vegetation and mangroves have been lost.
Social context	• The Bundjalung people are the traditional custodians of the land • The North Creek catchment is home to an estimated 34,000 people, concentrated within the urban centers of Ballina, East Ballina, West Ballina and the townships of Lennox Head and Skennars Head • The population of Ballina Shire is predicted to grow by between 20 and 28 % by 2036, with the main growth centres at Ballina North, Lennox Head and Cumbalum
Economic context	• The economy of the Ballina Shire is underpinned by health care, construction and retail trade • The economy is relatively resilient (diversified) • Tourism and agriculture, forestry and fishing are also key industries • Oyster harvesting in the lower estuary is sensitive to environmental factors, including water quality, resulting in annual fluctuations in production and value
Stakeholder and community values	• A diversity of stakeholders have an interest in the CMP development • An Agency Reference Group has been established to collaborate during the CMP development • Key values identified by the community (via survey) included native vegetation, biodiversity, waterbirds, swimming and fishing

Section	Key points
	• Key threats to values identified by the community (via survey) included rubbish, urbanisation, agriculture, stormwater discharge, loss of riparian vegetation, poor drainage.
Land use / tenure	• North Creek catchment is host to a mosaic of public and private land tenure which is subject to a number of local, regional and state management arrangements
Coastal management areas	• There is some overlap of the coastal management areas with planned urban growth and proximity areas • Coastal wetlands and littoral rainforests are given the highest priority for management; there is approximately 20 km^2 of coastal wetlands and 0.8 km^2 of littoral rainforests in the North Creek catchment • It is possible that the boundaries of some coastal management areas will need to be revised as part of the CMP process
Existing management plans	• There are five key existing management plans for the North Creek catchment; the Richmond River Estuary CZMP, Ballina Nature Reserve Management Plan, Ballina Floodplain Risk Management Plan, Ballina Local Environmental Plan, and Ballina Development Control Plan • The majority of recommendations and actions from existing plans are in early stages of implementation • Limited funding opportunities and administrative challenges have been a barrier to coastal management, as well as challenges with effecting desirable change on privately owned land

Barriers

There are a range of barriers / challenges for developing and implementing management actions to address priority issues (e.g. drainage, water quality) for the North Creek catchment. These barriers have been identified in some of the previous relevant reports (e.g. the CZMP 2012) as well as being raised in stakeholder discussions for this scoping study, and include:

- Limitations in funding opportunities - funding/resources limited by Council's budget
- Limitations in system understanding – e.g. complex surface water, groundwater and tidal dynamics
- Challenges with administrative / governance arrangements
- Challenges with effecting desirable change on privately owned lands, which is, in practice, one of the most significant elements of the governance discussion
- Timeframes to implement actions are often long and require sustained effort to engage stakeholders on desired outcomes
- The time lag between land use planning and execution of development. Significant barriers to achieving best practice outcomes are common (accounting for changing topography, existing/emerging issues, sea level rise).
- The complexity of implications of sea level rise on ecology, existing development, agriculture at a localised scale.

Opportunities

The recent coastal reforms provide an opportunity to overcome barriers through the funding of integrated Coastal Management Programs. The key opportunities for the North Creek catchment CMP include:

- The CMP process enables a holistic consideration of the issues facing the catchment and improved system understanding.
- The concurrent community engagement process will enable ongoing interaction with stakeholders on issues, thus bringing science and existing information to the collective discussion.
- Engagement with agencies across issues on a catchment basis.
- The CMP process will provide a platform and business case for future funding investment as part of the new Coastal Management Framework.
- Ability to incorporate and deliver existing goals and actions in other strategic documents that are aligned with the CMP.
- Funding available through NSW Coasts and Estuaries fund (50:50) and other sources, can assist with rolling out priority studies and actions as part of the CMP process.

There is currently strong community support and interest in the CMP development. The community survey undertaken as part of this scoping study identified that the North Creek catchment provides significant social, economic and environmental values to the community. This includes scenic and amenity values and recreational opportunities. The promotion of the protection and enhancement of these values has the potential to help enhance community support for the management of North Creek. Community support can act as an enabler for catchment management initiatives through providing political pressure and motivation for collaborative partnerships.

Key issues / challenges
Key management issues for the North Creek catchment have been identified through the synthesis of previous work and research (Section 3), and the stakeholder and community engagement process (Section 3.14).

The key management issues for the North Creek CMP identified from the overall strategic context to the CMP in Section 3 include:

- Catchment runoff
  This includes - agricultural diffuse runoff, diffuse urban stormwater and acid sulfate soils runoff. For the purposes of the scoping study, these stressors are combined and referred to collectively as catchment runoff.

- Altered hydrology
  This includes – changing patterns of surface and groundwater interactions, and altered drainage patters across the catchment.

- Climate change
  This focuses on the implications of climate change on sea level rise and increasing tidal inundation across the catchment.

- Sand mining and dredging
  This includes sand mining activities in the catchment, and dredging in the lower estuary reaches.

- Governance / administration
  This refers to the challenges / perceived challenges associated with governance and administrative arrangements for coastal management in the region.

This review and key issues inform the first-pass risk assessment (in Section 5) which is used to prioritise management issues and priority studies/assessments for the later stages of the CMP process.

4 CMP vision and objectives

Developing a future vision and objectives for the North Creek catchment is a strategic focus of the North Creek catchment Community and Stakeholder Engagement Plan (C&SEP) (see Attachment A). This will be an ongoing participatory process that will be shaped over the course of the CMP development and informed by stakeholder interests as well as outcomes from the technical investigations.

A preliminary vision and objectives have been identified following the initial consultation with stakeholders during the scoping study process. This vision will be built on and further refined during Stage 2 and 3. The preliminary vision for the North Creek catchment that is intended to guide the implementation of the Coastal Management Program (i.e. what the CMP is trying to achieve) is:

"A healthy estuary, resilient ecosystems, and a sustainable, productive catchment."

The vision for the CMP process to achieve this is:

"Through evidence based, and dialogue-based collaboration with the catchment's key agency stakeholders and wider community, the CMP process will develop a shared understanding of the coastal and catchment processes of the North Creek catchment and the social, economic and environmental constraints upon those accountable for the implementation of its CMP."

A list of the key stakeholders involved in the process is outlined in Attachment A.

Preliminary objectives linked to the vision statement are provided in Table 19. These are preliminary and will be further developed as the CMP process progresses, with the intent of developing measurable objectives once the outcome of technical investigations is known and the detail of the CMP objectives can be further refined. During Stage 2 and 3 there will be a significantly improved understanding of the environmental, social and economic conditions, values and constraints within the catchment. Consequently, clear and measurable objectives will be able to be identified.

Table 19. Preliminary objectives for the North Creek catchment

Value	Objective
Estuary health	Enhance the condition of the estuary by improving water quality entering from the catchment and protecting and enhancing fringing ecosystems
Wetland	Maximise the ecological health and resilience of coastal wetlands within the catchment
Sustainable industries	Promote economically viable industries which limit the impacts on ecosystems and are resilient to changes associated with climate change
Liveable communities	Create communities which integrate with, and limit the impacts on, the natural environment

North Creek estuarine reach – visioning for a healthy estuary

5 Scope of the CMP

This section includes assessments completed for this scoping study to assist in defining the forward scope of the CMP. This includes:

- A first-pass risk assessment for the key issues (identified in Section 3)
- Prioritisation of issues, studies and recommendations for the CMP forward work program over subsequent Stages of the CMP development.

5.1 First-pass risk assessment

Approach

The first pass risk assessment for the Ballina Shire utilises a similar approach as the threat and risk assessment framework for the NSW Marine Estate (MEMA 2015). The risk assessment has been conducted for three planning horizons, present-day, 2050 and 2100, to consider the emerging risks. The trajectory for future planning horizons assumes no management action is taken beyond current practices (includes only business as usual activities).

For each issues, the likelihood and consequence of a negative impact on key values was assessed using the criteria in Table 20 and Table 21. The likelihood and consequence were then used to assign the level of risk according to the risk matrix in Table 22. The risk to key environmental, social and economic values in the North Creek catchment is provided in Table 23, Table 24 and **Table 25** respectively. The risk assessment is informed by the strategic context to the CMP set out in Section 3, as well as stakeholder engagement discussions during the scoping study development.

Outcomes were cross-checked with the threat and risk assessment (TARA) conducted by NSW Marine Estate using their online tool. Given the broad spatial extent considered by TARA, adjustments were made to reflect the background review specific to the North Creek catchment. Discretion was used to alter the prioritisation of issues based on their final ranking where an issue ranked above another, but management of the lower ranking issue was considered more complex.

Table 20. The likelihood scale adopted for the risk assessment (MEMA 2015)

LIKELIHOOD LEVEL	Description
Rare	This threat is extremely unlikely to be realised at a level that would impact on the benefit within a 20-year period.
Unlikely	This threat is not expected to be realised at a level that would impact on the benefit in a 10-year period, but could be expected in a 20-year period.
Possible	This threat is not expected to be realised at a level that would impact on the benefit every year, but could be expected in a 10-year period.
Likely	This threat is not expected to be continuous, but could be expected to be realised at a level that would impact on the benefit every year.
Almost certain	This threat is expected to be realised at a level that would impact on the benefit frequently throughout a year or more-or-less continuously.

Table 21. The consequence scale adopted for the risk assessment (MEMA 2015)

CONSEQUENCE LEVEL	Description
Insignificant	Realisation of this threat would not have a discernible impact on the benefit at a state-wide scale.
Minor	Realisation of this threat would have only a small or very temporary impact on the benefit at a state-wide scale.
Moderate	Realisation of this threat would significantly reduce the benefit over the medium term (5-10 years) at a state-wide scale, or have major consequences for a sensitive benefit at a regional level.
Major	Realisation of this threat would substantially reduce the benefit for an extended period (10-20 years), but not totally or permanently, at a state-wide scale, or would have catastrophic consequences for a sensitive benefit at a regional level.
Catastrophic	Realisation of this threat would effectively terminate delivery of the benefit either permanently or for a very extended period (>20 years) at a state-wide scale.

Table 22. The matrix used to determine the level of risk as a function of consequence and likelihood of a threat being realised (MEMA 2015).

LIKELIHOOD	LEVEL OF RISK				
ALMOST CERTAIN	MINIMAL	LOW	MODERATE	HIGH	HIGH
LIKELY	MINIMAL	LOW	MODERATE	HIGH	HIGH
POSSIBLE	MINIMAL	MINIMAL	LOW	MODERATE	HIGH
UNLIKELY	MINIMAL	MINIMAL	MINIMAL	LOW	MODERATE
RARE	MINIMAL	MINIMAL	MINIMAL	MINIMAL	LOW
CONSEQUENCE LEVEL	INSIGNIFICANT	MINOR	MODERATE	MAJOR	CATASTROPHIC

Environmental values

Table 23 provides the first-pass risk assessment based on consideration of two key environmental values within the North Creek catchment, estuary water quality and biodiversity. Water quality and biodiversity are also interlinked, so the results should also be viewed in terms of the combined / overall risk.

Catchment runoff, altered hydrology and climate change are understood to be the main present and/or emerging risks to key environmental values for the North Creek catchment.

The high risk of catchment runoff and altered hydrology impacting on environmental values is linked to associated poor water quality and changing flow patterns, and increasing tidal inundation is expected to be key emerging risk in the future (as discussed in Section 3).

Table 23. Risk assessment for the environmental values of the North Creek catchment for the present-day, 2050 and 2100 planning horizons

Environmental values							
Issue / threat	**Estuary water quality**			**Biodiversity**			**Overall risk**
	Present	**2050**	**2100**	**Present**	**2050**	**2100**	
Catchment runoff	Mod	High	High	Mod	High	High	High
Altered hydrology	Mod	High	High	Mod	High	High	High
Climate change	Min	Low	High	Low	High	High	Mod
Sand mining and dredging	Low	Low	Mod	Min	Min	Low	Low - Mod
Governance / administration	Mod	Mod	Mod	Low	Low	Mod	Mod

Social values

A first-pass risk assessment for the key social values within the North Creek catchment, scenic amenity and recreation, is summarised in Table 24.

Catchment runoff, altered hydrology, sand mining and dredging, are understood to be the main present and emerging risks to social amenity and recreation values for the North Creek catchment.

The overall risk of catchment runoff to the social values of the North Creek catchment is high. This is linked to the impact of runoff on water quality, which would affect both the scenic amenity and recreation value of the waterways. The impact is greater on recreation as poor water quality could have ill health effects. The risk is also high for altered hydrology as the drainage works could affect flows to the waterways, impacting water quality (e.g. flushing effects) and levels (e.g. boating access). Recreation values are anticipated to be most impacted as the mid to lower reaches of North Creek are highly valued by residents.

The present risk of climate change to scenic amenity and recreation is minimal, however, it may escalate to a high risk by 2100. Climate change may affect scenic amenity by raising water levels and impacting existing vegetation communities. The recreation value may be diminished by climate change in a similar manner; sea level rise may impact access to waterways. Shoaling in the lower estuary currently provides habitat for shorebirds and fish species. The mining of these shoals for sand would result in a loss of habitat which was

viewed as contributing to the scenic amenity. It may also affect the fish population where fishing is highly valued. The overall risk of sand mining to the social values is moderate to high.

The present risk of governance to scenic amenity and recreation is low but this may increase to moderate by 2100 as the remaining threats to the catchment go unmanaged and the issues escalate.

Table 24. Risk assessment for the social values of the Ballina Shire for the present-day, 2050 and 2100 planning horizons

Social values							
Issue / threat	Scenic amenity			Recreation			Overall risk
	Present	2050	2100	Present	2050	2100	
Catchment runoff	Mod	High	High	High	High	High	High
Altered hydrology	Mod	High	High	High	High	High	High
Climate change	Min	Low	High	Min	Mod	High	Mod
Sand mining and dredging	Mod	Mod	Mod	High	High	High	Mod - High
Governance / administration	Min	Low	High	Low	Mod	High	Mod

Economic values

Table 25 outlines the first-pass risk assessment for the key economic values of tourism, agricultural production and aquaculture.

Catchment runoff, altered hydrology and climate change are understood to be the main present and emerging risks to the economic values of the North Creek catchment. Further economic assessment is also presented in Section 6.2.

It is anticipated that (with no intervention) catchment runoff risk of impact on agricultural production and oyster farming will increase in the future. Tourism is impacted by catchment runoff as it affects the scenic amenity and recreational capacity of the waterways.

Table 25. Risk assessment for the economic values of the Ballina Shire for the present-day, 2050 and 2100 planning horizons

Economic values										
Issue / threat	**Tourism**			**Agricultural production**			**Aquaculture**			**Overall risk**
	Present	**2050**	**2100**	**Present**	**2050**	**2100**	**Present**	**2050**	**2100**	
Catchment runoff	Mod	High	High	Min	Low	Mod	Mod	High	High	High
Altered hydrology	Low	Mod	High	Low	Mod	High	Low	Low	Mod	High
Climate change	Min	Min	High	Min	Mod	High	Min	Low	High	Mod - High
Sand mining and dredging	Low	Mod	Mod	Min	Min	Min	Min	Low	Mod	Mod
Governance / administration	Min	Min	Low	Min	Min	Low	Min	Min	Low	Low - Mod

Final ranking of issues

Based on an appreciation of the risk rankings across environmental, social and economic values, an overall priority ranking of management issues is shown in Figure 36. The purpose of this ranking is to provide an appreciation of which management issues have the greatest current and future potential impacts on the diversity of values in the North Creek catchment. This enables an appreciation of how management effort and actions should be prioritised for the CMP, including studies required in Stage 2 of the CMP development, and evaluation / prioritisation of management options in Stage 3 of the CMP development.

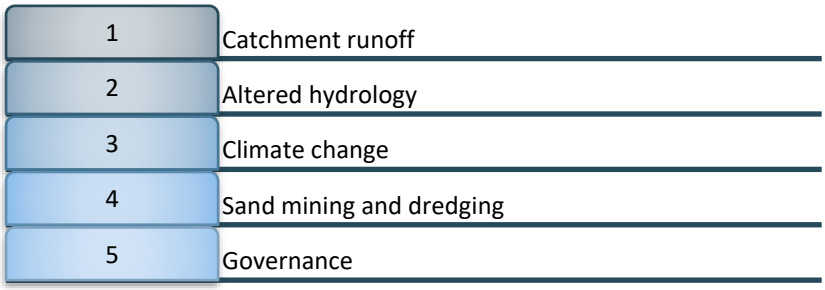


Figure 36. *Final ranking of key management issues for the North Creek catchment*

5.2 Priority issues and recommendations

The scoping study process across Section 3 to 5 of this document has provided an appreciation for:

- The technical studies and plans completed to date, and the state of current knowledge on coastal values and management challenges for the North Creek catchment (Section 3)
- The key management issues for the North Creek CMP, and priority issues as informed by a first-pass risk assessment (Section 3 and Section 5)
- Recommendations/strategies in existing plans (including the CZMP) to be carried forward into the CMP (for evaluation of options in Stage 3) (Section 3)
- Gaps/opportunities for additional improvement of the knowledge base for the CMP development (Section 3 and Section 5)

A summary of the key existing management sources relevant to the priority issues, and recommended gaps to fill as part of the Stage 2 CMP process (or beyond) is provided in Table 26.

Additional studies are also recommended that could be included in Stage 2 of the CMP development, or alternatively as part of the CMP actions (Table 26 and Table 27).

Recommended studies and indicative budgets are nominated for inclusion into the forward works program in Section 7.

Table 26. Summary of key issues, including gaps to fill for CMP Stage 2 (or Stage 3/action in the CMP)

ID	Management issue/Threat	Description	Level of risk	Assessment of Knowledge Gaps		Recommendation for further studies	Responsible Agency and costing	CMP stage	Priority for Stage 2 inclusion
				Knowledge Gap	Importance				
1	Altered hydrology	The hydrology and drainage pattern of the catchment continues to change. This is leading to a variety of hydrological issues across the catchment including poor water quality, changes to ecological communities and impacts on landholders. The issues is likely to be exacerbated by sea level rise.	High	Given the low relief of the catchment, high resolution digital elevation data are required in order to model catchment hydrology at the level of precision required.	*Very important* – modelling of the catchment cannot occur without this information. A number of recommended studies depend on this information.	a) Collection of high-resolution topographic data to 0.1 m vertical resolution of entire catchment b) Bathymetric survey of all key drains and estuary channel c) Development of hydrodynamic model of the catchment to assess flow dynamics and drainage pathways and impacts on existing land uses. Coupled catchment-coastal model including tidal and storm tide inundation.	BSC, Rous County Council $250 - $350,000	Stage 2	High
		The drainage works within the catchment impacts on landholders, catchment and estuary ecosystems. There is limited integration between catchment drainage and estuary health.	High	The condition of drains is not well understood. This includes the impacts on adjacent land uses and ecosystems.	*Important* – Understanding the existing drainage regime will be critical to determining the viability of certain land uses within the catchment	d) Mapping of drain condition and capacity based on the outcomes of studies 1 (a), 1 (b) and 1 (c) e) Assessment of the impacts of drains on adjacent land uses and ecosystems f) Economic analysis of the cost and benefits of existing drainage works g) Review of governance arrangements for drains management	BSC, Rous County Council $60,000	Stage 2 OR Stage 3 or action out of CMP	Moderate
2	Catchment Runoff	Agricultural and urban development, drainage works and disturbance	High	The catchment drivers (and their spatial and	*Very important* – understanding the drivers of	a) Implement North Creek Water Quality Monitoring Program (WQMP) which will include	BSC, Rous County Council	Stage 2	High

ID	Management issue/Threat	Description	Level of risk	Assessment of Knowledge Gaps		Recommendation for further studies	Responsible Agency and costing	CMP stage	Priority for Stage 2 inclusion
				Knowledge Gap	Importance				
		of acid sulfate soils has degraded water quality within the North Creek estuary		temporal variations) of pollutant generation.	water quality is critical to enable management	ambient and event based monitoring for over 18 months across different areas of the catchment b) Development of Source Catchment model of surface and groundwater pathways using outputs from study 1 (c) and WQMP to assess pollutant pathways through the catchment	$150,000		
3	Climate change	Projected sea level rise will have significant impacts on environmental, social and economic impacts within the catchment	High	The tidal amplitude and influence within the catchment for the present and future time frames (20, 50 and 100 years)	*Very important* – This information is required to help the economy, ecosystems and communities adjust to the impacts of climate change (inform adaptation options)	a) Use the hydrodynamic model developed in study 1 (c) to assess tidal inundation for a range of likely climate change scenarios including: • Impacts on aquifer systems and discharge of acid water • Assessments of key ecosystems that will be impacted • Assessment of key land uses that will be impacted by sea level rises and changes to climate • Assessment of socio-economic impacts of sea level rise and changes to climate Actions should feed into the Climate Action Strategy, and then results of the actual studies into the Local Growth Management Strategy (Agricultural Lands section).	BSC $100,000	Stage 2 / feed into Climate Action Strategy	Moderate

ID	Management issue/Threat	Description	Level of risk	Assessment of Knowledge Gaps		Recommendation for further studies	Responsible Agency and costing	CMP stage	Priority for Stage 2 inclusion
				Knowledge Gap	Importance				
4	Sand accumulation in estuary	Sand mining of shoals is currently being considered to improve water quality and provide a sand resource.	Moderate	The impact of dredging on water quality and tidal inundation is unknown	*Important* – prior to assessing dredging proposals the full impacts of the works on the catchment and estuary needs to be understood	a) Use the hydrodynamic model developed in study 1 (c) to assess impacts of dredging to assess impacts on tidal exchange b) The degree of sediment ingress into North Creek and therefore the rate to potential depletion of sand resource in the lower Richmond River c) Use the catchment model developed in study 2 (b) to assess a range of dredging/catchment scenarios including: • Sand resource value and economics • Assess impacts on estuarine habitat, shorebirds, cultural heritage • Implementation impacts (i.e. dewatering, noise and vibration, traffic planning, detailed works planning etc.) • Economic analysis of the cost and benefits of proposed dredging works d) Community engagement on the ecological values of shoals in lower estuary environments	BSC $250,000	Stage 2 OR Stage 3 or action out of CMP	Moderate

Table 27. Additional knowledge gaps and recommended studies for North Creek catchment (CMP Stage 2 or beyond)

ID	Management issue/Threat	Description	Level of risk	Assessment of Knowledge Gaps		Recommendation for further studies	Responsible Agency and costing	CMP stage
				Knowledge Gap	Importance			
5	Land use planning	Land use planning decision are currently made with considerable uncertainty surrounding future conditions (i.e. seal level rise, drainage)	High	The long term sustainability and economic viability of certain land uses.	*Very important* – Will assist in helping the communities and economies of the catchment be viable into the future	a) Based on the outputs of the climate change and catchment runoff assessments economic analysis should be undertaken to determine the viability of each industry in different areas of the catchment b) Based on the outcomes of 5 (a) determine land use zones and identify management objectives for each zone Actions should feed into the Climate Action Strategy, and then results of the actual studies into the Local Growth Management Strategy (Agricultural Lands section).	BSC $30,000	Stage 2 OR Stage 3 or action out of CMP - Feed into Climate Action Strategy
6	Ecosystems (vegetation)	Vegetation communities are highly fragmented within the catchment.	Moderate	There has been some mapping within the Ballina Nature Reserve and of littoral rainforest and coastal wetlands Naturally occurring vegetation across the catchment is not fully known.	*Moderate* - Would be very useful in planning riparian and other revegetation projects and would assist with long term planning for Ballina Nature Reserve.	a) Mapping of existing vegetation communities across the catchment b) Mapping of pre-European vegetation communities if possible c) Priority zones for linkages and reinstatement of natural vegetation d) Based on the climate change studies determine the likely changes to vegetation community Note that these studies feed into a Biodiversity Strategy.	BSC $50,000	Stage 2 OR Stage 3 or action out of CMP - Biodiversity Strategy
7	Ecosystems (Saltmarsh, seagrass, mangrove)	Saltmarsh, seagrass and mangrove communities are very important to the estuary ecology and provide significant ecosystem services.	High	Existing communities are mapped, but there are knowledge gaps around potential for reinstatement and migration under climate change scenarios. The potential for	*Important* – these areas support fish populations and provide significant ecosystems services	a) Based on the climate change studies determine the likely changes to saltmarsh, seagrass and mangrove communities b) Map potential reinstatement locations c) Identify potential opportunities for migration with sea level rise	BSC $25,000	Stage 2 OR Stage 3 or action out of CMP

ID	Management issue/Threat	Description	Level of risk	Assessment of Knowledge Gaps		Recommendation for further studies	Responsible Agency and costing	CMP stage
				Knowledge Gap	Importance			
				reinstatement and the impacts of climate change are not well understood.		e) Develop a draft saltmarsh, seagrass and mangrove migration policy		
8	Ecosystems (fish and wild oyster populations)	The estuary is a very important habitat for fish and wild oysters.	High	Regular monitoring not undertaken, species and populations information is largely anecdotal. Scientific basis for recovery can't be established without monitoring.	*Important* – anecdotal information is concerning but no supporting monitoring data.	a) Baseline and regular monitoring required to characterise existing population and changes over time. b) Monitor of cultured oyster health during WQMP implementation to identify parameters (and potentially land-uses) which impact on morbidity and mortality oy oysters	BSC, DAF $40,000	Stage 2 OR Stage 3 or action out of CMP
9	Ecosystems (Shorebirds)	The estuary and catchment provide important habitat for shorebirds. Current information and monitoring of lower estuary exists and will be monitored through dredging investigation and activities.	Moderate	Upper estuary and catchment usage unknown.	*Moderate* – not essential but would be simple to expand dredging related monitoring	a) Expand monitoring relating with dredging to include upper estuary.	BSC $20,000	Stage 2 OR Stage 3 or action out of CMP
10	Ballina Nature Reserve (BNR)	The Ballina Nature Reserve is a large area of the catchment that is classified as a coastal wetland. Drainage through the area has been extensively modified.	High	There is little understanding of the ecological values and drainage pathways within the Ballina Nature Reserve.	*Important* - Consideration of management and conservation values cannot be updated without this work.	a) Determine the current drainage characteristics of the Ballina Nature Reserve based on the outputs from study 1 (c) b) Assess the ecological condition of the ecosystem c) Based on the climate change studies determine the likely changes to ecosystems within the Ballina Nature Reserve d) Update actions list within the Ballina Nature Reserve Plan of Management	BSC, Rous County Council, NPWS $50,000	Stage 2 OR Stage 3 or action out of CMP

ID	Management issue/Threat	Description	Level of risk	Assessment of Knowledge Gaps		Recommendation for further studies	Responsible Agency and costing	CMP stage
				Knowledge Gap	Importance			
						e) Seek legal counsel on pathways by which coastal wetlands can be disturbed for improved hydrological and ecological outcomes		

6 Preliminary business case and forward program

6.1 Preliminary economic analysis

Overview
The purpose of this section is to introduce the best-practice approach for completing the full economic business case (to be delivered over Stages 2 and 3), and to identify key infrastructure and service types that will be the focus of the analysis. The full economic business case will estimate the existing and future risks throughout North Creek, indicate the net benefits of each adaptation option (or package of options) and will ultimately influence final plan development (in Stage 4). The economic business case builds-on to the biophysical investigation (undertaken for this CMP and as part of previous regional studies), supplying decision-makers with additional information to inform the best way forward. The process presented is consistent with State investment frameworks.

This preliminary assessment includes:

- Data to inform the economic assessment
- Defining the economic 'base case'
- Determining the preferred adaptation approach
- Financing mechanisms
- A case study on tidal inundation implications based on high level scoping study information.

Data to inform the economic assessment
To understand how the economy might be affected by a changing climate the full economic business case for the CMP will include an economic assessment of each priority issue. The precision of the analysis relies on the availability and quality of suitable data, and how it is used.

A summary of the main data types that are likely to be required for the full economic business case are listed in Table 28. The economic assessment will use data from several sources, including primary studies, grey literature and previous assignments completed. Expert judgement is used where information gaps are encountered. Given the quality of the input data, the economic analysis will include significant sensitivity analysis to underpin informed decision-making.

Table 28. Data to inform the economic assessment

Priority issues	Potential impacts	Biophysical data (typically) required	Economic data (typically) required
Catchment runoff	Poor downstream water quality	Change in water quality parameters (e.g. TSS, TN, TP)	Pollution abatement costs
Altered hydrology	Reduced water availability	Loss of productivity (e.g. yield reduction)	Gross margins for impacted agricultural outputs
	Poor downstream water quality	Change in water quality parameters (e.g. TSS, TN, TP)	Pollution abatement costs
	Risks to fauna	Any available risk assessments	Benefit-transfer (e.g. avoided management cost)
Climate change (resulting in sea level rise, erosion)	Flood inundation of various land uses and infrastructure (incl. land loss)	Stage-damage assessment (built-assets)	Stage-damage curves from previous flood assessments
		Loss of productivity (e.g. yield reduction)	Gross margins for impacted agricultural outputs
		Area of natural asset by type	Value of ecosystem services (using a benefits-transfer approach)

Priority issues	Potential impacts	Biophysical data (typically) required	Economic data (typically) required
		Loss of biodiversity (i.e. change in extent and condition of key biodiversity assets)	Values from primary studies
		Damage to tourism assets	Reduction in revenues to tourism operators
	Poor downstream water quality	Change in water quality parameters (e.g. TSS, TN, TP)	Pollution abatement costs
	Loss of land and infrastructure	Erosion assessment (land use areas)	Value of production / infrastructure / ecosystem services
Sand mining	Poor downstream water quality	Change in water quality parameters (e.g. TSS, TN, TP)	Pollution abatement costs
	Flood inundation of various land uses and infrastructure (incl. land loss)	Area of natural asset by type	Value of ecosystem services (using a benefits-transfer approach)
		Loss of biodiversity (i.e. change in extent and condition of key biodiversity assets)	Values from primary studies
		Damage to tourism assets	Reduction in revenues to tourism operators

The focus of the detailed economic assessment will be determined by the biophysical risk assessments (assets at risk), the economic base case (the economic risk of doing nothing differently) and the available adaptation options.

Defining the economic 'base case'

Defining the economic base case is a fundamental step in developing the full business case. For this analysis it enables an assessment of risk, estimates potential economic damage and loss from coastal inundation and erosion in the absence of intervention. It will provide foundational data that will be used to undertake the cost-benefit analysis of the possible management and adaptation options. The base case can be thought of as a register of all relevant land uses and other components that might be affected under different flood conditions and over multiple planning horizons.

Error! Reference source not found. depicts how information derived from the base case analysis is used to d etermine the benefit of adaptation. Simply, the figure highlights that the economic value of an asset may decline over time due to coastal hazard impacts where this is no adaptation. However, with adaptation the economic outcomes are improved and that improvement is quantified as the benefit. This approach to analysis is leading practice and will provide an informed basis for the development of the CMP.

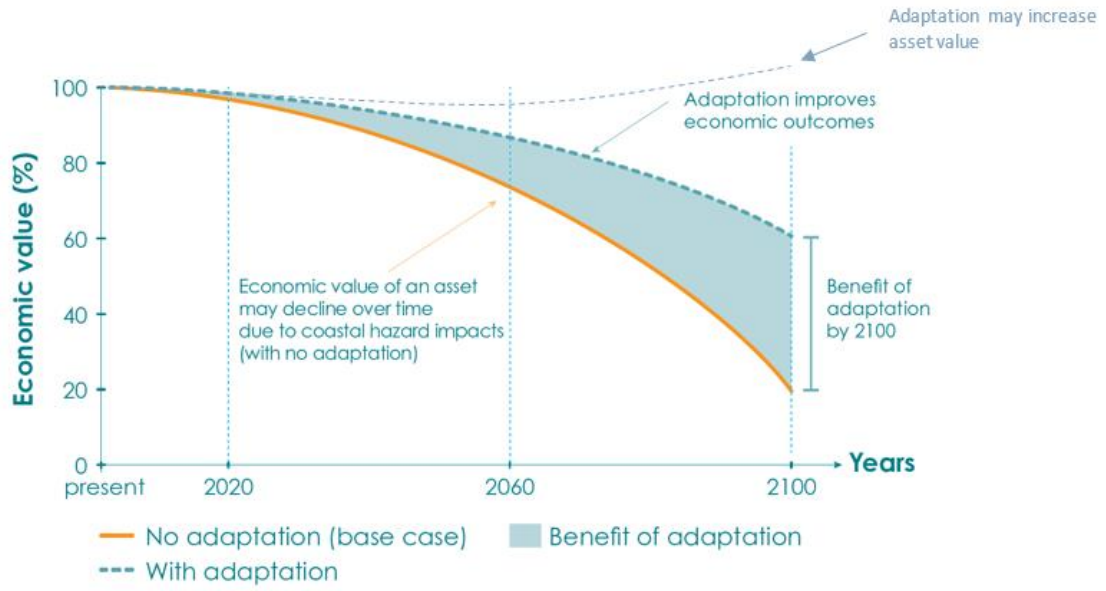


Figure 37. *Conceptual model of how base case information is used to determine the benefit of adaptation/management*

The base case is presented in terms of 'damages' (e.g. asset damage to buildings or infrastructure) and 'losses' (e.g. losses of economic value to key industries, such tourism because of loss of infrastructure). The damages and losses are assessed as the total sum of exposed assets (for a certain likelihood of AEP in a given year).

The timing of coastal risk events is not known and therefore the average annual damage (AAD) is estimated at each time period. AAD is the probability-weighted estimate of damage and loss. It can be understood using the standard risk equation:

$$Risk = 'expected\ damage' = \sum_{i=1}^{\infty} damage\ (of\ hazard\ event\ i)\ \times likelihood\ (of\ hazard\ event\ i)$$

where damage is a function of exposure and sensitivity of assets, and the likelihood of damage or loss occurring is based on the modelled annual exceedance probability. The AAD is the best-practice approach to estimate potential economic impacts of flood hazards (and for CBA of natural disasters) in a given year.

Overview of key asset classes and valuation

Table 29 has been included to provide an overview of key asset classes at risk, including an initial estimation of replacement costs in the event that the coastal hazard damages the asset. These costings can be used as a starting point for future analysis. At a later stage of the CMP they should be revised with Council to ensure they are appropriate for the North Creek catchment at that time.

Table 29. Discussion of key asset classes (including indicative damage/loss estimate)

Type	Component	Units	Low estimate	High estimate	Reference/Comment
Pipes	Pipe (sewerage)	$/linear m	164	201	Coastal hazards (e.g. inundation and erosion) threaten the stability and performance of the pipe network. Data measuring the metres of pipe affected by coastal hazards at each township in North Creek will be determined during Stage 2 of the analysis. The damage can then be approximated in dollars using the replacement costs taken from Rawlinsons (2018).[4] If the Shire has site specific data this will be preferred to Rawlinsons.
	Pipe (stormwater)	$/linear m	213	260	
Road infrastructure	Roads	$/lane km	$150,000		Similar to the pipe network, roads are threatened by coastal hazards. The costs of the road per kilometre will vary depending on the type of road – i.e. whether a road is a major road or minor road. Gargett (2017) estimates the current value of a paved undivided road at $150,000 per km.[5] The cost of traffic signals and culverts has been taken from Rawlinsons (2018).
	Traffic signals	$ per set	110,000	137,000	
	Culvert	$/linear m	1,565	1,915	
Residential / Commercial buildings	Flood damage (slab on ground)	$/m^2	Variable		See discussion under *Economic costs of flood risk* (below) on the stage-damage relationship of different asset types.
	Flood damage (raised)				
	Flood damage (industrial)				
	Flood damage (other commercial)				
	Erosion damage	$/m^2	1,324	2,866	Erosion threatens the integrity of a structure. It differs from flooding because erosion will likely compromise the stability of the foundations and therefore put the entire structure at risk. At this stage of the process it is likely that an asset will be assumed irreparably damaged if it is within the erosion zone (in a given time period) – determined Stage 2. Construction costs can be estimated using the online tool provided by BMT Quantity Surveyors (https://www.bmtqs.com.au/construction-cost-table). At this stage of the CMP process adjustments have not been made to convert replacement cost estimates from Brisbane (as the closest major city) to North Creek.
	Airport	$/structure	n/a	n/a	Further research required (to be completed at a later stage, if necessary)

[4] Rawlinsons (2018) Australian Construction Handbook is viewed as a leading authority on the various aspects of Australian construction costs.
[5] Gargett (2017). Growth in the Australian Road System. Department of Infrastructure and Regional Development: Information Sheet. Australia Government. Accessed at <https://www.bitre.gov.au/publications/2017/files/is_092.pdf> on 22/11/2019.

Type	Component	Units	Low estimate	High estimate	Reference/Comment
Other infrastructure	Carpark	$/structure	n/a	n/a	Further research required (to be completed at a later stage, if necessary)
	Jetty	$/structure	n/a	n/a	Further research required (to be completed at a later stage, if necessary)
Agriculture / Aquaculture	Macadamia trees/nuts	Gross margin[6] ($/ha)	-2,189	5,995	The production of Macadamia nuts is a significant agricultural industry throughout the Ballina Shire and more broadly North Coast NSW. In 2015/16 macadamia nuts were the largest commodity produced in the Shire, contributing 46.3% to the Shire's agricultural value and 39.8% of the value of macadamia nut production in New South Wales (ABS 2017). Coastal hazards threaten the productivity of agricultural land. A study completed for North Coast NSW provides an indication of the estimated gross margin per hectare for macadamia trees (Quinlan 2004).[7] The study should be treated with extreme caution given that is was published 15 years ago; however, it provides insight into the differences of gross margins given the age of a macadamia tree. The gross margins vary between -$2,189 and $5,995 (2018$) for a 3 year old tree and a 15 year old tree, respectively. This is critical for this assessment because of the substantial time lag between the establishment of a new tree crop and profitable production. For example, if productive mature macadamia trees are damaged during a coastal hazard event, and they need to be replaced, there will be at least 5 years before the production turns an annual profit.
	Sugar cane	Gross margin ($/ha)	1,360	2,769	Sugarcane is another important crop in Ballina Shire. Similar to the discussion of macadamia trees above, coastal hazards (e.g. inundation) threaten the production of sugar cane. Sugar cane is susceptible to saline (e.g. marine) water which affects the yield. Initial estimated gross margins have been obtained from a tool produced by Sunshine Sugar for NSW farmers (http://sunshinesugar.com.au/new-to-the-industry/information-for-new-growers/19-new-grower-information.html). The low estimate is based on the plant cane value and the high estimate is from the ratoon cane. Both values have been converted to 2018$.
	Oysters	Gross margin ($/m)	TBC	TBC	Despite the oyster harvest area in North Creek closing in 2006, leases within the estuary can still be utilised for farming of oysters, which only require transportation to Mobbs Bay in the Richmond River for depuration prior to harvest. Given there are less than five oyster operators within the lower Richmond/North Creek estuaries, DPI NSW cannot release the economic production data for this system due to confidentiality considerations. Consequently, it is not possible at this time to determine the economic value of oyster production and the gross margins secured. The gross margin for oysters will need to be confirmed in the following stages of the CMP.

[6] The gross margin equals the revenue minus the variable (non-fixed) costs of production.

[7] Quinlan, K. (2004). Macadamia costs and returns for northern NSW. NSW Department of Primary Industries. Accessed at <https://www.agmrc.org/media/cms/macadamiacostsandreturnsfornorthern_7BB3544DE59D5.pdf> on 18/11/2019.

Type	Component	Units	Low estimate	High estimate	Reference/Comment
Natural / environmental assets	Coastal forests and wetlands	$/ha/yr	543	3,692	Natural assets provide a range of 'services' that contribute to human wellbeing through both their extent and condition. Some of the key services include tourism (recreation and visual aesthetic), attenuation of wave energy and erosion protection, carbon storage and sequestration, and maintaining nursery. The initial unit estimations have been determined using a benefit transfer process, which is where the benefits identified in a primary study in a given location are then adjusted for a different location. The values provided here represent the benefit from the Whitsundays (with no adjustment), which will be adjusted (where necessary) for the North Creek catchment at a later stage of the CMP process.
	Mangroves	$/ha/yr	3,591	9,563	
	Beach	$/ha/yr	3,000,000	5,400,000	It should be noted that beach assets generate three values. Firstly, use values associated with visitation. Secondly existence values (they are valued by the community purely because they exist). Thirdly, as they provide a degree of coastal protection to assets inland of the beach (beach absorbs energy from storm events). These values are highly variable depending on the specific beach asset.
Tourism	Average spend per night	$/night	69	221	Tourism Research Australia publishes data relating to tourism at the local government level. The adjacent data is based on a four-year average from 2014 to 2017 (TRA 2019). Disaggregated tourism data specifically for North Creek does not appear to be publicly available. Anecdotally, if the region is temporarily affected by a hazard (e.g. a significant storm) then we would likely see tourists that have already travelled to North Creek partake in a non-coastal activity (e.g. shopping). In many cases this would result in a substitution of expenditure in the region – not lost expenditure. However, a potentially profound issue is the risk that tourists who are considering travelling to the region perceive that the region has been damaged by the coastal hazards and choose not to visit North Creek altogether. This would result in a loss to the region's economy. From a desktop analysis, it is difficult to appreciate the extent of the tourism market in North Creek and the visitors' preferences. At later stages of the CMP, it will be valuable if Council could help contextualise the North Creek tourism sector and ground-truth estimations.

Economic costs of flood risk to building assets

The economic cost of flood risk to building assets (the consequence component of a risk assessment) varies with the depth of flooding and building type. Depending on the flood event, the costs may include:

- Direct internal damage (e.g. wall linings, floorings, wiring, curtains etc.)
- Direct external damage (e.g. window frames, external wall materials)
- Direct structural damage (e.g. footings for elevated houses)
- Indirect damage (e.g. chattels).

Using vulnerability curves developed by Geosciences Australia and insurance data from the 2011 floods in South East Queensland, it is possible to estimate stage-damage curves for different flood heights for different build asset types.[8] The stage-damage relationship for residential and commercial buildings is shown in Figure 38.[9] The relationships indicate that slab-on-ground and raised construction builds (both including residential assets) are significantly affected at 100mm height and then trends at a flatter incline after that. A key driver of this is the susceptibility of internal wiring within the house that will most likely be destroyed during a flood. Alternatively, the stage-damage profile for industrial (e.g. a warehouse) and other commercial buildings exhibit a steadily increasing relationship reflecting the different purpose, needs and construction of the asset.

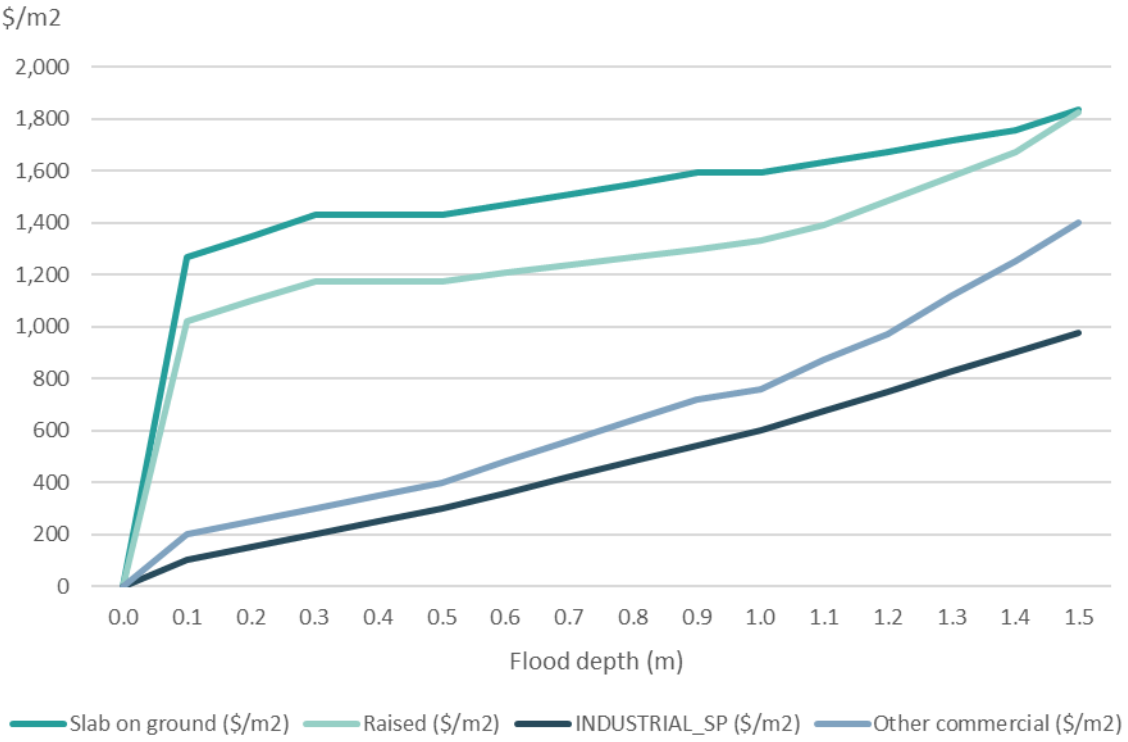


Figure 38. Estimated direct stage-damage curves for buildings ($/m^2)

Source: NCEconomics modelling based on Geoscience Australia (2017) Vulnerability of Australian Houses to Riverine Inundation. Analytical and empirical vulnerability curves, BMT-WBM (2017) Brisbane River Strategic Floodplain Management Plan. Technical Evidence Report.

[8] At this stage of the CMP process the data presented captures the stage-damage relationship in South East Queensland. In the following stages of the CMP process it may be appropriate to adjust the relationship reflecting conditions in North Creek.

[9] The stage-damage curves are based on the modelled estimates used for the Brisbane River Strategic Floodplain Management Plan (BMT-WBM (2017) Brisbane River Strategic Floodplain Management Plan. Technical Evidence Report).

Determining the preferred management options through economic analysis
A full cost benefit analysis (CBA) will be completed in Stages 2 and 3 of the CMP process to indicate the viability of management options, ranking them based on their economic efficiency.

CBA is a comprehensive approach that identifies and values as many relevant benefit streams (e.g. flood protection, recreation) and costs (e.g. construction costs, land foregone) as possible. Both market and non-market values (e.g. public amenity) are considered. Importantly, per NSW government (2017), CBA is required to be undertaken for any new or altered capital, recurrent or regulatory action for any policy, program, project, proposal or initiative. Therefore, the CBA output is a vital input if Council seeks State co-investment in any of the coastal management measures.

For this CBA, the benefits will be the estimated reductions in base case damage and loss that can be attributed to the performance of the management options (refer to **Error! Reference source not found.**). The costs are t he estimates of the lifecycle costs of each option. There are two key decision rules in CBA that guide whether an option is economically viable. The first is the benefit cost ratio (BCR), which is expressed as the benefits (in dollars) divided by the costs. This suggests that an option is appropriate if the BCR is greater than one – the higher the ratio the better the option. The other rule is a net present value (NPV) assessment, which is calculated by subtracting the benefits from the costs (in present day dollars). If the NPV is greater than zero then the option is viable.

Benefits are closely linked to the values and characteristics of the community, land use, assets in the exposure zones, catchments and receiving environment. Several different types of economic valuation methodologies will be used to undertake the CBA. This will likely include a mix of market valuation (e.g. gross margins for products), non-market valuation approaches (e.g. revealed preference – travel cost method) and benefit-transfer. The approach to developing a CBA must be participatory to ensure that key benefits and costs are scoped for inclusion in the analysis. Council and community are best placed to uncover intangible benefits and costs that are unique to North Creek.

The quality of data for coastal analysis can vary. Therefore, sensitivity analysis must be undertaken to provide confidence in modelled outcomes. Sensitivity analysis highlights how results are likely to change under alternative assumptions/inputs or within certain tolerances. Best-practice approach to sensitivity analysis requires the use of monte-carlo simulations, which calculates a range of possible results for any specified variable. This process enables the analyst to locate which input is driving the outcome of the model and then determining if further work is required to improve confidence in that input/s.

The results from the CBA can be used to rank each adaptation option based on its economic efficiency. This information can then be provided to decision-makers as a key input to prioritise the best outcome for North Creek.

Case study for tidal inundation
A preliminary loss assessment has been undertaken as part of the CMP scoping study.[10] The purpose of the assessment is to gain an appreciation for the potential magnitude of impact of the projected increase in tidal inundation for the North Creek catchment (in the absence of intervention).

In Section 3.4, indicative areas that may be impacted by increasing tidal area were considered, based on the CoastAdapt high level HAT plus sea level rise projections. As a case-study, an initial valuation of horticultural land potentially impacted by tidal inundation for 2050 and 2100 planning horizons has been considered.

Table 30. Indicative areas impacted by projected tidal areas (based on CoastAdapt modelling)

	Total Area inundated 2050 (ha)	Total Area inundated 2100 (ha)	Change (ha)	% change
Agricultural Land (hort)	521	799	279	54

Agricultural values that were derived from the gross margins (revenues less operational costs) of dominant regional crops – sugarcane and macadamia.[11] That is, the economic value of the permanent losses of agriculture is estimated as the capitalised value of annual gross margins foregone. A 50:50 mix of sugarcane and macadamia crop (gross margins have been capitalised) has been assumed for the purposes of the high-level assessment. Unit rates for the crops are noted in Table 29.

The estimated loss to agricultural (horticulture) land due to tidal inundation in 2050 is estimated to be in the order of $14 million, potentially increasing to $22 million by 2100.

Natural assets in the catchment
An indicative estimate of natural asset values across the catchment, based on current mapped areas and unit rates from Table 29 include:

- Total mangrove/saltmarsh areas are valued at **$720,000** to **$1,870,000** per year
- Coastal forests (Ballina Nature Reserve) are valued at **$365,900 to $2,488,400** per year
- Sea grass ecosystems in the North Creek estuary are values at **$15,300** to **$27,800 to** per year

These values are indicative estimates only, and should be considered in conjunction with broader economic values of the catchment described in Section 3 as the basis for investment in the CMP process.

Financing mechanisms
The total approximate cost for the proposed studies is in the order of $600,000 to $700,000 (refer Table 26 and Table 27). The Ballina Shire Council is envisaged to incur the primary administrative burden as the driver of the CMP process. More detailed estimate for the total cost of the CMP can be determined by the BSC through the allocation of labour against each action listed in the forward program (Table 31).

Funding has been made available to support local government in the management of coastal issues (such as for hazard mapping). This funding is accessible through the Coastal and Estuary grants program. Five streams of funding exist, one for planning and studies and four for implementing works identified in certified coastal zone or estuary management plans. The planning stream will fund:

- Development of CMPs (including individual stages) or the transition of a CZMP to a CMP, consistent with the in the NSW Coastal Management Manual

[10] This is a preliminary estimate only. The values presented here should not be relied upon for decision making. Instead, they are included to guide discussion, and preliminarily indicate the possible magnitude and extent of loss to agricultural land due to a changing climate. A full economic analysis should be undertaken in Stages 2 and 3.
[11] Gross margin is calculated by subtracting the variable cost from the revenue.

- Studies to understand coastal processes and map coastal hazards/coastal vulnerability area
- Studies to understand threats to the objectives of coastal management areas within the NSW coastal zone
- Investigations and designs for infrastructure works recommended in a certified CZMP or CMP
- Cost-benefit analyses and distributional analysis of who pays.

Each of the recommended actions listed in this scoping study fall within the funding requirements for the planning stream.

The preliminary economic assessment for the CMP scoping study has indicated that there is a strong case for investing in the CMP priority studies and CMP development for North Creek. This is based on consideration of the potential implications of tidal inundation impacts on agriculture alone being in the order of up to $14 million by 2050, and the ecosystem services values of natural assets in the catchment being in the order of up to $1 million per annum.

6.2 CMP Stages 2 to 5 forward work program

Ballina Shire Council is the primary (lead) agency responsible for the development of the North Creek CMP. Fast tracking is not considered for the North Creek CMP due to the degree of risk and uncertainty identified. The management issues are complex and interrelated and will require completion of the recommendations through Stages 2 and 3 in order to inform an effective CMP.

Established partnerships exist with Rous County Council and other key stakeholders for the delivery of the recommended studies for Stage 2 of the CMP and beyond (refer Table 26, Table 27). The spatial scope of the CMP is confirmed as the full North Creek catchment and estuary.

The proposed forward program for the CMP development is outlined in Table 31.

Table 31. The forward program for the remaining stages of the CMP process for the North Creek catchment

Milestones and Actions			Estimated cost ($)	Estimated completion date
STAGE 1 – Determine the scope of the CMP				
Draft completion				Jun-19
Review and feedback				Nov-19
Final report and grant acquisition				Dec-19
STAGE 2 – Determine risk, vulnerabilities and opportunities			**$540,000 (upper total)**	
Confirm Stage 2 scope and objectives (project team meeting) and update project plan			5,000	Mar 20
Refine understanding and fill high priority knowledge gaps – Stage 2 studies			$400,000 - $500,000	Sep-20
1. Altered hydrology	a)	Collection of high-resolution topographic data to 0.1 m vertical resolution of entire catchment	$250,000 - $350,000	
	b)	Bathymetric survey of all key drains and estuary channel		
	c)	Development of hydrodynamic model of the catchment to assess flow dynamics and drainage pathways and impacts on existing land uses. Coupled catchment-coastal model including tidal and storm tide inundation.		
2. Catchment runoff	a)	Implement North Creek Water Quality Monitoring Program (WQMP) which will include ambient and event based monitoring for over 18 months across different areas of the catchment	$150,000	
	b)	Development of Source Catchment model of surface and groundwater pathways using outputs from study 1 (c) and WQMP to assess pollutant pathways through the catchment		
Update understanding of threats to coastal values and management opportunities			5,000	Oct 20
Update of risk assessment			10,000	Oct 20
Identify timing and priorities for responses/actions, thresholds and lead times			5,000	Nov 20

Milestones and Actions	Estimated cost ($)	Estimated completion date
Preparation for planning proposal to amend coastal management areas	5,000	Nov 20
Stage 2 communication and engagement as per Community and Stakeholder Engagement Plan	10,000	Nov - Dec-20
STAGE 3 – Identify and evaluate options	**$112,500**	
Confirm Stage 3 scope and objectives (project team meeting) and update project plan	5,000	Jan 21
Identify and collate management options across all priority issues	20,000	Feb 21
ARG meeting and confirm and refine all management options	10,000	Feb 21
Evaluate and prioritise management options across all priority issues – efficacy, economic cost-benefit, plan for implementation	60,000	Mar 21
Identify pathway and timing of actions	7,500	Mar-21
Stage 3 communication and engagement as per Community and Stakeholder Engagement Plan	10,000	Feb – Mar 21
STAGE 4 – Prepare, exhibit, certify and adopt CMP	**$52,500**	
Confirm Stage 4 scope and objectives (project team meeting) and update project plan	5,000	Apr 21
Preparation of draft CMP	30,000	Jun-21
ARG meeting to discuss draft CMP	7,500	Jun 21
Exhibition of the draft CMP and the Planning Proposal		Jun-21
Review and adoption of the draft CMP		Sep-21
Submission of the draft CMP to the Minister for certification		Sep-21
Publishing of the Certified CMP in the Gazette		Dec-21
Stage 4 communication and engagement as per Community and Stakeholder Engagement Plan	10,000	
TOTAL Phases 2 - 4		**$600,000 - 705,000**
STAGE 5 – Implement, monitor, evaluate and report		
Implement actions in the published CMP		
Implement an effective monitoring, evaluation and reporting (MER) program		
Monitor indicators, trigger points and thresholds		
Amend, review and update the CMP		
Report to stakeholders and the community on progress and outcomes through the IP&R framework		

6.3 Links to existing programs

Several programs exist which are likely to benefit the North Creek CMP through the provision of information and support for the delivery of the recommended actions. These are summarized below.

Marine Estate Management Strategy

Key actions that the Marine Estate Management Strategy will deliver in Stage 1 (2018 -2020) can be found at the NSW Marine estate website. The Marine Estate Management Authority will also deliver pilot program in the Richmond River catchment. This pilot project involves on ground works to address priority threats and risks to the social cultural and economic values of environmental assets in the Richmond River estuary, including North Creek. Many agencies including DPI Fisheries, North Coast Local Land services and EES will be involved. The actions relevant to the development of a coastal management program for North Creek involve:

- A floodplain assessment involving capturing information about existing drainage infrastructure assets, landscape values and constraints in data acquisition phases in order to populate a multicriteria analysis to inform objective and holistic management decision making for agencies involved in floodplain management; and
- Bank management, marine vegetation and foreshore structure strategies.

The Marine Estate Management strategy also lists two actions targeted at LGA's which involve the implementation of a targeted marine litter campaign and the development of a Marine Litter Working Group.

Richmond River Governance Framework

The NSW government in collaboration with local councils in the Richmond River catchment is developing a revised governance framework that will establish the responsibility for delivering improved river health outcomes in the Richmond River catchment. The outcomes of this co-developed framework may inform or even fulfill the requirements of the recommended governance review for Stage 2 of the North Creek CMP.

NSW Adaptation Research Hub

The NSW Adaptation Research Hub is in the process of producing research material which can further enhance the understanding of the local scale impacts of climate change. Multiple projects are directly relatable to the inundation hazard facing the North Creek catchment and will inform the approach for studies in Stage 2.

IP&R Framework

The Integrated Planning and Reporting framework is established under Chapter 13 of the Local Government Act 1993. It allows for NSW councils to understand how the multiple plans interact within the larger governance framework to ensure holistic and sustainable planning. The CM Act 2016 requires that CMPs to be given effect within the IP & R framework (Figure 39. This means that the CMP and its identified activities should align with the broader community strategic plan, consider community priorities and ensure that its activities are feasible, financially viable and able to be resourced.

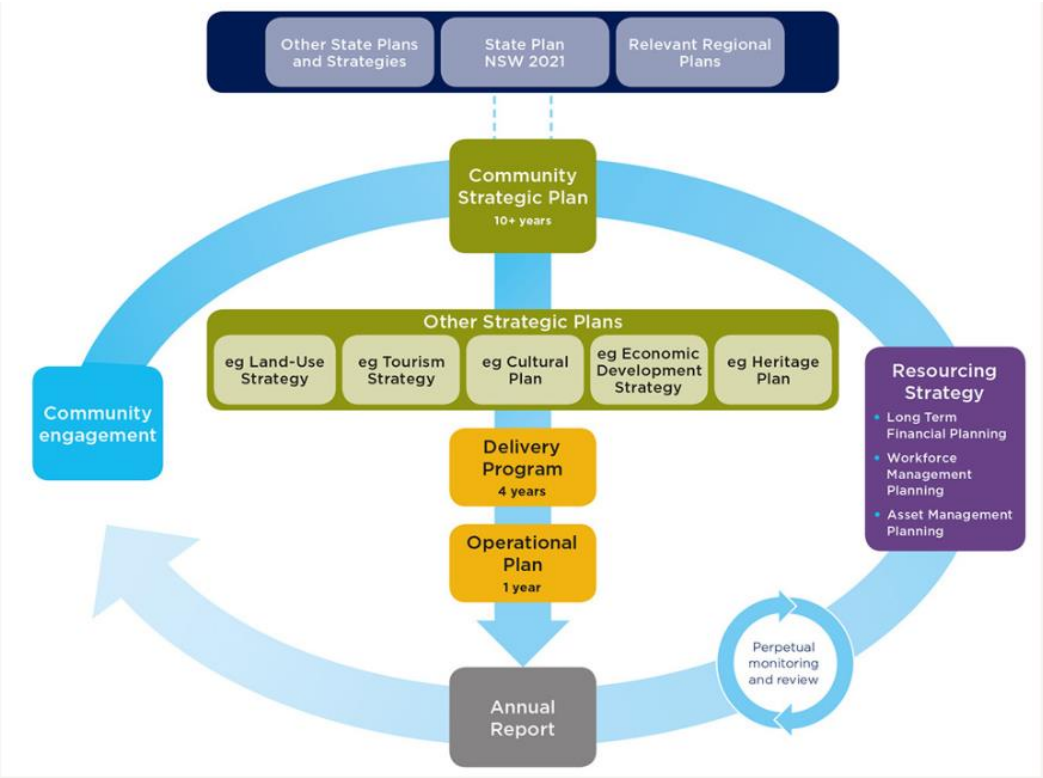


Figure 39. *An overview of the integrated planning and reporting framework (OLG 2018).*

7 References

Australian Bureau of Statistics., 2017. *Census of Population and Housing (usual residence data)*. Accessed online 08/01/2019, https://atlas.id.com.au/ballina.

Aquatic Biogeochemical & Ecological Research. (ABER) 2008. *Review of water quality data form the Richmond River Estuary,* Draft.

Alluvium, 2012, *River Styles assessment and mapping in the Northern Rivers CMA area*. Report by Alluvium for the NSW Office of Water and Northern Rivers Catchment Management Authority.

Atkins, M.L., Santos, I.R., Ruiz-Halpern, S., Maher, D.T., 2013. *Carbon dioxide dynamics driven by groundwater discharge in a coastal floodplain creek*. J. Hydrology. 493, 30–42.

Ballina Shire Council (BSC) 2003. *Little Fishery Creek, Estuary Care Project.* Information Bulletin.

Ballina Shire Council (BSC) 2006. *Chickiba Lakes Acid Sulfate Soils and Wetland Management Plan.*

Ballina Shire Council (BSC) 2012. *Ballina Shire Local Disaster Plan.*

Ballina Shire Council and GeoLink, 2016. *Coastal Zone Management Plan for the Ballina Shire Coastline*.

Ballina Shire Council (BSC) 2017a*. Ballina Shire Koala Management Strategy*.

Ballina Shire Council (BSC) 2017b*. Ballina Shire Economic Development Strategy.* Council report version.

Ballina Shire Council (BSC) 2018. *Ballina Shire Council Delivery Program and Operational Plan 30 June 2018 review*.

Ballina Shire Local Emergency Management Committee (BSLEMC) 2016. *Ballina Shire Local Emergency Management Plan August 2016.*

Barlow, F.T.H., 1975. *Newrybar Swamp Drainage Report.* Richmond River County Council Flood Mitigation Authority, Lismore NSW.

Bureau of Meteorology (BOM), 2018. *Climate data for Ballina Airport*. Accessed online 14/12/2018, http://www.bom.gov.au/climate/averages/tables/cw_058198.shtml.

Church, J.A., K.L. McInnes, D. Monselesan, and J. O'Grady, 2016. *Sea-Level Rise and Allowances for Coastal Councils around Australia – Guidance Material*. CSIRO Report, 64 pp. Accessed online 1/2/2019, http://coastadapt.com.au/factsheets/sea-level-rise-and-allowancescoastal-councils-around-australia-csiro-guidance-material.

Clarke, J., Heady, C., Erwin, T., 2017.*Temperature and Rainfall Extremes data for CoastAdapt: Methods used to develop projections of temperature and rainfall extremes for use on the NCCARF CoastAdapt website*. CSIRO Report, 20 pp. Accessed online 3/12/2018, https://coastadapt.com.au/factsheets/temperature-and-rainfall-extremes-data-csiro-methodsreport.

Creese R.G., Glasby T.M., West G., and Gallen C., 2009. *Mapping the habitats of NSW estuaries*. Industry & Investment NSW Fisheries Final Report Series 113. Port Stephens, NSW, Australia. ISSN 1837-2112. 95pp.

CSIRO and Bureau of Meteorology 2015, *Climate Change in Australia Information for Australia's Natural Resource Management Regions: Technical Report*, CSIRO and Bureau of Meteorology, Australia.

CSIRO, 2016. *Understanding Climate Change projections as outlined in the IPCCs fifth assessment report*. Accessed online 12/12/2018, https://www.climatechangeinaustralia.gov.au/en/climate-campus/modelling-and-projections/understanding-projections/.

De Ceglie S., Sivell L., 2018, *NSW Crown Land reforms have commenced – what do local councils need to know?* Accessed online 12/12/2018, https://www.maddocks.com.au/nsw-crown-land-reforms-commenced-local-councils-need-know/.

Department of Environment, Climate Change and Water NSW (DECCW) 2010*, Northern Rivers Regional Biodiversity Management Plan, National Recovery Plan for the Northern Rivers Region*. Department of Environment, Climate Change and Water NSW, Sydney.

Department of Environment and Energy, 2015. *EPBC protected matters search tool*. Accessed online 12/12/2018 http://www.environment.gov.au/webgis-framework/apps/pmst/pmst.jsf.

Department of Infrastructure, Planning and Natural Resources (DIPNR) 2005, *Northern Rivers Farmland Protection Project, Final Recommendations*, Department of Primary Industries NSW

Department of Planning and Environment, 2015*. NSW Seamless Geology Zone 56*. Accessed online 12/12/2018. https://datasets.seed.nsw.gov.au/dataset/nsw-seamless-geology-zone-56.

Department of Planning and Environment, 2018*. SEPP Coastal management - Littoral Rainforest*. Accessed online 10/12/2018. https://data.nsw.gov.au/data/dataset/sepp-coastal-management-littoral-rainforest.

Department of Primary Industries (DPI) 2004, *Richmond River mullet haul reopens under historic deal between anglers and commercial fishers*, Media release, Accessed online 10/12/2018. https://www.dpi.nsw.gov.au/content/archive/news-releases/fishing-and-aquaculture/2004/24_mar_04_-_richmond_river_mullet_haul_reopens_under_historic_deal_between_anglers_and_commercial_fishers.

Department of Primary Industries (DPI) 2019, *Comparison productivity data for the Mobbs bay harvest area*. Provided by I. Lyall, Commercial Fisheries and Aquaculture, January 2019.

Enviro Solutions, 2017, *Newrybar Quarry Soil and Water Management Plan, Environmental Impact Statement Technical reports bundle for the McGeary's Sand Quarry and Future Recreation Facility*, Planners North.

Gahan, K., 2018. *Historic Land Use and North Creek: Pre-1788 to the Present*, Draft, Ballina Shire Council.

Hawley, M., Mortimer, K., 2018. *The Coastal Management Act 2016 & Coastal Management SEPP have commenced*. Lindsay Taylor Lawyers. Accessed online 12/12/2018 http://www.lindsaytaylorlawyers.com.au/in_focus/index.php/2018/04/alert-the-coastal-management-act-2016-coastal-management-sepp-have-commenced/#.W2vq1ugzba8.

Hydrosphere Consulting, 2011, *Coastal Zone Management Plan for the Richmond River Estuary (CZMP). Volume 1*.

Hydrosphere Consulting, 2016, *North Creek Dredging Scoping Study, Prepared for Ballina Shire Council.*

Hydrosphere Consulting, 2018, *North Creek Dredging Sediment Investigation Report*, *Prepared for Ballina Shire Council*

Hydrosphere Consulting, 2017, *Coastal Zone Management Plan for the Richmond River Estuary: Mid-Term Review.*

Lewis S.E., Sloss C.R., Murray-Wallace C.V., Woodroffe C.D. & Smithers S.G. 2013. *Post-glacial sea-level changes around the Australian margin: a review.* Quaternary Science Reviews 74, 115–138.

McLeod, I.M., Boström-Einarsson, L., Creighton, C., D'Anastasi, B., Diggles, B., Dwyer, P.G., Firby, L., Le Port, A., Luongo, A., Martínez-Baena, F. and McOrrie, S., 2019 *Habitat value of Sydney rock oyster (Saccostrea glomerata) reefs on soft sediments*. Marine and Freshwater Research.

Morand D.T., 1994. *Soil Landscapes of the Lismore-Ballina 1:100,000 Sheet report*. NSW Department of Land and Water Conservation, Sydney.

Morton M.N., 1990. *Community structure, density and standing crop of fishes in a subtropical Australian mangrove area*. Marine Biology 105, 385-394.

Mummery, J.C., 2016. *Available data, datasets and derived information to support coastal hazard assessment and adaptation planning. CoastAdapt Information Manual 3*, National Climate Change Adaptation Research Facility, Gold Coast.

Murray-Wallace C.V. & Belperio A.P., 1991. *The last interglacial shoreline in Australia, a review*. Quaternary Science Reviews 10, 441–461.

National Climate Change Adaptation Research Facility (NCCARF), 2018. *Sea-level rise and future climate information for coastal councils.* Accessed online 12/12/2018 https://coastadapt.com.au/sea-level-rise-information-all-australian-coastal-councils#NSW_BALLINA.]

National Institute of Economic and Industry Research (NIEIR), 2018*. Accessed through Id community demographic resources.* Accessed online 15/01/2018, https://economy.id.com.au.

National Parks and Wildlife Service (NPWS), 2003. *Ballina Nature Reserve Plan of Management*.

New South Wales Government (2017). NSW Government Guide to Cost-Benefit Analysis (TPP17-03). March 2017.

New South Wales Department of Environment and Climate Change (NSW DECC), 2007. *Land Use: New South Wales.* Accessed online 12/12/2018, https://datasets.seed.nsw.gov.au/dataset/nsw-landuseac11c/resource/bd2a0fd4-4813-44bb-a9b0-05d2daabcd9a.

North Coast Local Land Services (NCLLS), 2016. *North Coast Local Strategic Plan*.

Northcote, K.H., 1978. Soils and Land Use. In *Atlas of Australian Resources*, Division of National Mapping, Canberra.

NSW Water Solutions, 2009, *Ballina - Lennox Head recycled Water Master Plan*, Environmental Impact Statement, September.

Office of Environment and Heritage (OEH) 2017a. *NSW Landuse 2013 Layer*. Accessed online 12/12/2018, https://datasets.seed.nsw.gov.au/dataset/nsw-landuse-2013.

Office of Environment and Heritage (OEH), 2017b. *Soil Landscapes of Central and Eastern NSW*, NSW Office of Environment and Heritage, Sydney.

Office of Environment and Heritage (OEH) 2018a. *NSW Coastal Management Manual Part A*. NSW. NSW Office of Environment and Heritage, Sydney.

Office of Environment and Heritage (OEH) 2018b. *NSW Coastal Management Manual Part B*. NSW. NSW Office of Environment and Heritage, Sydney.

Office of Environment and Heritage (OEH) 2018c. *Richmond River Governance and Funding Project – Factsheet.* NSW. NSW Office of Environment and Heritage, Sydney.

Office of Environment and Heritage (OEH) 2018d. *Sea Level and Coasts*. Accessed online 10/12/2019, https://climatechange.environment.nsw.gov.au/Impacts-of-climate-change/Sea-level-and-coasts.

Office of Environment and Heritage (OEH) 2018e. *SEED BioNet species sightings database*, Accessed online 12/12/2018, https://datasets.seed.nsw.gov.au/dataset/nsw-bionet-species-sightings-data-collection8a9c4.

Office of Environment and Heritage (OEH) 2018f. *Coastal Estuary Grants*, Accessed online 12/12/2018, https://www.environment.nsw.gov.au/topics/water/coasts/coastal-and-estuary-grants.

Parker, P., 2017. *Flora and Fauna Survey of Lot 3 DP8033962, Lot 10 DP1010302 and Lot 1 DP1028883, Newrybar Swamp road, Lennox Head*. Environmental Impact Statement Technical Report for McGeary's Sand Quarry and Future Recreation Facility. Planners North.

Rogers, K., Mills, M., Lovelock, C., 2014. *Existing spatial projections of coastal wetland response to sea-level rise in the East Coast NRM cluster*. University of Queensland and the University of Wollongong.

Rous County Council (RCC), 2017. North Creek Water Quality – Jun 2017, Data logger report. Accessed online 10/12/2018, https://rous.nsw.gov.au/cp_themes/default/search.asp.

Ryder, D., Mika, S., Richardson, M., Schmidt, J. and Fitzgibbon, B., 2015. *Richmond Eco health Project 2014: Assessment of River and Estuarine Condition*, University of New England, Armidale.

Santos, I.R., et al., 2016. *Assessing the recharge of a coastal aquifer using physical observations, tritium, groundwater chemistry and modelling*, Sci Total Environ.

Schrobback, P., 2015. *Economic analyses of Australia's Sydney rock oyster industry*. Doctoral Thesis. School of Economics and Finance, Queensland University of Technology.

Tourism Research Australia (2013). Thumbs up from Australians for domestic beach holidays. Tourism Fact Sheets: Tourism Australia.

TRA [Tourism Research Australia] (2018). Local government area profiles 2018. Accessed at <https://www.tra.gov.au/Regional/Local-Government-Area-Profiles/local-government-area-profiles > on 06/11/2019

Wong, V.N.L.., Walsh S., Morris S., 2018. *Climate affects fish-kill events in subtropical estuaries of eastern Australia.* Marine and Freshwater Research 69, 1641-1648.

Wong, V.N.L., Johnston, S.G., Bush, R.T,, Sullivan, L.A,, Clay, C,, Burton, E.D. & Slavich, P.G., 2010, *Spatial and temporal changes in estuarine water quality during a post-flood hypoxic event*, Estuarine, Coastal and Shelf Science, vol. 87, no. 1, pp. 73-82.

WBM, 2012, *Ballina Floodplain Risk Management Study*, Exhibition Version.

WBM, 2013. *Ballina Floodplain Risk Management Plan, Final Report.*

WBM, 2015, *Newrybar Swamp Drainage and Flood Mitigation Study,* Final Report.

WBM, 2017a, *Hydrologic, Hydraulic and Water Quality Assessments for the Cumbalum Urban Release Area Precinct B*, Final Report.

WBM, 2017b, *New South Wales Marine Estate Threat and Risk Assessment Report*, Final Report.

Attachment A
Community and Stakeholder Engagement Plan

North Creek catchment - Coastal Management Program

Community and Stakeholder Engagement Plan

ballina
shire council

Document history

Revision:

Revision no.	03
Author/s	Misko Ivezich Alex Sen Elisa Zavadil
Checked	Elisa Zavadil
Approved	Misko Ivezich

Distribution:

Revision no.	01
Issue date	October 2018 Suzanne Acret (Ballina Shire Council)
Revision no.	02
Issue date	May 2019 Suzanne Acret (Ballina Shire Council)
Revision no.	03
	December 2019 Suzanne Acret (Ballina Shire Council)

Citation:

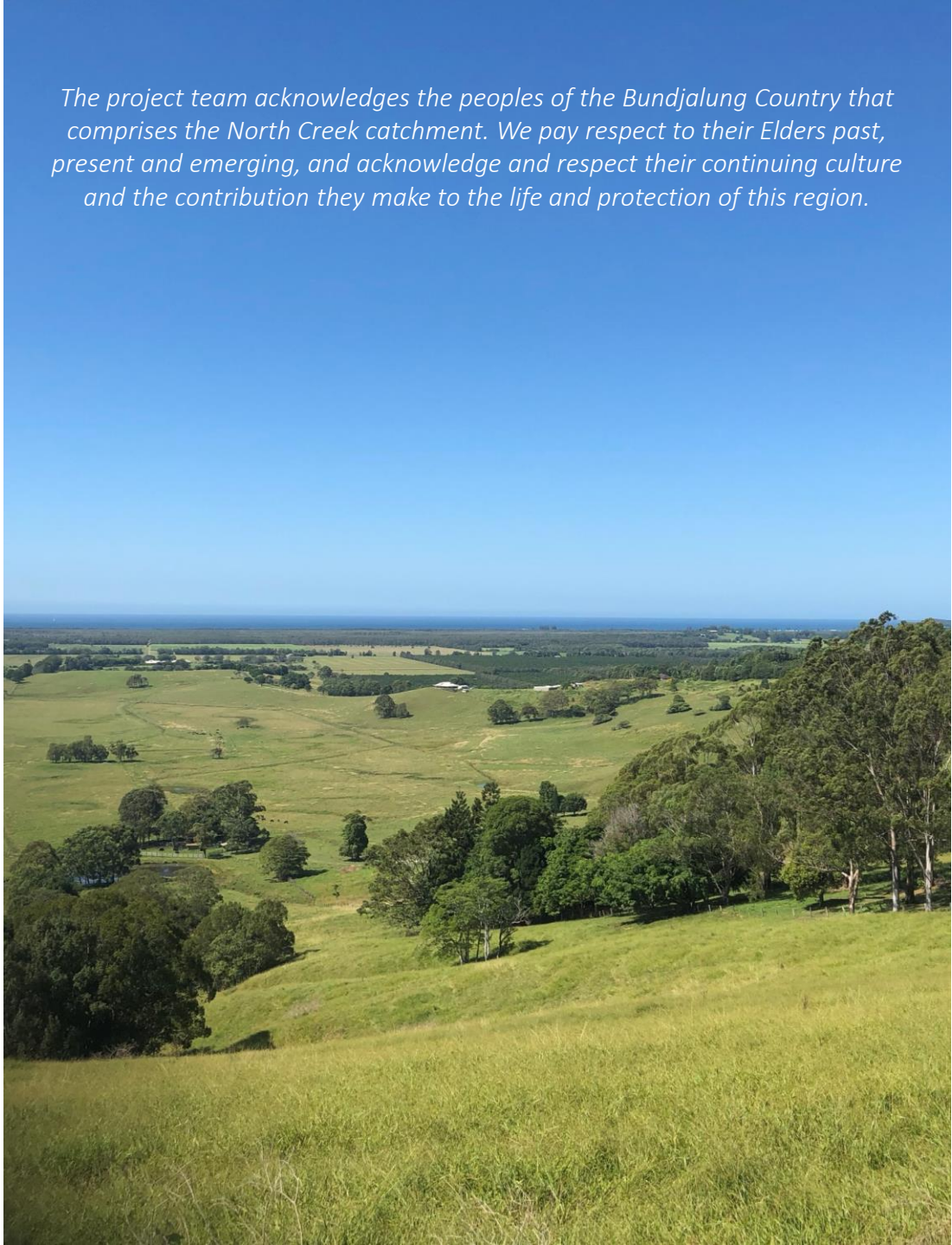
Please cite as: Alluvium (2019) North Creek Coastal Management Program – Stage 1 Scoping Study. Report by Alluvium for Ballina Shire Council.

.

ballina shire council

alluvium

The project team acknowledges the peoples of the Bundjalung Country that comprises the North Creek catchment. We pay respect to their Elders past, present and emerging, and acknowledge and respect their continuing culture and the contribution they make to the life and protection of this region.



Foreword

Councils role and commitment

Ballina Shire Council have commenced development of a new Coastal Management Program (CMP).

As part of this process Council are committed to:

- *Engaging with the community and other key stakeholders to develop a shared understanding of the values of the North Creek Catchment*
- *Facilitating knowledge sharing about catchment management challenges and opportunities, now and in the future*
- *Incorporating community and key stakeholder feedback into the development of the CMP*
- *Keeping the community and key stakeholders informed throughout the CMP process.*

ballina shire council alluvium

Contents

Introduction

Ballina Shire Council is developing a Coastal Management Program (CMP) for the North Creek catchment. The CMP process is in accord with the five stages defined by the NSW Government Coastal Management Framework (Figure 1).

The Coastal Management Framework is based on recent legislative reform introduced by the NSW government for a holistic approach to coastal management. This approach attempts to integrate multiple tiers of government through the development of Coastal Management Programs (CMP).

North Creek is a tributary of the Richmond River estuary. The catchment has a history of management challenges related to poor water quality and drainage, with adverse impacts on estuary health as well as agricultural and fisheries industries.

This Community and Stakeholder Engagement Plan (also referred to in the document as C&SEP or 'the Plan') has been developed as part of the Stage 1 scoping study for the North Creek CMP. The Plan should be read in conjunction to the Stage 1 North Creek CMP Scoping Study report.

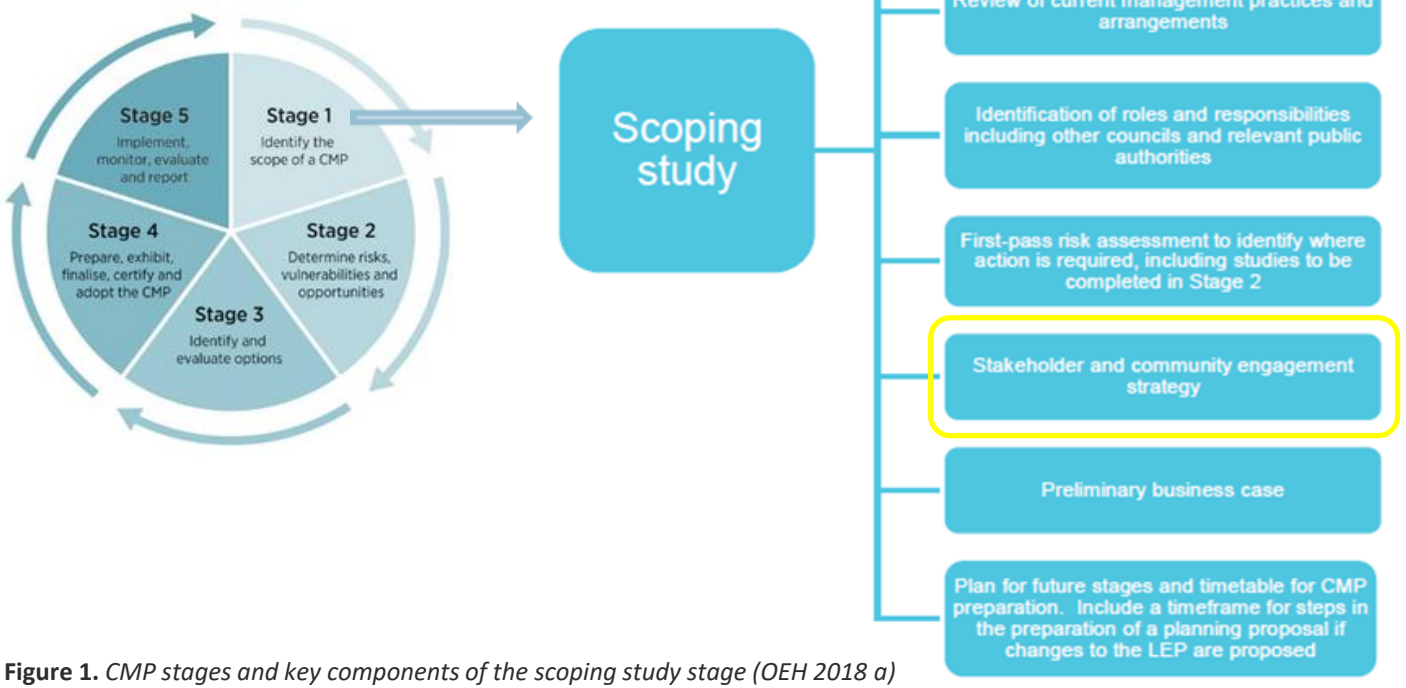


Figure 1. *CMP stages and key components of the scoping study stage (OEH 2018 a)*

Purpose

Purpose

The purpose the North Creek CMP C&SAP is to identify (OEH 2018b):

- Which individuals and organisations should be involved in the review, preparation and implementation of the CMP
- How and when they will be offered engagement opportunities
- How their input will be incorporated into the planning process.

Considerations

Key considerations in the development of the C&SAP have included (OEH 2018b):

- Previous / current coastal planning processes and initiatives
- Demographic structure of the community including length of residence and future projections of population growth
- The complexity of coastal management issues and the level of risk
- Which individuals, organisations and public authorities are relevant and their relative interest and influence in CMP outcomes
- Specific consultation required to align with the preparation of a planning proposal
- The community's values, aspirations, perceptions and attitudes to the coast
- The level of community satisfaction with council's previous consultation and coastal management performance
- Diverse community preferences as to how and when they are engaged in the planning processes
- How to design an equitable, inclusive and legitimate process
- Specific consultation requirements that may apply, for example, Traditional Owners.

How to use this document

This document should be consulted at the beginning of each Stage of the CMP process. The Ballina Community and Stakeholder Engagement Plan comprises:

- ✓ Context and strategic elements of the C&SEP
- ✓ An Implementation Plan, with actions relevant to each CMP Stage.

As the CMP progresses, it is anticipated that variations to the C&SEP may be required. Variations should ensure a strong link is maintained to the engagement objectives for each Stage.

ballina shire council alluvium

Key elements of the C&SEP

This North Creek Community and Stakeholder Engagement Plan (C&SEP):

- Introduces the context and the values of the North Creek Catchment
- Outlines the significance of effective engagement in the development of the CMP
- Identifies key stakeholders and groups for the CMP process
- Outlines the generic and specific purpose and objectives for engagement at each Stage of the CMP process
- Identifies the optimal timing and delivery method of engagement activities (and supporting communication materials)
- Identifies key governance and internal communication processes
- Documents the agreed C&SEP activities.

These elements of the SC&EP has been developed to be consistent with the relevant guidelines for the Coastal Management Program.

North Creek catchment

The North Creek catchment is located north of Ballina along the coast of northern New South Wales (Figure 2). With a catchment area of 122 km^2, the creek drains south for approximately 28 km before its confluence with the Richmond River near its mouth in Ballina.

The intertidal flats of lower North Creek and the Richmond River provide a sheltered environment for recreation, threatened migratory shorebirds and other fauna. The mid to lower zones of North Creek are highly valued by tourists and locals for swimming, boating and fishing. A designated recreational fishing haven is situated within the lower estuary, except for the commercial mullet fishery at Missingham Bridge which is operated seasonally. Commercial oyster culture occurs in North Creek and within the Richmond River in Mobbs Bay.

The upper catchment supports agriculture such as sugarcane and livestock where tidal influence is limited. A complex network of drainage infrastructure has been installed to allow these agricultural developments. The Ballina Nature Reserve occupies a large area of the mid-section of North Creek and provides habitat for flora and fauna, including threatened species. Ongoing urban development is occurring within the catchment on the fringes of both Ballina and Lennox Head.

Changes to land use and drainage works are understood to have had a significant impact on water quality within the estuary. The drainage works have often intercepted Acid Sulfate Soils and increased the connectivity for surface runoff entering the estuary. This has had adverse impacts for the estuary ecosystem and the fisheries industry. While the channelization works have facilitated agricultural development, drainage issues are a major concern for the community following even small rainfall events. A tailored CMP for the North Creek catchment has the potential to significantly increase the economic and ecosystem services provided by the estuary and catchment.

ballina shire council alluvium

North Creek catchment - location

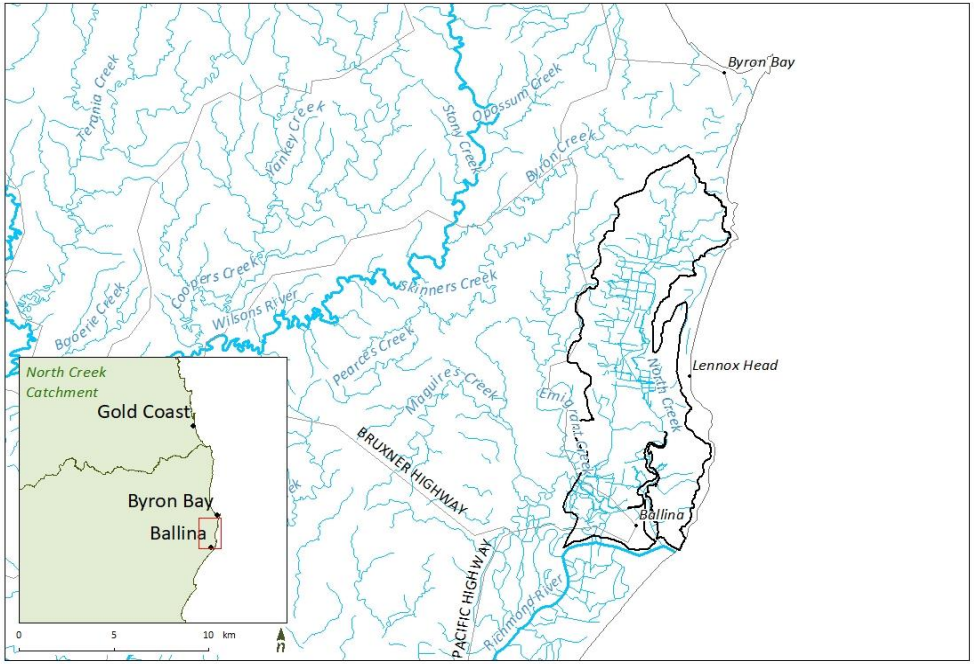


Figure 2. *North Creek catchment*

Demographic profile

Population

The North Creek catchment lies in the heart of Ballina Shire Local Government Area and includes parts of the major population centers of Ballina and Lennox Head.

At the time of the 2016 census[1], the median age of people in Ballina was 55 years. Children aged 0 - 14 years made up 11.7% of the population compared to the State average of 18.5%.. People aged 65 years and over made up 36.3% of the population compared to the State average of 16.2%.

Of occupied private dwellings in Ballina, 34.7% were owned outright (compared to State average of 32.2%), 16.5% were owned with a mortgage (compared to State average of 32.2%), and 40.2% were rented (compared to State average of 31.8%).

The main population growth areas are Ballina North, Lennox Head (spanning the eastern catchment boarder) and Cumbalum (spaning the western catchment border). Population numbers in these areas are predicted to grow buy 20 – 28% by 2036[1]. Population growth in other smaller settlements is expected to be in the order of up to 5% by 2036.

Settlements

The residential areas in the North Creek catchment include areas of Ballina, followed by several smaller settlements, several of which span the North Creek catchment boundary. Rural residential properties are also scattered across the catchment. At the time of the ABS 2016 census, population numbers of associated residential areas were:

- Ballina (North and Island) – 8,655
- East Ballina – 5,571
- West Ballina – 3,023
- Lennox Head – 6,407
- Skennars Head – 1,158
- Broken Head - 225
- Cumbalum – 1,522
- Newrybar - 444
- Tinternbar - 822
- Knockrow - 192

1. https://quickstats.censusdata.abs.gov.au/census_services/getproduct/census/2016/quickstat/
2. 2. https://forecast.id.com.au/ballina/about-forecast-areas/?WebID=170

Demographic profile

Employment

At the time of the 2016 census, the top employment industry in Ballina was Aged Care Residential Services (6.1% of workers). Other major industries of employment include Supermarket and Grocery Stores 4.1%, Other Social Assistance Services 3.2%, Accommodation 3.2% and Hospitals 3.2%.

Similar employment trends hold for surrounding settlements (e.g. Lennox Head, Cumbalum) with major employment industries including hospitals, cafes and restaurants, aged care services, plus primary education.

The most common occupations in Ballina and surrounding regions include Technicians and Trades Workers 15.7%, Professionals 15.4%, Labourers 14.8%, Community and Personal Service Workers 14.1%, and Sales Workers 12.3%.

Diversity

The most common ancestries in Ballina are English 30.9%, Australian 29.1%, Irish 9.5%, Scottish 8.0% and German 2.8%. At the time of the census:

- The percentage of Aboriginal and/or Torres Strait Islander people in the Ballina region was 4.3%, compared to a State average of 2.9%.
- The majority of residents, 78.8%, were born in Australia, compared to the State average of 65.5%.

Communities – southern catchment

The Southern end of the North Creek Catchment(Figure 3) includes areas of Ballina (North and Island) and East Ballina on either side of the North Creek channel, as well the inland areas of Skennars Head.

Two road crossings across North Creek provide access to the coastline further north.

Key issues of stakeholder interest in the southern part of the catchment include management of sedimentation in the North Creek estuarine channel (sand bar accretion and movement), water quality and recreation / amenity.

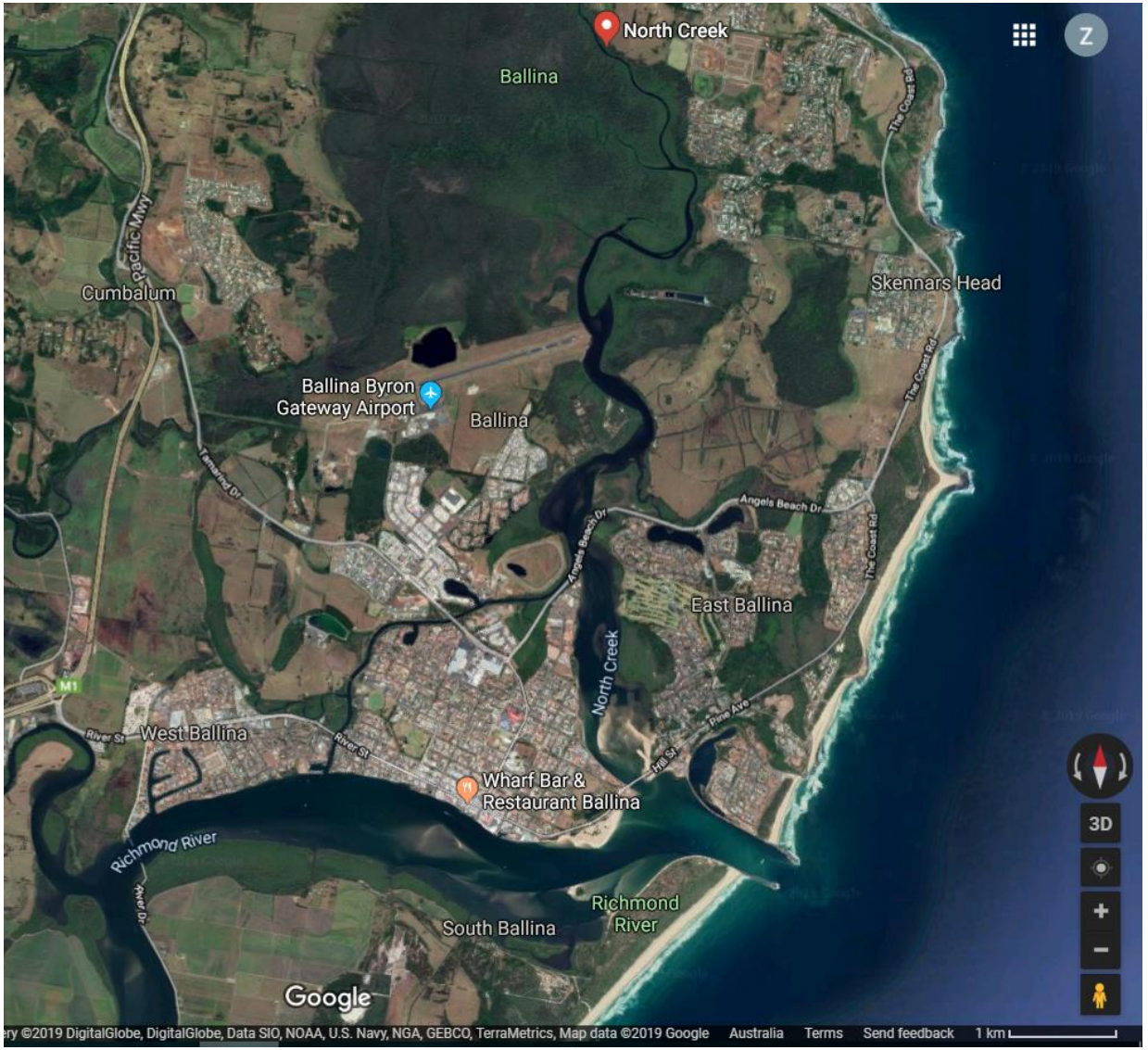


Figure 3. *North Creek catchment – southern end aerial image (Source: Google 2019)*

Communities – central catchment

The central part of the North Creek Catchment (Figure 4) includes inland areas of Lennox Head, scattered rural residences, and bordering communities of Cumbalum, Knockrow, and Tinternbar.

Key issues of stakeholder interest in the central catchment include protection of the Ballina reserve area, agricultural productivity, and management of drainage, erosion and water quality for the North Creek waterway and floodplain.

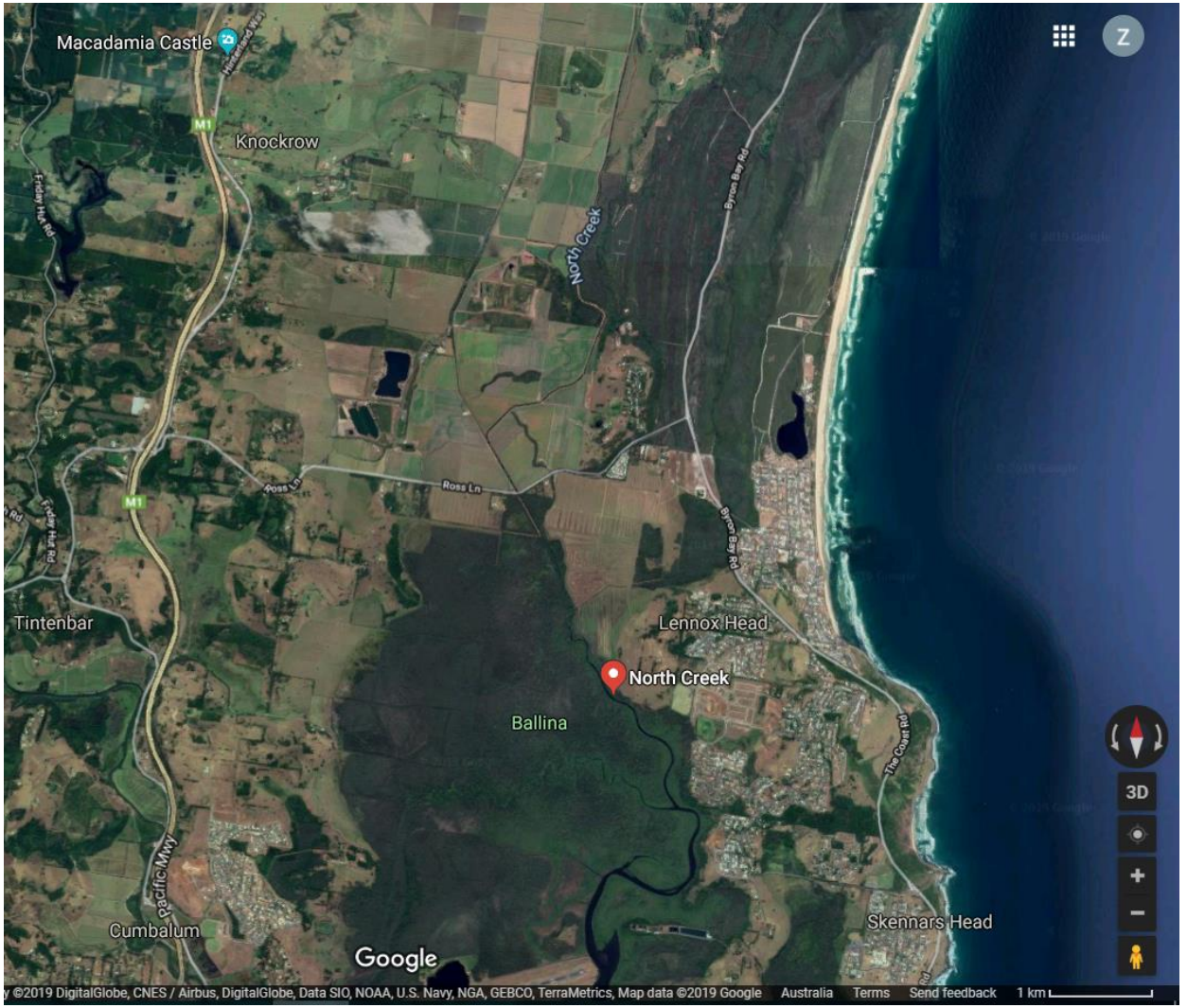


Figure 4. *North Creek catchment – central area aerial image (Source: Google 2019)*

Communities – northern catchment

The northern part of the North Creek Catchment (Figure 5) includes rural residential properties and small bordering settlements of Broken Head and Newrybar.

Key issues of stakeholder interest in the northern catchment include agricultural productivity, and management of drainage, erosion and water quality for the North Creek waterway and floodplain.

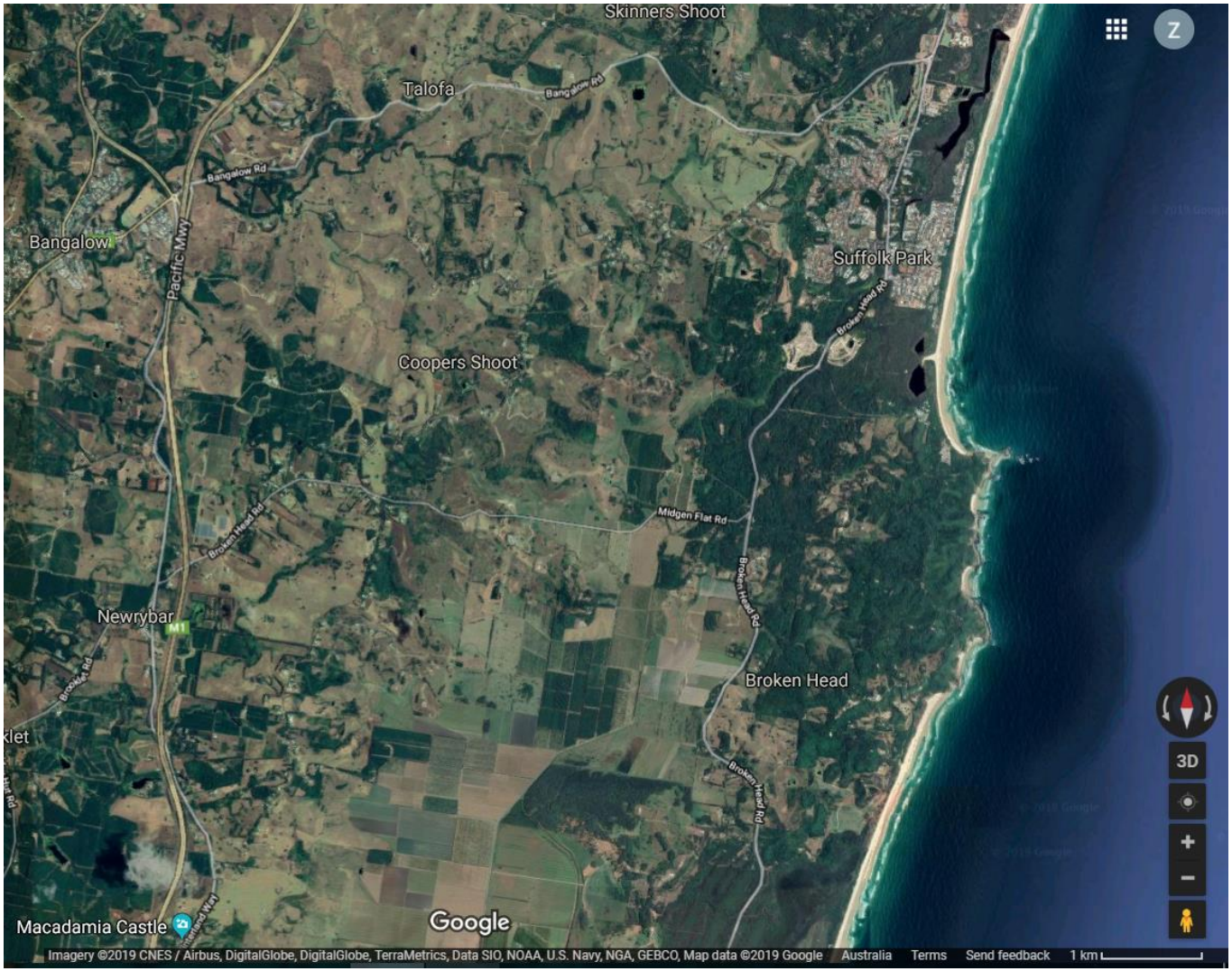


Figure 5. *North Creek catchment – northern area aerial image (Source: Google 2019)*

Key values – Indigenous

The Shire's Aboriginal culture and heritage
The Ballina Shire, including North Creek catchment area, has important Aboriginal culture and heritage values.

The following overview is documented on the Ballina Shire website - Source: https://www.ballina.nsw.gov.au/cp_themes/default/page.asp?p=DOC-ONO-01-56-87.

It is well understood that prior to European settlement of the Ballina Shire area the Bundjalung people were its custodians, having cared for and lived off the land for thousands of years. The many natural features and landforms that make up the Ballina Shire landscape were understood by the Bundjalung people to be the creation of their Dreamtime ancestors.

Bundjalung people tell of how, before the coming of white man, they lived in harmony with the natural environment. Like other Indigenous culture, the Bundjalung people suggest they belong to the land and the land to them. The land provided a wide variety of foods including fish, crustaceans, mammals, birds, reptiles vegetables and fruits. Shelters were made of timber, bark, branches and palms. Fire was used to cook food and timber, rock and fibres used to make tools and utensils with which to hunt, gather and prepare food. Individuals were part of a complex kin and tribal grouping that frequently moved across different parts of the land in search of food and in response to seasonal change and for ceremony. Bundjalung peoples' culture and traditions evolved over many thousands of years with the passing down of knowledge from previous generations and adapting to environmental change.

Management of Aboriginal Heritage matters in the shire is overseen by JALI Local Aboriginal Land Council and is supported by the National Parks and Wildlife Act (1974) and the NSW Heritage Act (1977) which provide legal protection for Aboriginal sites and relics in NSW, including sites yet to be recorded.

Jali Local Aboriginal Land Council

More information is available at: https://www.ballina.nsw.gov.au/cp_themes/default/page.asp?p=DOC-ONO-01-56-87

Key values – Indigenous

North Creek values

North Creek and its catchment also has specific significance to the Bundjalung people. Gahan (2018) provides a summary the Bundjalung custodianship of the North Creek catchment before 1840. Key points from this summary include (Gahan 2018):

- Today it is recorded that the Bundjalung people occupied the Creek's catchment from, at least, 4000BC – that is for over 6000 years.
- A vast kitchen midden once stretched for hundreds of metres along North Creek. The midden predominately consisted of oyster shell provide an indication of the extensive use of North Creek by the Bundjalung peoples over many centuries.
- Only a remnant of this midden remains intact.
- The Bundjalung peoples viewed the catchment as an integrated, cyclical system and as a result were careful and systematic in what they took from the environment. This knowledge was recorded and passed on through oral traditions of storytelling and song.
- The natural sand shoals in the lower estuary were utlised for permanent fish traps.
- Long wide nets were also used to capture ground dwelling species such as paddy melons and bandicoots.
- Small bands of extended family groups often came together to have much larger gatherings. Early European settlers in the area witnessed and recorded such meetings at Chickiba Lake, when oysters were in abundance.

Jali Local Aboriginal Land Council have been consulted during the development of this document, and in respect to these discussions culturally sensitive information/sites are not included in this report.

Key values – Other cultural values

European history

The European history of the regions includes the following key events:

- 1828 - Henry John Rous sailed along the east coast. He has been widely celebrated as the first European to explore the Richmond River.

- 1840s – 1850s - A permanent settlement at Ballina by Europeans dates from the early 1840s. Small groups of cedar cutters and their families are recorded to be the earliest to relocate here – this included on land at Prospect on North Creek, and at Shaw's Bay where the North Creek joined the Richmond River. A small stream near Shaw's Bay provided freshwater for the first European settlers.

- Throughout the 1840s cedar cutters and traders were the primary European inhabitants. The Bundjalung people continued to live within the catchment. Bundjalung men were known to also work for the cedar cutters during this period and provided local knowledge. In the 1850s the Native Police rode into Ballina and executed a dawn raid on Bundjalung families camped on the northern side of North Creek, many people were murdered or wounded.

- 1860s - From the early 1860s a new land legislation known as the Robertson Land Acts spurred a further wave of European migration to the Richmond River. The legislation enabled settlers to select land parcels for farming or improvement provided it was occupied. This encouraged farming families to the district. Land located on the North Creek floodplain was amongst the first areas to be farmed in Ballina.

  Early farming practices in the catchment included mixed-cropping, sugar cane production, cattle grazing and dairying. These activities drastically changed the landscape through the clearing of native vegetation. Farming was popular in the North Creek catchment due to the fertile soils.

- 1870s - In 1870 a vehicular ferry was installed across North Creek, along the North Creek Road, to enable the transport of produce and people to and from the farms established along the North Creek.

- 1880s - The establishment of the mill at Broadwater in 1881 saw much of the floodplain areas south of Ballina cleared and cultivated for sugar cane, marking a change in land use that continues to the present day.

Key values – Other cultural values

European history (continued)

The European history of the regions includes the following key events:

- 1890s – By the 1890s, diary farming also became a dominant landuse in the region. The processing of timbers was also an important industry in the Ballina area throughout the closing decades of the nineteenth century.

- While modest timber houses for many decades dominated both the rural and urban landscape, a number of larger and 'finer' domestic houses from the turn of the century remain in the Ballina area. A number of domestic buildings now form part of the Norton Street Heritage Trail in Ballina, including the restored Ballina Manor. Other historical buildings and community halls are present in the towns and across the rural landscape.

- 1900s onwards - In 1906, the Newrybar Drainage Trust established – under the NSW Water and Drainage Act – 'to drain off the flood waters, and so rendering the land fit for grazing and agriculture'. Water was drained from the swamp into North Creek. This resulted in a major transition in ecosystems as the wetland communities were lost the drainage works and farming.

  Engineering works within the Richmond River and North Creek increased navigability of the waterways which enabled the North Creek to be an important transport corridor between the farms in the catchment and the Ballina community.

  Further drainage works through the 20th Century led to the widespread loss of wetlands and the expansion of agricultural throughout the catchment.

The Ballina Manor in 1925
(Source: http://www.australiagenweb.org/nsw/richmond-tweed/ballina/historicbuildings.htm)

More information can be found at:
https://www.ballina.nsw.gov.au/cp_themes/default/page.asp?p=DOC-ZAA-26-48-72

Key values – ecosystem values

Ecological

The North Creek Catchment has a diversity of ecosystem values. Most notable include (Figure 6):

- Native vegetation and ecosystems (waterway, wetland and floodplain) associated with Ballina Nature Reserve and littoral reserve areas
- Koala habitat areas
- Mangrove, seagrass and saltmarsh in the estuarine reaches.

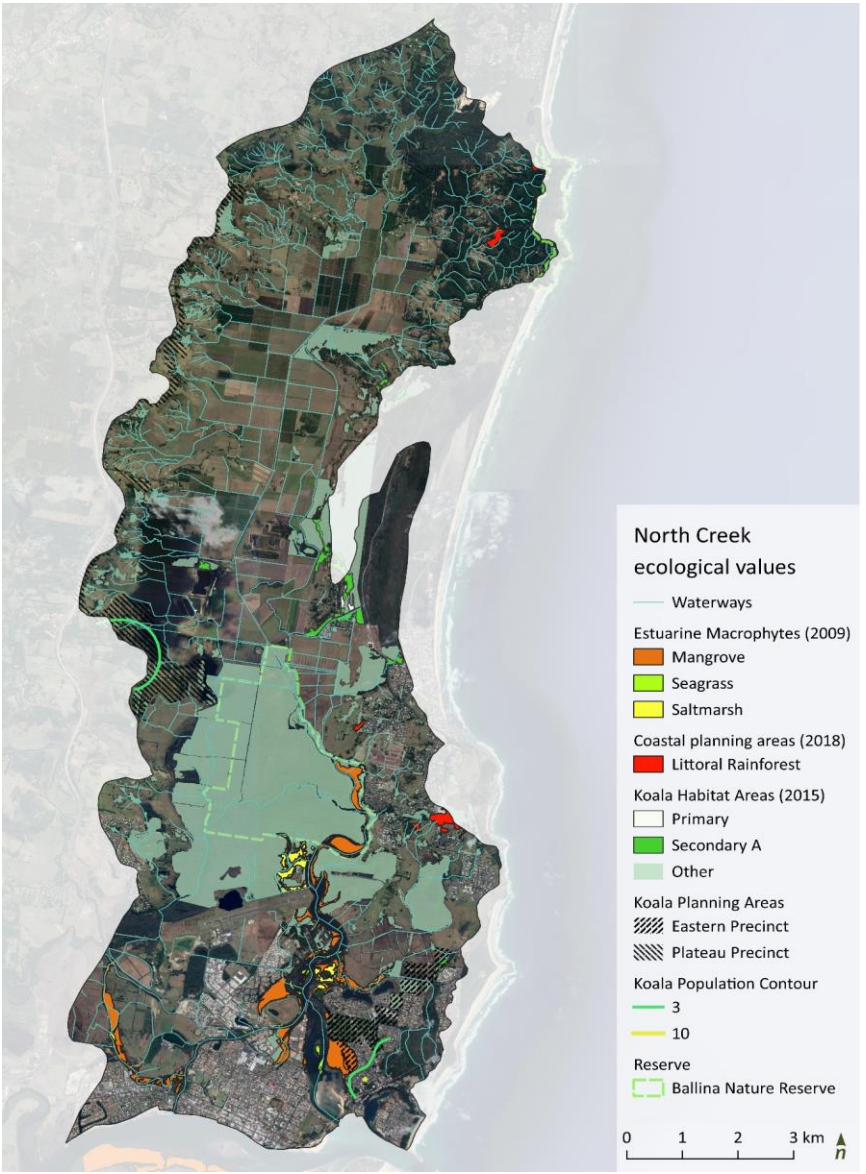


Figure 6. Key known ecological values of the North Creek catchment

Key values – Socio-economic

Key economic industries for the North Creek catchment include:

- Health care
- Tourism
- Agriculture and fishing.

The top employment industry in Ballina and surrounds is the Health Care sector and supporting services to residential growth.

Tourism is an important part of the Ballina Shire economy with over 1,500,000 international and domestic visitors in 2017/2018 (Tourism Research Australia, 2019). The majority of these visitors are likely to visit within the summer months and school holidays to enjoy the coastal environment and waterways, including parts of the North Creek catchment, particularly Ballina and Lennox Head.

The topography and proximity of the North Creek catchment acts as gateway to the most widely accessed coastal zone within the Shire, providing access and the scenic amenity which are key to the health of tourism in the Shire.

The upper North Creek catchment is predominately utilised for agricultural activities, namely horticulture (sugar cane, citrus and increasing macadamia) and pastoral use. In 2015/16 macadamia nuts were largest commodity produced in the Shire, contributing 46.3% to Ballina Shire's agricultural output (ABS 2016). Although in decline, fishing and oyster farming remain key economic values for the catchment.

ballina shire council alluvium

What will successful communication and engagement look like?

North Creek CMP

Successful communication and engagement for the North Creek CMP will comprise six outcomes:

- ✓ A shared understanding of:
  - the cultural, social, ecological and economic values provided by the North Creek catchment
  - the issues and coastal hazards affecting communities and ecosystems
  - risk and implications for the protection of public and private assets
- ✓ Optimal use of resources (time and financial)
- ✓ Stakeholders have the capacity to contribute meaningfully to the CMP development and long term implementation
- ✓ Planning and management decisions are based on evidence, knowledge, and dialogue
- ✓ Shared accountability and responsibility for managing coastal hazards
- ✓ Maximum acceptance of planning outcomes and decisions (in short and long term).

ballina shire council alluvium

What will successful communication and engagement look like?

The broad objectives for engagement during the North Creek CMP process include that:

- ✓ There is open communication with community and stakeholders to ensure there is transparency in all decisions
- ✓ There is broad acceptance of the catchment and coastal processes and the constraints which estuary and catchment management must operate
- ✓ Decisions are evidence based using the best available science and information.

To achieve the intended outcomes and objectives, the process of engagement for the North Creek CMP will follow the progression of discussion and understanding outlined in Figure 7.

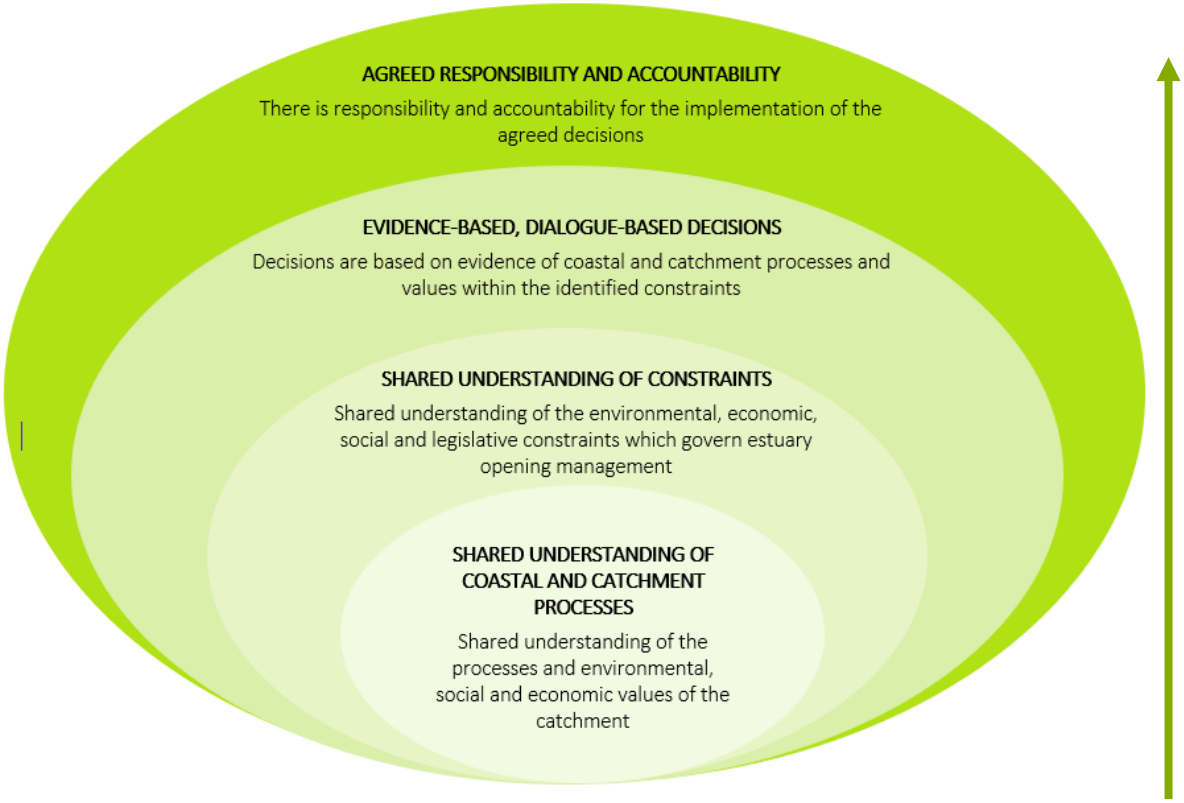


Figure 7. Process of engagement

Principles of effective engagement and communication

Underpinning the delivery of the North Creek CMP are a number of engagement **principles**.

1. **Appropriateness** – communication and engagement strategies and actions:

- Will be written in an appropriate language for the target audience
- Delivered through appropriate communication platforms, channels and pathways
- Implemented in a timely manner and respects the time of others
- Reflect the appropriate level of participation and associated commitment (Figure 8).

Depending on the stage of the CMP process, public consultation will include elements of inform, consult and involve (Figure 8).

2. **Consult and engage early and often as necessary** - Communication and engagement has already commenced with the development of the Stage 1 scoping study. Communication and engagement should have a clear purpose and occur in a timely manner with each Stage.

3. **Know your audience and be inclusive** – A stakeholder analysis has been developed as part of this Plan (Attachment 1) but should be regularly reviewed to ensure all stakeholders are captured. Opportunities for all stakeholder sectors and audiences should be accommodated for in some form.

4. **Respect, transparency and open communication** – Trust and meaningful relationships are essential to effectively achieve the objectives of the CMP.

INCREASING IMPACT ON THE DECISION

	INFORM	CONSULT	INVOLVE	COLLABORATE	EMPOWER
PUBLIC PARTICIPATION GOAL	To provide the public with balanced and objective information to assist them in understanding the problem, alternatives, opportunities and/or solutions.	To obtain public feedback on analysis, alternatives and/or decisions.	To work directly with the public throughout the process to ensure that public concerns and aspirations are consistently understood and considered.	To partner with the public in each aspect of the decision including the development of alternatives and the identification of the preferred solution.	To place final decision making in the hands of the public.
PROMISE TO THE PUBLIC	We will keep you informed.	We will keep you informed, listen to and acknowledge concerns and aspirations, and provide feedback on how public input influenced the decision.	We will work with you to ensure that your concerns and aspirations are directly reflected in the alternatives developed and provide feedback on how public input influenced the decision.	We will look to you for advice and innovation in formulating solutions and incorporate your advice and recommendations into the decisions to the maximum extent possible.	We will implement what you decide.

Figure 8. Scale of public participation (Source: IAP2)

Principles of effective engagement and communication

5. **Understand the risks and be prepared** – An initial risk analysis (Attachment 2) has been undertaken as part of the Plan development and has been recommended to be reviewed at regular intervals.
6. **Utilise existing approaches and mechanisms** – early engagement with key stakeholders including BSC has identified many existing channels that will be optimised prior to new approaches being developed.
7. **Share the load –** While the BSC has core responsibility for development of the CMP, there are many roles and opportunities for others to take lead responsibility for specific actions and activities this includes the role of community advocate.
8. **Consistent, simple messages** – The CMP process potentially involves many complex processes and challenging concepts, every effort should be given to ensuring all communication materials reiterate common messages and concepts explained in simple and concise language. Key messages for each Phase of the CMP are identified in this Plan.
9. **Visual and engaging** – An emphasis has been placed on designing communication and engagement activities and tools that are visually appealing, highly engaging, interactive and professional. Every effort should be given to ensuring mapping products and visual tools are accurate, easy to understand, and minimise the potential for misinterpretation (e.g. Attachment 3).
10. **Adaptive and flexible** – A monitoring and evaluation framework has been developed to ensure the Action Plan is regularly reviewed and updated to reflect any changing context, situation, or new information. This review process will also ensure there is a continual learning loop and appropriate reflection of what has worked well and what could be done better.

ballina shire council alluvium

North Creek CMP stakeholder groups

At a high-level, the following stakeholder groups have been identified with varying interests in the CMP process. An understanding of these groups informs the methods of engagement and communication recommended for the CMP. A specific list of key stakeholders is provided in Attachment 1.

Infrastructure and public asset owners

This stakeholder group have a key interest in protecting and maintaining public assets and infrastructure such as roads, sewerage systems, pipes, national parks, recreational assets (e.g. public boat ramps).

They are likely to require a high degree of communication and engagement throughout the development of the CMP to identify key assets and potential mitigation strategies.

Example stakeholders include: Ballina Shire Council, NSW State Government, Rous County Council, NSW Maritime.

Refer Attachment A
for stakeholder summary and
level of participation

Private asset owners

This stakeholder group have an interest in protecting their private assets such as property, business, commercial assets (e.g. crops) and infrastructure (e.g. irrigation infrastructure).

They are likely to require communication and engagement on all aspects of the CMP that will have an impact on their owned assets.

Example stakeholders include: property owners, local business owners, sugarcane farmers, commercial and tourism operators.

General interest in the management and protection of North Creek

These stakeholder refer more broadly to the general community that are interested in the management of the catchment. For those generally interested, regular updates and publicly accessible information may be a suitable level of communication and engagement throughout the CMP.

Public asset user groups

This stakeholder group have an interest in protecting public assets that they use. This may include recreational assets (e.g. boat ramps), environmental assets (e.g. wetlands, national parts, beaches), and other public services and amenities.

They are likely to require communication and engagement surrounding public assets of value.

Example stakeholders include: Recreational fishers, Ballina Fisherman's Co-op, businesses that rely on public assets.

Other interested parties

Other interested parties includes stakeholders that may not necessarily hold a stake in the CMP, but may be a source of information, or generally interested in the outcomes of the CMP.

Examples include: Universities, other agencies.

Traditional Owners

Traditional owners are custodians of the land and interested in protecting cultural values, environmental values and private assets. This includes cultural sites and connection to country.

They are likely to require communication and engagement on all aspects of the CMP process that is relevant to management of the landscape.

Cultural and environmental asset protection special interest groups

This stakeholder group is interested in protecting and enhancing cultural and environmental assets in the catchment.

This may includes environmental values in areas of significance and broadly across the shire, for example waterway health and water quality, soil erosion and condition, and biodiversity.

Examples include: Jali (including indigenous land and sea rangers), Ballina Coast Care, Ballina Environment Society.

North Creek CMP stakeholder groups

Agency Reference Group
An Agency Reference Group (ARG) has been formed as part of the Stage 1 scoping study to provide guidance on the study and also latter stages of the CMP. The ARG consists of members from:

- **Ballina Shire Council**
- **Rous County Council**
- **Office of Environment and Heritage (OEH)**
- **Department of Industry – Fisheries**
- **Department of Industry – Lands**
- **NSW Maritime**
- **North Coast Local Land Services NRM**
- **Jali Local Aboriginal Land Council**

Throughout the CMP the ARG will ***Collaborate*** based on the IAP2 public participation framework.

Key stakeholders
ARG members provided a list of key stakeholders with interests in the catchment which should be engaged throughout the CMP process. These stakeholders had a diverse range of interests in the North Creek catchment and included:

- **Landholders**
- **Oz Fish**
- **Ballina Fisherman's Co-op**
- **Australian Seabird Rescue**
- **Steinhardt's Oysters**
- **Richmond Oysters**
- **Ballina Environment Society**
- **Ballina Coast care**
- **Richmond River Cane Growers Limited**
- **Australian Macadamia Society**
- **NSW farmers representation**

Throughout the CMP these key stakeholders will need be ***involved*** based on the IAP2 public participation framework.

ballina shire council alluvium

Strategies and activities

There are a number communication and engagement strategies and tools that are proposed to underpin the development of the North Creek CMP. These are summarised in the following sections, and initial actions are then identified for each Stage.

Branding: *To help build public recognition of the North Creek CMP and Council's commitment to integrated coastal and catchment management*

- Establish **a customised 'brand' and look** for use in all communication materials. This may include use of Council's logo with a CMP tag line or tailored graphic elements that are identifiable to the North Creek CMP. This is an optional task, however is useful for building awareness and buy-in for the project and helps with communications materials.

Establish key networks: *To help build capacity and maintain strong networks to support engagement and decision-making*

- Continue the **Agency Reference Group (ARG)** that includes representatives of key stakeholders and interest groups
- Identify and tailor engagement for any additional **special interest groups** as the CMP development progresses.

Strategies and activities

Knowledge sharing: *To guide stakeholders through technical components of the CMP, building knowledge and understanding, and to receive local information that will assist in creating a strategy that is tailored to the need of the North Creek catchment*

- Deliver **targeted workshops and meetings** for the ARG (as a minimum) to review technical outputs and implications, and guide the CMP work program
- **Stakeholder workshops** (refer Table 1, and to be tailored as the process progresses).
- Undertake **personalised briefings and project updates** to key individual organisations and groups on as needs basis
- On-line community **values and knowledge surveys**

Communications: *To help build general awareness and understanding across the community*

- Establish a dedicated **website** or webpage information to ensure consistent communication and activity coordination
- Develop and disseminate regular **progress updates** (e.g. Attachment 3)
- Develop and disseminate project **fact sheets** suitable for a range of technical and non technical audiences on key topics
- Prepare targeted **media releases** in line with the proposed key messages for distribution locally and regionally
- Utilise local **social media** outlets to disseminate key information this includes BSC media as well as those of key stakeholder groups

Create a shared history and vision for the North Creek catchment: *To build a shared understanding of historical events, and identify values sought for the future North Creek coastal catchment landscape*

- Encourage the community to **submit photos and stories of historical events, and identify values sought for the catchment** via the project website, knowledge surveys and face-to-face engagement
- **Develop a timeline** for the North Creek catchment to communicate the shared history and vision for the future

ballina shire council alluvium

CMP engagement objectives, outcomes and activities by Stage

The initial engagement objectives and outcomes for each Stage of the North Creek CMP process are outlined in Table 1. This is to be updated as the project progresses.

Table 1. Engagement objectives and outcomes for each Stage of the CMP development

CMP stage	Objectives (Why do we want to engage)	Outcome (What will success look like)	Strategies and key activities (What will be done)	Timing
Stage 1 - Identify and scope CMP	• Identify the social, economic and environmental values of the North Creek catchment. • Identify the key threats to the values within the catchment. • Ensure all key stakeholders have a common understanding of the estuary and catchment's economic, ecological, social and cultural values, and issues affecting their management • Identify management objectives for the CMP	Shared understanding of the catchment-scale economic, ecological, social and cultural values, and issues affecting their management Identify key objectives for the CMP based on protecting values	• ARG meeting at start of project to help define objectives of CMP • Contact key stakeholders by phone and/or email to discuss their concerns • Develop community brochure outlining CMP process • Community survey to determine values and threats • Stakeholder workshops to discuss drainage/ issues • ARG meeting/review of recommendations for Stage 2	Complete
Stage 2 - Determine risks, vulnerabilities and opportunities	• Communicate the proposed study approaches and any inherent uncertainty • Ensure different perspectives are incorporated in the analysis of consequences and likelihood	Community and stakeholder acceptance of the outcomes of the risk assessment	• Updated community brochure outlining the outcomes of Stage 1 and recommended studies being undertaken in Stage 2 • Contact directly affected landholders about studies which may be occurring on or near their properties • ARG meeting to discuss outcomes of studies and update risk assessment • Feedback from stakeholders on risk assessment	Refer to Scoping study forward program

CMP engagement objectives, outcomes and activities by Stage

The initial engagement objectives and outcomes for each Stage of the North Creek CMP process are outlined in Table 1. This is to be updated as the project progresses.

Table 1. Engagement objectives and outcomes for each Stage of the CMP development

CMP stage	Objectives (Why do we want to engage)	Outcome (What will success look like)	Strategies and key activities (What will be done)	Timing
Stage 3 - Identify and evaluate options	• Determine the acceptability of management actions to stakeholders and the community • Engage public authorities about implications for their assets and responsibilities	Community and stakeholder acceptance that the decision process used to select options is evidence based	• ARG meeting to discuss preliminary management options implications for their assets and responsibilities • Workshops with key stakeholders who may be impacted by certain actions (to be determined following Stage 2/3) • Contact directly affected landholders or residents who occupy land which may be affected by recommended changes to coastal management area maps • Updated community brochure outlining the outcomes of Stage 2 and recommended actions agreed to in Stage 3	Refer to Scoping study forward program
Stage 4 - Prepare, exhibit, finalise, certify and adopt the CMP	• Seek feedback on the draft CMP	Feedback on Draft CMP used to inform final CMP	• ARG meeting to discuss preliminary CMP recommendations and implications for their assets and responsibilities • Exhibit draft CMP publicly • Prepare document outlining how feedback on draft CMP was used to finalise CMP	Refer to Scoping study forward program

Monitoring and evaluation

Ongoing monitoring and evaluation (M&E) of communication and engagement throughout the life of the CMP is a beneficial process for reviewing how the program is being received by the community and key stakeholders, which stakeholders have been engaged, and reflecting on whether appropriate outcomes have resulted from communication and engagement throughout.

The input provided by stakeholders and the community during the CMP process is important to help shape the technical scope and approach to each subsequent stages of the CMP. Reflecting at the end of each phase is necessary to ensure that the input provided through engagement is appropriately shaping the CMP process.

Additionally, it is possible that the CMP will be delivered by multiple agencies, and documenting the successes and challenges of engagement and communication will be a valuable activity for providing continuity and trust with various stakeholder groups. Having a record of key learnings through the development of the CMP will also be a useful resource during implementation.

Two monitoring and evaluation options for the CMP engagement process are presented below. Option one is considered as the acceptable minimum effort, while option two refers to a more detailed monitoring and evaluation approach.

Option 1: Periodically review communication and engagement

Schedule a internal reflection/review with the project team at the end of each CMP Stage to consider input provided through engagement and how this will shape subsequent Stages. Reflecting on key evaluation questions may be useful to inform this review.

Provide regular opportunities to stakeholders (through existing channels of communication) to communicate if they are happy with the level of communication and engagement.

Option 2: *Detailed monitoring and evaluation approach*

This approach would involve an increased effort to collate data to assist with answering Key Evaluation Questions, and reporting on outcomes.

Monitoring and evaluation

Key evaluation questions for engagement M&E

The following key evaluation questions include one question that simply relates to the delivery of activities and outputs, while the other three relate to the achievement of outcomes:

1. Were all engagement activities delivered and received as planned in the Community and Stakeholder Engagement Plan?

2. Did engagement activities, and the subsequent inclusion of stakeholder input into the CMP contribute to Outcome 1?

3. Did communication and engagement activities promote shared accountability and responsibility for management of the North Creek catchment, and the decisions resulting from the CMP?

4. Was communications and engagement delivered in the most efficient way possible, and build community capacity and interest (e.g. relationships and networks) to continue to provide input?

In answering all of these questions, efforts should be made to identify opportunities for improvement either in the continued development of the CMP or during implementation of the CMP.

Evaluation timeframes

For the life of the project, periodic evaluations that seek to answer the key evaluation questions would be suited at:

1. Completion of Stage 1
2. Completion of Stage 2 - 3
3. Completion of Stage 4

Data collection

Data collection that may be used to determine if communication and engagement has been successful can include:

- Numeric data on the delivery of outputs e.g. how many workshops held, stakeholders engaged etc.
- Internal review/reflection at the end of each Stage
- Evaluation surveys (following workshops and other engagement activities)
- Seeking feedback from stakeholders and broader North Creek community

Attachment

Summary of stakeholders

1

Attachment 1 – Summary of stakeholders

Stakeholder Group	Description	IAP2 level of public participation
Infrastructure and public asset owners	This stakeholder group have a key interest in protecting and maintaining public assets and infrastructure such as roads, sewerage systems, pipes, national parks, recreational assets (e.g. public boat ramps). They are likely to require a high degree of communication and engagement throughout the development of the CMP to identify key assets and potential mitigation strategies. Example stakeholders include: Ballina Shire Council, NSW State Government, Rous County Council, NSW Maritime	Involve/collaborate
Private asset owners	This stakeholder group have an interest in protecting their private assets such as property, business, commercial assets (e.g. crops) and infrastructure (e.g. irrigation infrastructure). They are likely to require communication and engagement on all aspects of the CMP that will have an impact on their owned assets. Example stakeholders include: property owners, local business owners, sugarcane farmers, commercial and tourism operators.	Consult
General interest in the management and protection of North Creek	These stakeholder refer more broadly to the general community that are interested in the management of the catchment. For those generally interested, regular updates and publicly accessible information may be a suitable level of communication and engagement throughout the CMP.	Inform/consult
Public asset user groups	This stakeholder group have an interest in protecting public assets that they use. This may include recreational assets (e.g. boat ramps), environmental assets (e.g. wetlands, national parts, beaches), and other public services and amenities. They are likely to require communication and engagement surrounding public assets of value. Example stakeholders include: Recreational fishers, Ballina Fisherman's Co-op, businesses that rely on public assets.	Inform/consult
Other interested parties	Other interested parties includes stakeholders that may not necessarily hold a stake in the CMP, but may be a source of information, or generally interested in the outcomes of the CMP. Examples include: Universities, other agencies.	Inform/consult
Traditional owners	Traditional owners are custodians of the land and interested in protecting cultural values, environmental values and private assets. This includes cultural sites and connection to country. They are likely to require communication and engagement on all aspects of the CMP process that is relevant to management of the landscape.	Consult/involve/ collaborate
Cultural and environmental asset protection special interest groups	This stakeholder group is interested in protecting and enhancing cultural and environmental assets in the catchment. This may includes environmental values in areas of significance and broadly across the shire, for example waterway health and water quality, soil erosion and condition, and biodiversity. Examples include: Jali (including indigenous land and sea rangers), Ballina Coast Care, Ballina Environment Society.	Consult

Attachment 1 – Summary of stakeholders

Stakeholder Group	Description	IAP2 level of public participation
Agency Reference Group • Ballina Shire Council • Rous County Council • Office of Environmental and Heritage (OEH) • Department of Industry – Fisheries • Department of Industry – Lands • NSW Maritime • North Coast Local Land Services NRM • Jali Local Aboriginal Land Council	An Agency Reference Group (ARG) has been formed as part of the Stage 1 scoping study to provide guidance on the study and also latter stages of the CMP.	Collaborate
Key Stakeholders • Landholders • Oz Fish • Ballina Fisherman's Co-op • Australian Seabird Rescue • Steinhardt's Oysters • Richmond Oysters • Ballina Environmental Society • Ballina Coastcare • Richmond River Cane Growers Limited • Australian Macadamia Society • NSW farmers representation	ARG members provided a list of key stakeholders with interests in the catchment which should be engaged throughout the CMP process. These stakeholders had a diverse range of interests in the North Creek catchment	Inform/consult/ involve

Scale of public participation (Source: IAP)

INCREASING IMPACT ON THE DECISION

	INFORM	CONSULT	INVOLVE	COLLABORATE	EMPOWER
PUBLIC PARTICIPATION GOAL	To provide the public with balanced and objective information to assist them in understanding the problem, alternatives, opportunities and/or solutions.	To obtain public feedback on analysis, alternatives and/or decisions.	To work directly with the public throughout the process to ensure that public concerns and aspirations are consistently understood and considered.	To partner with the public in each aspect of the decision including the development of alternatives and the identification of the preferred solution.	To place final decision making in the hands of the public.
PROMISE TO THE PUBLIC	We will keep you informed.	We will keep you informed, listen to and acknowledge concerns and aspirations, and provide feedback on how public input influenced the decision.	We will work with you to ensure that your concerns and aspirations are directly reflected in the alternatives developed and provide feedback on how public input influenced the decision.	We will look to you for advice and innovation in formulating solutions and incorporate your advice and recommendations into the decisions to the maximum extent possible.	We will implement what you decide.

ballina shire council alluvium

Attachment

Communication and engagement risk management

2

Communication and engagement risk management

Risk	Likelihood (before – after)	Implications	Mitigation strategy
Consultation fatigue or consultation indifference	Medium – Low	Value of input from stakeholders reduced. Disconnection and disinterest from community, not aware of what's going on and how it might affect them.	Consultation will be planned to target specific stakeholders with key messages that are relevant to them. Let stakeholders know when the consultation process hits major milestones. Demonstrate that stakeholder contributions have been heard and understood. Implement Strategies to Re-engage stakeholders e.g. provide a good reason to come back. How will the consultation affect the outcomes? How will the issue under discussion directly affect them?
Failure to address misinformation or rumours promptly and clearly	Medium - Low	Unwarranted or disproportionate community concern. Loss of buy-in for the CMP. Misinformation may take attention away from real issues requiring consideration and discussion.	Consistent messages throughout all communication materials, and all stages of the CMP development. Identify a key spokesperson that will rapidly address any escalating concerns.
Failure to involve relevant stakeholders or represent local interests	Medium - low	Biased feedback that is not representative of the whole community. Rejection of the CMP by stakeholders that feel their interests and values have not been captured.	Work with council and systematically identify all relevant stakeholders and their likely communication needs. Allocate sufficient resources and time to implement the Community and Stakeholder Engagement Plan in full. Utilise networks such the ARG to develop efficient engagement methods.
Certain stakeholder groups feel that they are not being adequately engaged in the process or not getting their fair share of access to information	Medium – Low	Rejection of the CMP by stakeholders that feel the CMP was unfairly developed to benefit others.	Establishment of publicly accessible information sources (such as the website) and open lines of communication allows for all stakeholders to access information. Communication and engagement does not actively exclude any particular stakeholder groups. Reaffirm that the council is interested in the views of all stakeholders, not just those directly affected.
An extreme event occurs during the development of the CMP	High - Medium	Greater sense of urgency, and those effected may demand action now.	Ballina Shire confirms its role, commitment and aims of the project through its communication. Frame the event in a way that highlights the importance of developing a CMP to mitigate and prepare for future events.
Insufficient time allowed to effectively engage with the community about potential risks and impacts, and to properly consider stakeholder needs	High – low	Reduced input from stakeholders. CMP developed without full consideration of stakeholder interest and values.	Allocate sufficient resources and time to implement the Community and Stakeholder Engagement Plan in full. Utilise networks such the ARG to develop efficient engagement methods.
Inconsistent or contradictory messaging	Medium – Low	Creates confusion and distrust. Resolving confusion may take attention away from issues requiring consideration and discussion.	Consistent messages throughout all communication materials, and all phases of the CMP development. Brief project team members, and council project working group prior to community engagement to agree on messaging.
Assumption that property values will be adversely affected if mapped in coastal hazard areas	Medium - Low	Insurance premiums become unaffordable, or at worst, properties become uninsurable. New investment in the Shire hampered	Ensure adequate information is provided to ensure that the public understand the context in which technical studies and mapping has been developed. Ensure all spokespersons can respond appropriately to questions and issues raised by the public.

Attachment

Example communications materials – scoping study stage

3

GET INVOLVED!

We are interested in hearing from the community about their views on the North Creek catchment. Your knowledge and feedback can help shape the future management of North Creek.

We would like you to spend 5-10 mins and take part in a survey. Please visit Ballina Shire Council homepage for details of the survey - **www.ballina.nsw.gov.au**

If you would like to discuss the North Creek scoping study further Please contact Misko Ivezich on 0401 048 241 or misko.ivezich@alluvium.com.au for more information.

alluvium

ballina shire council

NORTH CREEK COASTAL MANAGEMENT PROGRAM
SCOPING STUDY

PURPOSE

The North Creek Coastal Management Program (CMP) Scoping Study (Stage 1) aims to work with the community to understand the issues and values within the North Creek catchment. This understanding will help target additional investigations and studies in later stages of the North Creek CMP process.

Oyster farming is an important industry in the North Creek estuary

CMP FRAMEWORK

Council has been talking with landholders, farmers and oyster growers about water quality and other issues affecting the North Creek catchment.

It is working within the new NSW Government Coastal Management Framework to deliver a plan to improve the health of the creek and its catchment. The recently released Coastal Management Manual sets out mandatory requirements and essential elements for a Coastal Management Program.

Council is talking directly to landholders and interest groups as part of the process. But we would also like to hear from the broader community about how they see North Creek.

Note that dredging is being investigated in the lower reaches as part of a separate process (although the processes are talking to each other). The Coastal Management Program is considering the catchment as a whole.

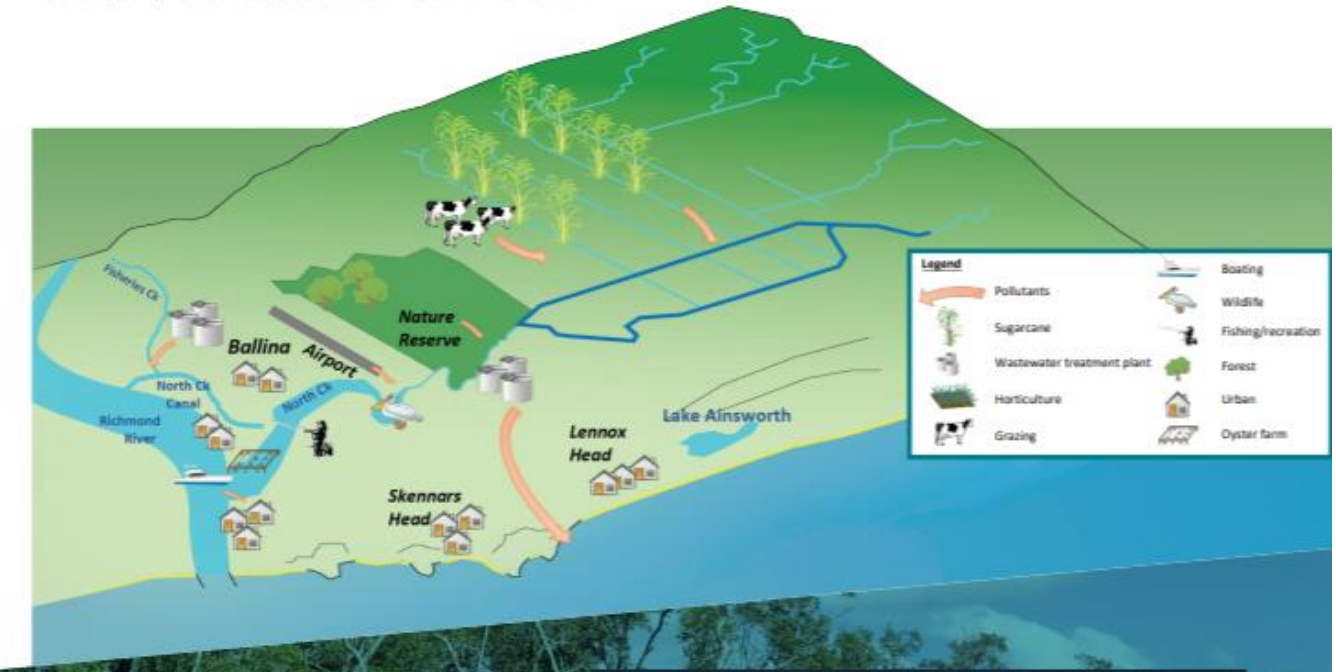
ABOUT THE CATCHMENT

North Creek is vital part of the Ballina region helping contribute to the economic, recreational and environmental values of the area.

Increasing land use pressure in the North Creek catchment is believed to have compromised the ability of North Creek and its receiving waters to support a functioning ecosystem. Urban development in the mid-catchment and drainage from agricultural areas in the upper and mid-catchment is contributing to high nutrient and sediment loads, and modified catchment hydrology.

These catchment pressures are believed to impact on estuary health. The estuary supports a range of important services including fish habitat, oyster production and recreation for Ballina's residents.

The social, environmental and economic impacts of poor water quality in the catchment are not currently well understood. Evidence of pressure due to poor water quality has already been identified in the Ballina Nature Reserve, by local volunteers and commercial oyster farmers. Over the years, a complex drainage network through the Nature Reserve has been constructed to manage drainage from surrounding grazing and horticultural areas, which has altered the area's natural ability to process floodwaters and pollutant loads.



Riparian habitat is important for estuary health and provides critical habitat for juvenile fish species

ballina shire council

alluvium

Attachment B
EPBC report

Australian Government
Department of the Environment and Energy

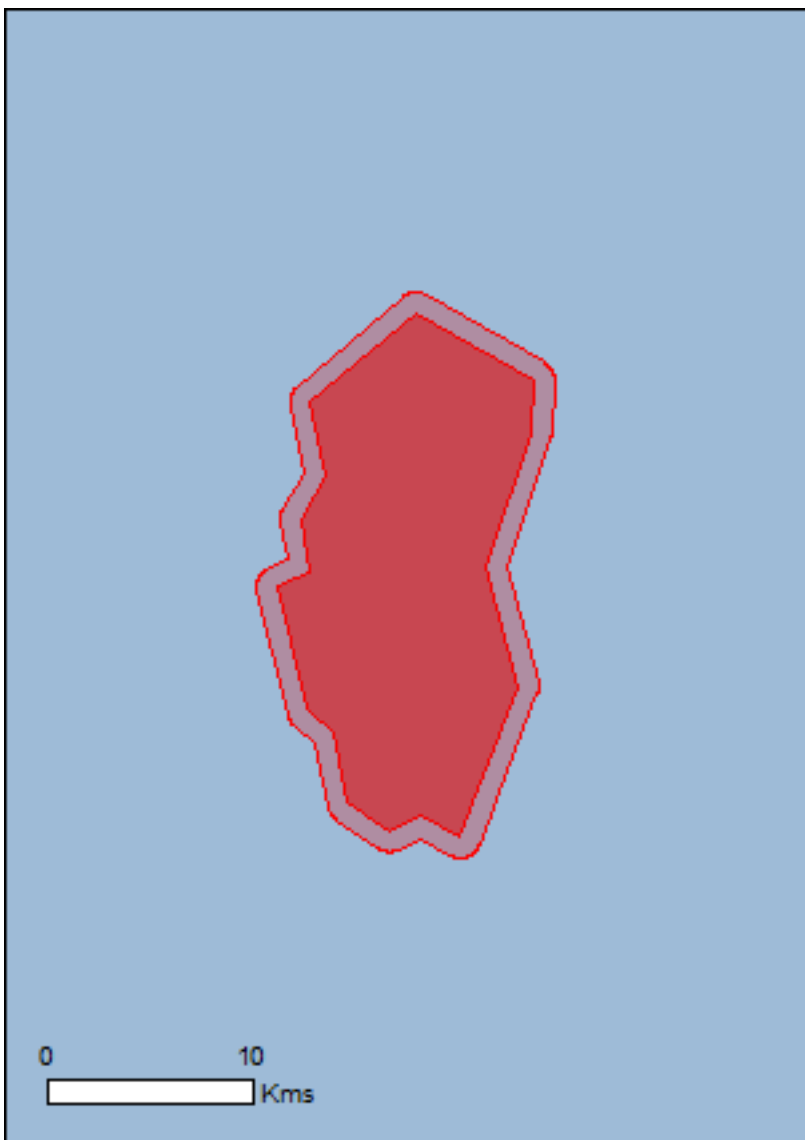
EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

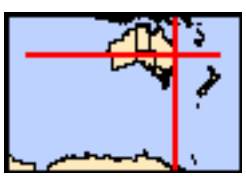
Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 15/10/18 15:25:06



This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010

Coordinates
Buffer: 1.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	3
Listed Threatened Species:	87
Listed Migratory Species:	77

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	3
Commonwealth Heritage Places:	None
Listed Marine Species:	110
Whales and Other Cetaceans:	12
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	3
Regional Forest Agreements:	1
Invasive Species:	36
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland ecological community	Endangered	Community likely to occur within area
Littoral Rainforest and Coastal Vine Thickets of Eastern Australia	Critically Endangered	Community likely to occur within area
Lowland Rainforest of Subtropical Australia	Critically Endangered	Community likely to occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Anthochaera phrygia Regent Honeyeater [82338]	Critically Endangered	Foraging, feeding or related behaviour likely to occur within area
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Cyclopsitta diophthalma coxeni Coxen's Fig-Parrot [59714]	Endangered	Species or species habitat may occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Species or species habitat may occur within area
Diomedea antipodensis gibsoni Gibson's Albatross [82270]	Vulnerable	Species or species habitat may occur within area

Name	Status	Type of Presence
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Species or species habitat may occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Species or species habitat may occur within area
Erythrotriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat likely to occur within area
Fregetta grallaria grallaria White-bellied Storm-Petrel (Tasman Sea), White-bellied Storm-Petrel (Australasian) [64438]	Vulnerable	Species or species habitat likely to occur within area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat likely to occur within area
Limosa lapponica baueri Bar-tailed Godwit (baueri), Western Alaskan Bar-tailed Godwit [86380]	Vulnerable	Species or species habitat known to occur within area
Limosa lapponica menzbieri Northern Siberian Bar-tailed Godwit, Bar-tailed Godwit (menzbieri) [86432]	Critically Endangered	Species or species habitat may occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Pachyptila turtur subantarctica Fairy Prion (southern) [64445]	Vulnerable	Species or species habitat known to occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat may occur within area
Pterodroma leucoptera leucoptera Gould's Petrel, Australian Gould's Petrel [26033]	Endangered	Species or species habitat may occur within area
Pterodroma neglecta neglecta Kermadec Petrel (western) [64450]	Vulnerable	Foraging, feeding or related behaviour may occur within area
Rostratula australis Australian Painted-snipe, Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area
Thalassarche cauta cauta Shy Albatross, Tasmanian Shy Albatross [82345]	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta steadi White-capped Albatross [82344]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche eremita Chatham Albatross [64457]	Endangered	Species or species habitat may occur within area

Name	Status	Type of Presence
Thalassarche impavida		
Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris		
Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche salvini		
Salvin's Albatross [64463]	Vulnerable	Species or species habitat may occur within area
Turnix melanogaster		
Black-breasted Button-quail [923]	Vulnerable	Species or species habitat may occur within area
Fish		
Epinephelus daemelii		
Black Rockcod, Black Cod, Saddled Rockcod [68449]	Vulnerable	Species or species habitat likely to occur within area
Frogs		
Litoria olongburensis		
Wallum Sedge Frog [1821]	Vulnerable	Species or species habitat known to occur within area
Mixophyes fleayi		
Fleay's Frog [25960]	Endangered	Species or species habitat may occur within area
Insects		
Argynnis hyperbius inconstans		
Australian Fritillary [88056]	Critically Endangered	Species or species habitat may occur within area
Phyllodes imperialis smithersi		
Pink Underwing Moth [86084]	Endangered	Breeding may occur within area
Mammals		
Balaenoptera musculus		
Blue Whale [36]	Endangered	Species or species habitat may occur within area
Chalinolobus dwyeri		
Large-eared Pied Bat, Large Pied Bat [183]	Vulnerable	Species or species habitat likely to occur within area
Dasyurus maculatus maculatus (SE mainland population)		
Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll (southeastern mainland population) [75184]	Endangered	Species or species habitat known to occur within area
Eubalaena australis		
Southern Right Whale [40]	Endangered	Species or species habitat likely to occur within area
Megaptera novaeangliae		
Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Petauroides volans		
Greater Glider [254]	Vulnerable	Species or species habitat may occur within area
Phascolarctos cinereus (combined populations of Qld, NSW and the ACT)		
Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) [85104]	Vulnerable	Species or species habitat known to occur within area
Potorous tridactylus tridactylus		
Long-nosed Potoroo (SE mainland) [66645]	Vulnerable	Species or species habitat known to occur within area

Name	Status	Type of Presence
[Pseudomys novaehollandiae](#) New Holland Mouse, Pookila [96]	Vulnerable	Species or species habitat likely to occur within area
[Pteropus poliocephalus](#) Grey-headed Flying-fox [186]	Vulnerable	Roosting known to occur within area
[Xeromys myoides](#) Water Mouse, False Water Rat, Yirrkoo [66]	Vulnerable	Species or species habitat likely to occur within area
Other		
[Thersites mitchellae](#) Mitchell's Rainforest Snail [66774]	Critically Endangered	Species or species habitat known to occur within area
Plants		
[Acronychia littoralis](#) Scented Acronychia [8582]	Endangered	Species or species habitat likely to occur within area
[Allocasuarina thalassoscopica](#) [21927]	Endangered	Species or species habitat likely to occur within area
[Arthraxon hispidus](#) Hairy-joint Grass [9338]	Vulnerable	Species or species habitat known to occur within area
[Baloghia marmorata](#) Marbled Balogia, Jointed Baloghia [8463]	Vulnerable	Species or species habitat likely to occur within area
[Bulbophyllum globuliforme](#) Miniature Moss-orchid, Hoop Pine Orchid [6649]	Vulnerable	Species or species habitat may occur within area
[Cryptocarya foetida](#) Stinking Cryptocarya, Stinking Laurel [11976]	Vulnerable	Species or species habitat known to occur within area
[Cryptostylis hunteriana](#) Leafless Tongue-orchid [19533]	Vulnerable	Species or species habitat may occur within area
[Cynanchum elegans](#) White-flowered Wax Plant [12533]	Endangered	Species or species habitat likely to occur within area
[Davidsonia jerseyana](#) Davidson's Plum [67219]	Endangered	Species or species habitat may occur within area
[Davidsonia johnsonii](#) Smooth Davidsonia, Smooth Davidson's Plum, Small-leaved Davidson's Plum [67178]	Endangered	Species or species habitat likely to occur within area
[Desmodium acanthocladum](#) Thorny Pea [17972]	Vulnerable	Species or species habitat may occur within area
[Diploglottis campbellii](#) Small-leaved Tamarind [21484]	Endangered	Species or species habitat likely to occur within area
[Elaeocarpus williamsianus](#) Hairy Quandong [8956]	Endangered	Species or species habitat may occur within area
[Endiandra floydii](#) Floyd's Walnut [52955]	Endangered	Species or species habitat known to occur within area

Name	Status	Type of Presence
Endiandra hayesii Rusty Rose Walnut, Velvet Laurel [13866]	Vulnerable	Species or species habitat likely to occur within area
Floydia praealta Ball Nut, Possum Nut, Big Nut, Beefwood [15762]	Vulnerable	Species or species habitat likely to occur within area
Fontainea oraria Coastal Fontainea [24038]	Endangered	Species or species habitat known to occur within area
Gossia fragrantissima Sweet Myrtle, Small-leaved Myrtle [78867]	Endangered	Species or species habitat likely to occur within area
Hicksbeachia pinnatifolia Monkey Nut, Bopple Nut, Red Bopple, Red Bopple Nut, Red Nut, Beef Nut, Red Apple Nut, Red Boppel Nut, Ivory Silky Oak [21189]	Vulnerable	Species or species habitat likely to occur within area
Isoglossa eranthemoides Isoglossa [16663]	Endangered	Species or species habitat likely to occur within area
Macadamia integrifolia Macadamia Nut, Queensland Nut Tree, Smooth-shelled Macadamia, Bush Nut, Nut Oak [7326]	Vulnerable	Species or species habitat known to occur within area
Macadamia tetraphylla Rough-shelled Bush Nut, Macadamia Nut, Rough-shelled Macadamia, Rough-leaved Queensland Nut [6581]	Vulnerable	Species or species habitat known to occur within area
Ochrosia moorei Southern Ochrosia [11350]	Endangered	Species or species habitat likely to occur within area
Owenia cepiodora Onionwood, Bog Onion, Onion Cedar [11344]	Vulnerable	Species or species habitat likely to occur within area
Phaius australis Lesser Swamp-orchid [5872]	Endangered	Species or species habitat known to occur within area
Randia moorei Spiny Gardenia [10577]	Endangered	Species or species habitat likely to occur within area
Syzygium hodgkinsoniae Smooth-bark Rose Apple, Red Lilly Pilly [3539]	Vulnerable	Species or species habitat likely to occur within area
Syzygium moorei Rose Apple, Coolamon, Robby, Durobby, Watermelon Tree, Coolamon Rose Apple [12284]	Vulnerable	Species or species habitat known to occur within area
Thesium australe Austral Toadflax, Toadflax [15202]	Vulnerable	Species or species habitat likely to occur within area
Reptiles		
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Breeding known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species

Name	Status	Type of Presence
		habitat known to occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Breeding likely to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Species or species habitat known to occur within area
Sharks		
Carcharias taurus (east coast population) Grey Nurse Shark (east coast population) [68751]	Critically Endangered	Species or species habitat likely to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Anous stolidus Common Noddy [825]		Species or species habitat likely to occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardenna carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Species or species habitat likely to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat known to occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Species or species habitat may occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Species or species habitat may occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Species or species habitat may occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat known to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area

Name	Threatened	Type of Presence
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat may occur within area
Sternula albifrons Little Tern [82849]		Species or species habitat may occur within area
Thalassarche cauta Tasmanian Shy Albatross [89224]	Vulnerable*	Species or species habitat may occur within area
Thalassarche eremita Chatham Albatross [64457]	Endangered	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Species or species habitat may occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Migratory Marine Species		
Balaena glacialis australis Southern Right Whale [75529]	Endangered*	Species or species habitat likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Breeding known to occur within area
Dugong dugon Dugong [28]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
Lamna nasus Porbeagle, Mackerel Shark [83288]		Species or species habitat may occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Breeding likely to occur

Name	Threatened	Type of Presence within area
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat known to occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Cuculus optatus Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat may occur within area
Hirundapus caudacutus White-throated Needletail [682]		Species or species habitat known to occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Monarcha trivirgatus Spectacled Monarch [610]		Species or species habitat known to occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat known to occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Arenaria interpres Ruddy Turnstone [872]		Roosting known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Roosting known to occur within area
Calidris alba Sanderling [875]		Roosting known to occur within area

Name	Threatened	Type of Presence
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Calidris ruficollis Red-necked Stint [860]		Roosting known to occur within area
Calidris subminuta Long-toed Stint [861]		Roosting known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area
Charadrius bicinctus Double-banded Plover [895]		Roosting known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Roosting known to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Roosting known to occur within area
Gallinago megala Swinhoe's Snipe [864]		Roosting likely to occur within area
Gallinago stenura Pin-tailed Snipe [841]		Roosting likely to occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Roosting known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Roosting known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting known to occur within area
Numenius phaeopus Whimbrel [849]		Roosting known to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Philomachus pugnax Ruff (Reeve) [850]		Roosting known to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Roosting known to occur within area

Name	Threatened	Type of Presence
Pluvialis squatarola		
Grey Plover [865]		Roosting known to occur within area
Tringa brevipes		
Grey-tailed Tattler [851]		Roosting known to occur within area
Tringa glareola		
Wood Sandpiper [829]		Roosting known to occur within area
Tringa incana		
Wandering Tattler [831]		Roosting known to occur within area
Tringa nebularia		
Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis		
Marsh Sandpiper, Little Greenshank [833]		Roosting known to occur within area
Xenus cinereus		
Terek Sandpiper [59300]		Roosting known to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Commonwealth Land - Australian Telecommunications Commission
Commonwealth Land - Director of War Service Homes
Commonwealth Land - Telstra Corporation Limited

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos		
Common Sandpiper [59309]		Species or species habitat known to occur within area
Anous stolidus		
Common Noddy [825]		Species or species habitat likely to occur within area
Anseranas semipalmata		
Magpie Goose [978]		Species or species habitat may occur within area
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba		
Great Egret, White Egret [59541]		Breeding known to occur within area
Ardea ibis		
Cattle Egret [59542]		Breeding likely to occur within area
Arenaria interpres		
Ruddy Turnstone [872]		Roosting known to occur within area
Calidris acuminata		
Sharp-tailed Sandpiper [874]		Roosting known to occur within area
Calidris alba		
Sanderling [875]		Roosting known to occur

Name	Threatened	Type of Presence
		within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Calidris ruficollis Red-necked Stint [860]		Roosting known to occur within area
Calidris subminuta Long-toed Stint [861]		Roosting known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat known to occur within area
Catharacta skua Great Skua [59472]		Species or species habitat may occur within area
Charadrius bicinctus Double-banded Plover [895]		Roosting known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Charadrius ruficapillus Red-capped Plover [881]		Roosting known to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Roosting known to occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Species or species habitat may occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Species or species habitat may occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Species or species habitat may occur within area
Diomedea gibsoni Gibson's Albatross [64466]	Vulnerable*	Species or species habitat may occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat known to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat known to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Roosting known to occur within area

Name	Threatened	Type of Presence
Gallinago megala Swinhoe's Snipe [864]		Roosting likely to occur within area
Gallinago stenura Pin-tailed Snipe [841]		Roosting likely to occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Heteroscelus brevipes Grey-tailed Tattler [59311]		Roosting known to occur within area
Heteroscelus incanus Wandering Tattler [59547]		Roosting known to occur within area
Himantopus himantopus Pied Stilt, Black-winged Stilt [870]		Roosting known to occur within area
Hirundapus caudacutus White-throated Needletail [682]		Species or species habitat known to occur within area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat likely to occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Roosting known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Roosting known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Monarcha trivirgatus Spectacled Monarch [610]		Species or species habitat known to occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat known to occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting known to occur within area

Name	Threatened	Type of Presence
Numenius phaeopus Whimbrel [849]		Roosting known to occur within area
Pachyptila turtur Fairy Prion [1066]		Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Philomachus pugnax Ruff (Reeve) [850]		Roosting known to occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat may occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Roosting known to occur within area
Pluvialis squatarola Grey Plover [865]		Roosting known to occur within area
Puffinus carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [1043]		Species or species habitat likely to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat likely to occur within area
Sterna albifrons Little Tern [813]		Species or species habitat may occur within area
Thalassarche cauta Tasmanian Shy Albatross [89224]	Vulnerable*	Species or species habitat may occur within area
Thalassarche eremita Chatham Albatross [64457]	Endangered	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Species or species habitat may occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Tringa glareola Wood Sandpiper [829]		Roosting known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Roosting known to occur within area

Name	Threatened	Type of Presence
Xenus cinereus Terek Sandpiper [59300]		Roosting known to occur within area
Fish		
Acentronura tentaculata Shortpouch Pygmy Pipehorse [66187]		Species or species habitat may occur within area
Campichthys tryoni Tryon's Pipefish [66193]		Species or species habitat may occur within area
Corythoichthys amplexus Fijian Banded Pipefish, Brown-banded Pipefish [66199]		Species or species habitat may occur within area
Corythoichthys ocellatus Orange-spotted Pipefish, Ocellated Pipefish [66203]		Species or species habitat may occur within area
Festucalex cinctus Girdled Pipefish [66214]		Species or species habitat may occur within area
Filicampus tigris Tiger Pipefish [66217]		Species or species habitat may occur within area
Halicampus grayi Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area
Hippichthys cyanospilos Blue-speckled Pipefish, Blue-spotted Pipefish [66228]		Species or species habitat may occur within area
Hippichthys heptagonus Madura Pipefish, Reticulated Freshwater Pipefish [66229]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippocampus kelloggi Kellogg's Seahorse, Great Seahorse [66723]		Species or species habitat may occur within area
Hippocampus kuda Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area
Hippocampus planifrons Flat-face Seahorse [66238]		Species or species habitat may occur within area
Hippocampus trimaculatus Three-spot Seahorse, Low-crowned Seahorse, Flat-faced Seahorse [66720]		Species or species habitat may occur within area
Hippocampus whitei White's Seahorse, Crowned Seahorse, Sydney Seahorse [66240]		Species or species habitat may occur within area
Lissocampus runa Javelin Pipefish [66251]		Species or species habitat may occur within area
Maroubra perserrata Sawtooth Pipefish [66252]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Micrognathus andersonii Anderson's Pipefish, Shortnose Pipefish [66253]		Species or species habitat may occur within area
Micrognathus brevirostris thorntail Pipefish, Thorn-tailed Pipefish [66254]		Species or species habitat may occur within area
Microphis manadensis Manado Pipefish, Manado River Pipefish [66258]		Species or species habitat may occur within area
Solegnathus dunckeri Duncker's Pipehorse [66271]		Species or species habitat may occur within area
Solegnathus hardwickii Pallid Pipehorse, Hardwick's Pipehorse [66272]		Species or species habitat may occur within area
Solegnathus spinosissimus Spiny Pipehorse, Australian Spiny Pipehorse [66275]		Species or species habitat may occur within area
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area
Solenostomus paradoxus Ornate Ghostpipefish, Harlequin Ghost Pipefish, Ornate Ghost Pipefish [66184]		Species or species habitat may occur within area
Stigmatopora nigra Widebody Pipefish, Wide-bodied Pipefish, Black Pipefish [66277]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area
Trachyrhamphus bicoarctatus Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Urocampus carinirostris Hairy Pipefish [66282]		Species or species habitat may occur within area
Vanacampus margaritifer Mother-of-pearl Pipefish [66283]		Species or species habitat may occur within area
Mammals		
Dugong dugon Dugong [28]		Species or species habitat may occur within area
Reptiles		
Astrotia stokesii Stokes' Seasnake [1122]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Breeding known to occur within area

Name	Threatened	Type of Presence
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Breeding likely to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Species or species habitat known to occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans		[Resource Information]
Name	Status	Type of Presence
Mammals		
Balaenoptera acutorostrata Minke Whale [33]		Species or species habitat may occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat likely to occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat likely to occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area

Extra Information

State and Territory Reserves [Resource Information]

Name	State
Ballina	NSW
Broken Head	NSW
Richmond River	NSW

Regional Forest Agreements [Resource Information]

Note that all areas with completed RFAs have been included.

Name	State
North East NSW RFA	New South Wales

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Acridotheres tristis Common Myna, Indian Myna [387]		Species or species habitat likely to occur within area
Anas platyrhynchos Mallard [974]		Species or species habitat likely to occur within area
Carduelis carduelis European Goldfinch [403]		Species or species habitat likely to occur within area
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Lonchura punctulata Nutmeg Mannikin [399]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Frogs		

Name	Status	Type of Presence
Rhinella marina Cane Toad [83218]		Species or species habitat known to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Feral deer Feral deer species in Australia [85733]		Species or species habitat likely to occur within area
Lepus capensis Brown Hare [127]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus norvegicus Brown Rat, Norway Rat [83]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Alternanthera philoxeroides Alligator Weed [11620]		Species or species habitat likely to occur within area
Anredera cordifolia Madeira Vine, Jalap, Lamb's-tail, Mignonette Vine, Anredera, Gulf Madeiravine, Heartleaf Madeiravine, Potato Vine [2643]		Species or species habitat likely to occur within area
Asparagus aethiopicus Asparagus Fern, Ground Asparagus, Basket Fern, Sprengi's Fern, Bushy Asparagus, Emerald Asparagus [62425]		Species or species habitat likely to occur within area
Asparagus plumosus Climbing Asparagus-fern [48993]		Species or species habitat likely to occur within area
Cabomba caroliniana Cabomba, Fanwort, Carolina Watershield, Fish Grass, Washington Grass, Watershield, Carolina Fanwort, Common Cabomba [5171]		Species or species habitat likely to occur within area
Chrysanthemoides monilifera Bitou Bush, Boneseed [18983]		Species or species habitat likely to occur

Name	Status	Type of Presence
		within area
Chrysanthemoides monilifera subsp. rotundata Bitou Bush [16332]		Species or species habitat likely to occur within area
Eichhornia crassipes Water Hyacinth, Water Orchid, Nile Lily [13466]		Species or species habitat likely to occur within area
Genista sp. X Genista monspessulana Broom [67538]		Species or species habitat may occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Opuntia spp. Prickly Pears [82753]		Species or species habitat likely to occur within area
Pinus radiata Radiata Pine Monterey Pine, Insignis Pine, Wilding Pine [20780]		Species or species habitat may occur within area
Sagittaria platyphylla Delta Arrowhead, Arrowhead, Slender Arrowhead [68483]		Species or species habitat likely to occur within area
Salvinia molesta Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Senecio madagascariensis Fireweed, Madagascar Ragwort, Madagascar Groundsel [2624]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus Asian House Gecko [1708]		Species or species habitat likely to occur within area

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-28.705771 153.628658,-28.725644 153.627285,-28.776813 153.607372,-28.822544 153.621792,-28.88028 153.596386,-28.871862 153.579907,-28.877874 153.565487,-28.867051 153.547634,-28.84059 153.540768,-28.831567 153.529781,-28.784637 153.516735,-28.778619 153.531155,-28.758756 153.527035,-28.742503 153.537335,-28.714203 153.531155,-28.679871 153.57716,-28.705771 153.628658

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

Department of the Environment
GPO Box 787
Canberra ACT 2601 Australia
+61 2 6274 1111

Attachment C
First ARG meeting minutes

Minutes

Meeting	Agency Reference Group Workshop: Scope, purpose and vision.
Location	Ballina Shire Council
Date and Time	1 May 2018 1-4 pm
Project	North Creek Coastal Management Plan – Scoping Study
Invitees	Suzanne Acret (BSC), Ben Fitzgibbon (OEH), Sara Cuthbertson (OEH), Stuart Hood (RCC), Patrick Dwyer (DPI- Fisheries), Tony Weber (Alluvium), Lisa Walpole (Alluvium), Misko Ivezich (Alluvium),
Apologies	Catherine Knight (NSW Crown Lands), Selina Stillman (DPI -Agriculture), Jali Local Aboriginal Land Council, Rod McDonagh (NSW Maritime) Peter Boyd (North Coast Local Land Services NRM)

Item

Zoning

Discussion on the Coastal Management Areas within the North Creek catchment which consist of Wetland areas (near the Ballina Nature Reserve) and Coastal Environment Area in the lower catchment. Key discussion points included:

- The current Coastal Environment Area zoning in the North Creek catchment only covers a small area of the catchment. If it can be demonstrated that the water quality in the estuary is significantly impacted by the upper catchment an application can be made to increase the Coastal Environment Area zone.
- Need to keep in mind planning implications of revised zoning controls
- The CMP is intended to be a 10 year plan. It is intended to be an iterative process - important to flag/earmark options for the future - evolutionary not revolutionary

Engagement

Broad discussion on existing and planned engagement opportunities, key points include:

- Perhaps should engage NSW Planning and Environment based on above zoning discussion
- Need to engage with the Sand mine along Newrybar Swamp Road - and Rachel from Ballina Shire Council (enviro officer) is the best contact
- Ballina Shire Council proposing a 'share your memories' day on banks of North Creek to understand social history
- Alluvium currently finalising community survey
- Focus of community engagement should be on 'Telling stories' rather than 'tell me your problems'
- Ballina Shire Council hoping to undertake a citizen science program surrounding mangrove health based on similar work undertaken by Dr Norman Duke

ACTIONS:

1. *Alluvium to finalise community survey*
2. *Alluvium to initiate contact with stakeholder groups*
3. *Alluvium and BSC to confirm format of stakeholder engagement activities*

Water Quality

Discussion on water quality issues within North Creek and how they will be assessed as part of the CMP. Key points include:

- Low DO has historically been an issue within the lower North Creek

- From looking at the Ecohealth monitoring data there does not appear to be an obvious single WQ issue – results are fairly typical of a disturbed estuary system
- Data-logger in North Creek (near NC2) Rous County Council website
- The proposed catchment model developed for this project will help understand what's happening now. Can also be used for future work to determine what might happen in the future as a result of changed land use, assess different management options and support CBA and other decision support tools. The modelling approach needs to consider connectivity and transport and feed into OEH's existing work.
- The proposed WQIP will help assess pollutant generation and transport processes in both time and space. It will build on existing monitoring data. A range of different monitoring options available all requiring varying degrees of time and resources – dependant on the key questions being asked. Alluvium to provide a range of options for WQIP each requiring varying degrees of resources/time.
- The WQIP will help understand the system and be used for engagement to 'put to bed' some potential misconceptions i.e. impact of Ballina Nature Reserve on WQ

ACTIONS:

- *Alluvium to develop RCAT tool*
- *Alluvium to prepare WQIP options*

General Comments

- Need to find the NSW quaternary geology maps of the study area which include a .kmz file
- Future land use layer need to be supplied to Alluvium (Suzanne to provide). 8000 + households are proposed which could have major impacts on the system if not well managed.
- The CMP needs to be strong on projected population growth and land use change - 'emerging issues'.
- The Richmond River has been flagged as a pilot for the Marine Estate Management Strategy - Risk Based Framework
- We need to be clear on the difference between flooding issues and drainage issues and understanding the impact of flood infrastructure /drainage on estuarine health. Flooding issues are beyond the scope of the CMP and should be addressed in a floodplain management study.
- Scoping Study needs to identify risks which include Sea level rise (SLR) (actions may be able to be managed more broadly in the Richmond River). Stage 2 may need to look at tidal inundation study.
- North Ck entrance, suite of coastal hazards need to be considered including climate change (i.e. rainfall intensities), SLR, coastal erosion etc.
- Oysters are a key driver of the study we need to determine what's driving their decline as part of the CMP

ACTIONS:

- *Alluvium to incorporate above comments into scoping study*

Vision

Minor changes to the vision statement outlined in the RFQ document shown in bold:

*The CMP will 'set out council's **and the state's** long term strategy for co-ordinated management of land **and waterways** within the North Creek catchment, with a focus on the coastal zone with the main objective being to meet the social, environmental and economic needs of local community as well as contribute to achieving the state's objectives'.*

Objectives

Objectives for both the study area and the broader CMP were outlined:

- Understand management issues and begin to understand the drivers (i.e. water quality, drainage etc.)

- Help design management strategies to improve catchment health
- Project 'future potential estuary impacts' such as climate change, population growth, land use change etc.
- Asses and describe social, environmental and economic values of the North Creek system.
- Identify and describe funding and financing to employment actions.
- Maximising drainage benefits/understanding limitations.
- CMP – Update understanding of physical and biogeochemical processes estuarine/floodplain
- Establish a framework for setting future targets and management.
- Provide a comprehensive assessment of actions suitable for mitigating or managing risks.
- Collate existing info and data, ID data gaps, info needs. The CMP should fill information gaps to hold a reasonably comprehensive understanding of the impacts to the health of the system.
- Understand the processes and values within the Ballina Nature Reserve
- Evolutionary not revolutionary
- Informing urban myths
- Understand the connectivity between the upper, mid, lower catchment and any cross connections to other sub-basins.
- Describe changes past and present, DYNAMIC.

SWOT Analysis

Discussion of the strengths, weaknesses, opportunities and threats for both the study area and the broader CMP were outlined:

Strengths:

- Iconic Status
- Multi agency
- Highly loved estuary
- Strong ecological values in parts/areas
- Small catchment
- Engaged community
- High ecological values in mid reaches
- Riparian veg mid catchment
- Small enough to make links for community to work together
- Nature Reserve

Weaknesses:

- Approved future developments
- Data gaps
- Community expectations
- Extended land use
- Entrenched Land-holder opinions
- Sea level rise impacts
- Drainage
- Future development
- Data Gaps
- Change to macadamias – will this be good?
- Existing rural land management – diffuse source pollution is not able to be prevented.

Opportunities:

- Anything is better than nothing
- Opportunities for collaborating with other organisations to obtain information

- Opportunity to engage with community to find out information that might not be known yet
- Community engagement
- Information gap filling
- Management action assessment
- Increased investment (certified CMP)
- Indigenous Rangers in WQIP
- Help develop other projects (e.g. floodgate planning)
- Trailblazing for future CMPs/planning
- Multi-agency MEMA (Marine estate strategy)
- Rapid land use change

Threats:

- Complexity
- Rapid land use change
- Politics
- Community perspectives
- SLR
- Land ownership/management arrangements
- Status Quo management
- Water Quality
- Urban development (future)
- Dredging (unknown)

ACTIONS:

- *Alluvium to incorporate above analysis into scoping study*

Attachment D
Stakeholder survey responses

Online survey

The survey was open to the public over May and July 2018. During this period 150 responses were collected. The survey comprised of 13 questions and took an average of eight minutes to complete. Questions aimed to capture the demographics of the respondents, their values, concerns, interest and observations within the catchment over time.

The results from key sections of the survey are provided in to . Key findings from the survey include:

- The majority (59%) of the respondents were greater than 50 years old ()
- The survey reached a wide distribution of occupations (). The most prominent categories were Retired (20%), Education, Training and Library Occupations (10%) and Management, Health Care and NRM each comprising seven percent.
- Other occupation groups included Farming Fishing and Forestry (six percent), Business and Financial (five percent), Arts, Design <entertainment Sports and Media (five percent) and Construction and Extraction (five percent).
- Most respondents (61%) did not identify as a member of any type of local activity group. 15% were part of local fishing groups, 14% community groups and 9% environmental groups.
- The areas of interest within the catchment varied. The most popular area of interest was overall catchment health (37%), 30% of respondents were interested in their primary areas of activity or residence such as urban areas, boat ramps, swimming areas and approximately 12% were interested in the areas around Ross Lane and the Ballina Nature Reserve.
- The following catchment values were ranked by the corresponding proportion of respondents as 'very important' : Native vegetation (76%), Biodiversity (70%), Waterbirds (69%), Scenic values (57%), Swimming (55%), Other (54%), Fishing (53%), Walking/Cycling (49%), Oysters/Aquaculture (42%) and Agriculture (20%) ().
- The top six threats facing the catchment as identified by respondents are pollution (rubbish) (62%), urbanisation (56%), agriculture (54%), stormwater discharge (52%), Loss of riparian vegetation (52%) and Poor drainage (46%) ().
- Only 15% of respondents listed climate change as a top 5 threat to North Creek.
- Most respondents provided reasons as to why the top threats are a risk to the North Creek catchment. Their responses revealed that most are concerned about the relationships between residential and agricultural development, increased runoff, reduced water quality and biodiversity. Two broad areas of focus were evident within the respondents. A significant proportion identified siltation and reduced tidal flushing as the primary factor while many others focus on the upstream factors, such as agricultural runoff, acid drainage and urban pollution.
- Respondents expressed a general lack of positive improvement to conditions over time (). 34% considered the siltation in the lower end of the estuary to be a negative change and 30% identified water quality decline. Riparian decline was also noted by 12% and other changes constituted 12%. Some 'other' changes noticed included improved sewage management and urban development.
- When asked to identify positive initiatives within the catchment, 68% of respondents couldn't or chose not to (). A combined total of 20% of respondents identified initiatives in either waterway regulation, riparian restoration or environmental education. Four percent also recognised initiatives relating to improvements in pathways for walkers and cyclists.
- Desired positive changes within the catchment were grouped into five main categories (). Approximately a quarter of the respondents requested improved environmental protection, 22% desired the dredging of the lower estuary to commence and another 22% desired improvements in water quality. 16% stressed the need for drain maintenance and nine percent expressed a desire for reduced development.

- 45% of respondents indicated that they will check the website to keep updated, 30% would be interested in attending future information sessions/workshops and 20% would like to remain informed by email.
- Most (97%) respondents left their contact details with the wish to be informed in the development of the Coastal Management Program.

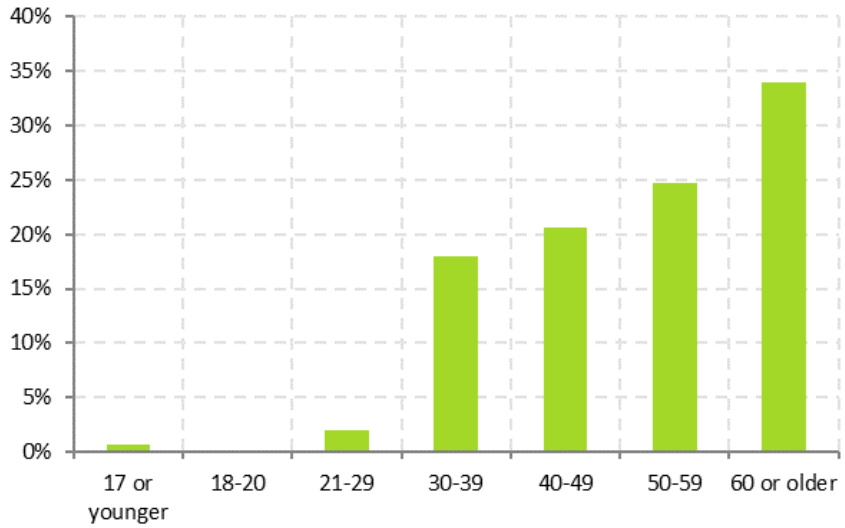


Figure 40. *Distribution of respondents by age group*

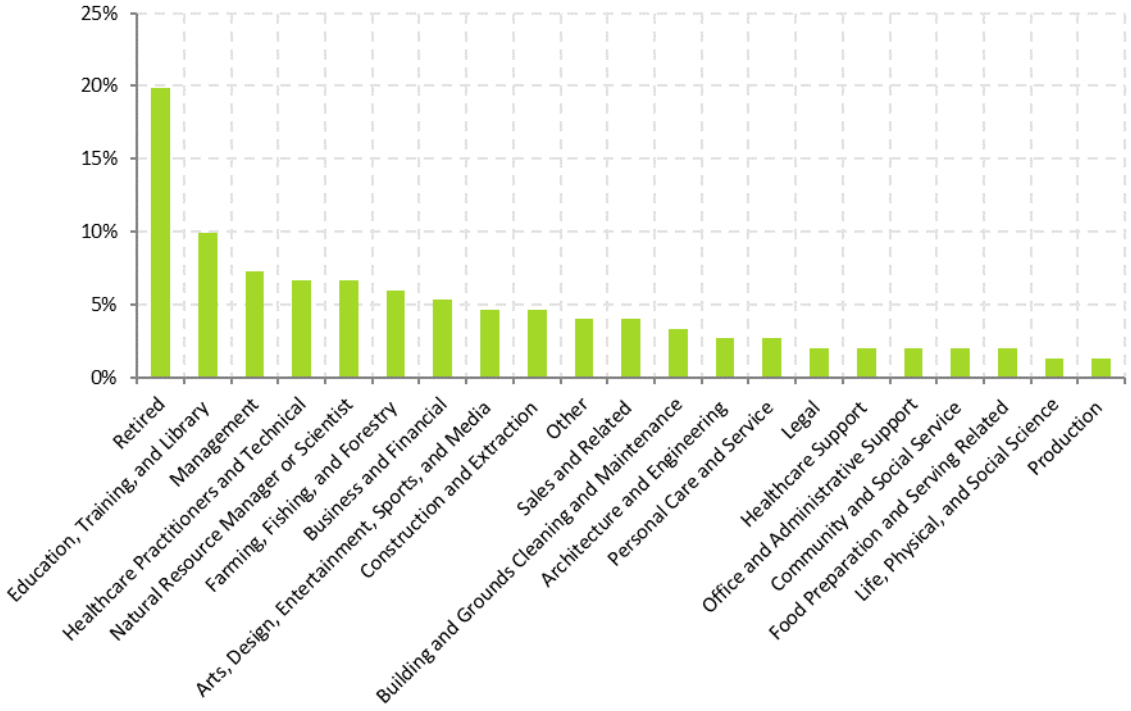


Figure 41. *Distribution of occupation across 150 respondents*

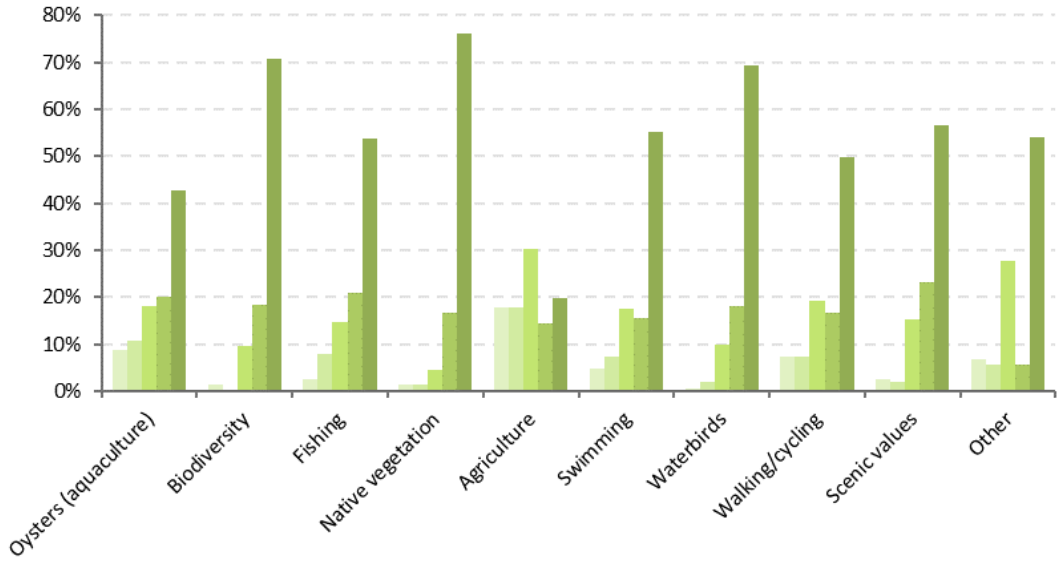


Figure 42. ***C****ommunity value importance levels, ranging from 'not at all important' (light green' to 'very important' (dark green)*

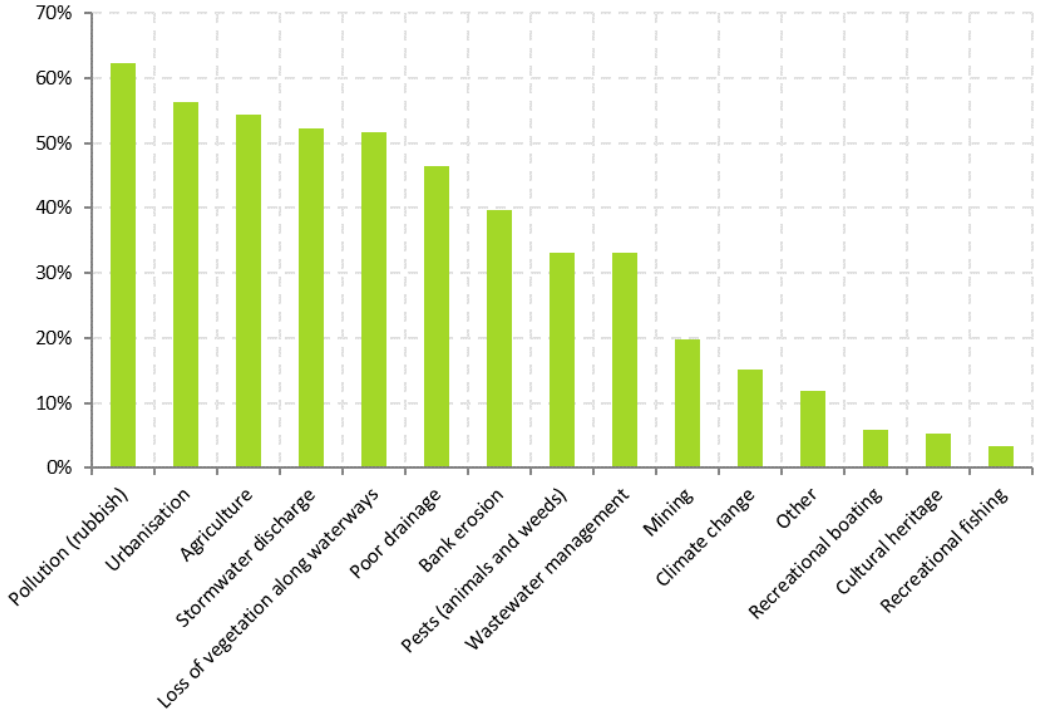


Figure 43. *Top threats considered by the community to be facing North Creek*

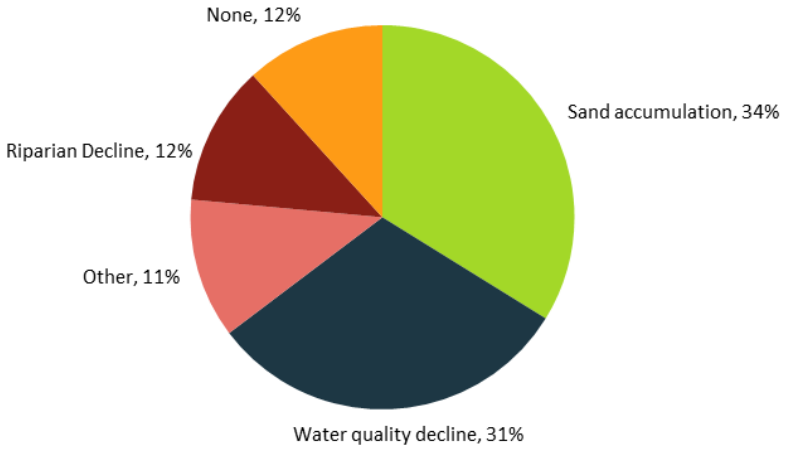


Figure 44. *The changes (positive or negative) witnessed in the catchment over time*

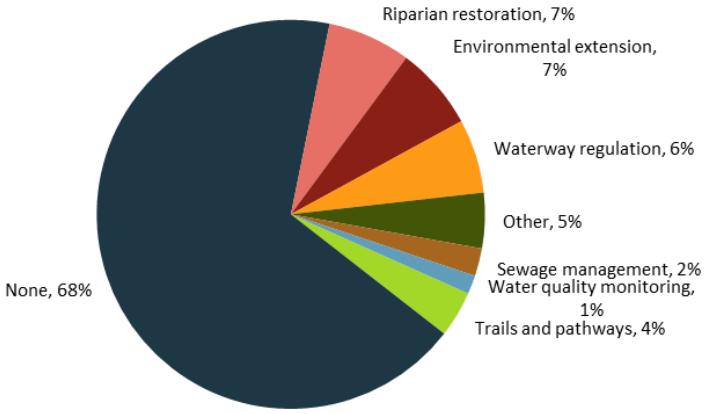


Figure 45. *Positive initiatives witnessed in the catchment in recent years*

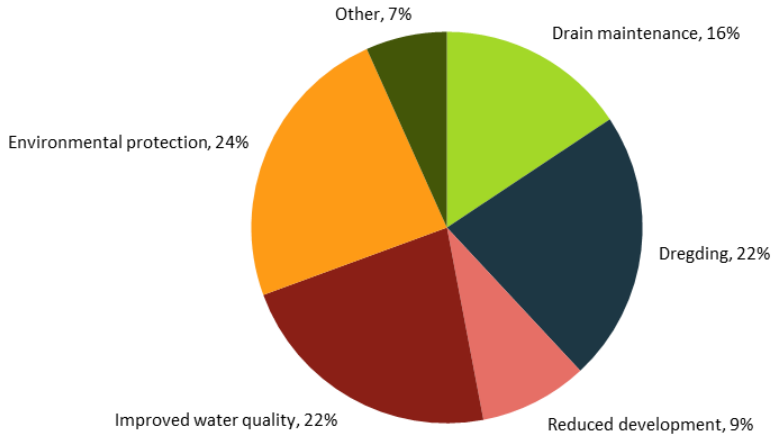


Figure 46. *The types of changes desired within the catchment*

Attachment E
Relevant policies

NSW Marine Estate Strategy 2018 - 2028

This overarching strategy coordinates the policy directions for managing the Marine Estate as a single continuous system over the next 10 years. It integrates all relevant NSW government agencies with local government, industry, stakeholders and communities.

The threat and risk assessment (TARA) of the NSW Marine Estate was conducted by the Marine Estate Management Authority and forms the basis for the strategy and is itself based on the perceptions of local communities, including Ballina. The North Creek CMP is required to consider the risk assessment which has identified the key threats facing the northern NSW coast. Stormwater pollution was found to be the highest priority threat – which is particularly relevant to the North Creek system given the increasing urban footprint.

The TARA was key in the development of eight management objectives which are listed in the strategy. A monitoring program will inform on strategy progress after five years and will also help to fill key knowledge gaps. Table 32 identifies the management actions in the strategy which relate to the North Creek CMP. Management action 1.5 for example requires the adoption of the risk-based framework for considering waterway health outcomes in strategic land-use planning decisions to improve the management of water pollution. This framework will assist in the development of management responses specific to the waterway issues faced by the North Creek catchment.

Table 32. Marine strategy objectives and actions relevant to the North Creek CMP

Objective	Actions relevant to North Creek CMP
1. Improving water quality and reducing litter for the benefit of marine habitats, wildlife and community	1.1 Improve water quality in agricultural and urban catchments using a pilot-based implementation of the Risk-based Framework. 1.2 Improve management of diffuse source- water pollution by: - Clarifying NSW Gov and local gov roles and responsibilities - Using mechanisms within existing policy. - Improving minimum standards and ensuring compliance 1.4 Implement a targeted marine litter campaign and establish a Marine Litter Working Group. 1.5 Develop monitoring, reporting and performance indicators for water quality actions, and incorporate them, and key knowledge gaps, into the monitoring program.
2. To protect coastal and marine habitats and associated species and enhance the health of the Marine Estate by improving the design, quality and ongoing management of foreshore development, use and waterway infrastructure.	2.1 Assess and manage cumulative and legacy impacts for estuary entrance modification and dredging by: - strategically dredging trained entrances to minimise the impact of interruptions to sand movement caused by entrance infrastructure and redeploying sand at erosion and sediment deprived locations - developing and incorporating practical design features that maximise marine habitat and recreational values into existing training walls during maintenance and upgrade works 2.6 Assess and manage cumulative and legacy impacts on foreshore development and land-use change in the coastal zone by: - reviewing and updating existing coastal design guidelines to promote best-practice designs in coastal urban environments. - implementing policy changes to enable adequate assessment of and response to the impact of existing infrastructure that modifies freshwater flows or drains wetlands when rezoning or when land-use change is considered to remediate the legacy impacts of older infrastructure.

3. Understand, adapt and increase resilience, to help mitigate the impacts of climate change on the NSW Marine Estate.	3.1 Enhance mapping of estuarine communities (such as saltmarsh and mangroves) to identify those communities most at threat from sea level rise under expected climate change scenarios and use this information to model areas of land suitable for retreat and those that should be prioritised for protection. 3.3 Build the knowledge and capacity of coastal and marine managers and the community to increase resilience to climate change in the Marine Estate through strategic adaptation planning and management. 3.5 Research and monitor the effects of climate change on the Marine Estate to fill knowledge gaps and inform future management actions, focusing on marine biodiversity and coastal communities.
4. Work with Aboriginal communities in the management of Sea Country to reduce threats and risks to Aboriginal cultural heritage	4.1 Work with Aboriginal communities to evaluate current arrangements for Aboriginal involvement in Sea Country management and decision-making and establish and implement a framework to ensure the involvement of Aboriginal people is effective and appropriate.
5. To understand and mitigate threats to threatened and protected species in NSW	5.6 Understand and reduce impacts of habitat modification on marine wildlife through mapping of key habitat areas, embedding rehabilitation and conservations actions in planning processes, and collaborating with land owners and the community to protect species and habitats.
6. To ensure that fishing and aquaculture is managed in a way that is consistent with ecologically sustainable health, heritage and social benefits of fishing and seafood consumption.	6.6 Apply best-practice guidelines for seagrass protection in the NSW Oyster Industry Sustainable Aquaculture Strategy.
7. To balance protection of coastal and marine habitats and species with ongoing access and safe and sustainable boating.	7.5 Improve awareness of threats to threatened and protected species, and compliance with regulations, through data sharing, education, social research and compliance planning to reduce impacts of boating.
8. Improve the social, cultural and economic benefits that the NSW community derives from the Marine Estate by responding to priority threats	8.1 Increase stakeholder and community awareness of Marine Estate values, management arrangements and promote safe and ecologically sustainable use of the Marine Estate by: - building on existing school and community education programs to encourage environmental stewardship, enhance self-compliance and promote physical and mental health benefits associated with nature - developing and promoting best practice guidance / codes of practice to reduce resource use conflicts - developing online information resources and expansion of digital technologies
9. To improve governance arrangements across the Marine	9.1 Improved co-ordination and integration across all levels of government (including cross-border and the land–sea interface) by developing a governance framework piloted at a catchment scale.

	Estate to support coordinated, transparent, inclusive and effective decision-making	9.2 Increased stakeholder and community participation by building capacity and awareness of coastal and marine management, piloted at a catchment scale and locally via marine park management planning pilots.

North Coast Regional Plan 2036

The NSW government's North Coast Regional Plan 2036 provides the overarching framework of vision, goals and actions designed towards a prosperous future. Investments will focus on further upgrades to the Pacific Motorway, hospitals, education and tourism. The plan sets regional planning priorities and guidance for regional and local planning decisions (Figure 47 SEQ Figure * ARABIC \s 1 8).

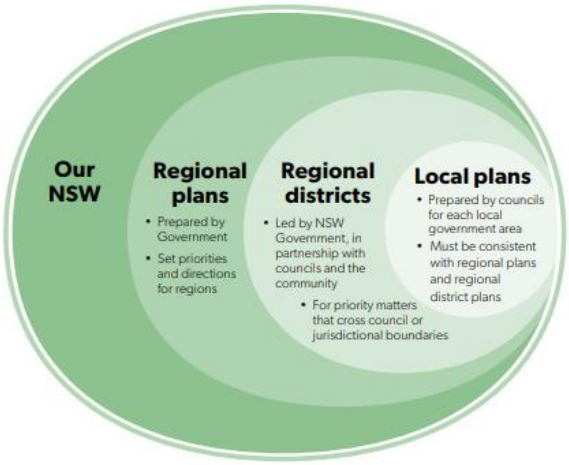


Figure 47 *The NSW state planning hierarchy (NCRP 2016).*

Four regionally based goals are set by the plan, they focus on enhancing the environment, economy, communities and lifestyle options. Three planning principles are also outlined as guides for growth on the North Coast, they aim to achieve a balance between urban expansion and the protection of coastal and environmental assets:

1. Direct growth in identified urban areas
2. Manage the sensitive coastal strip
3. Provide great places to live and work in a unique environment

A series of directives are expanded upon within each of the regional goals. Directives relevant to the North Creek CMP are included in Table 33.

Table 33 North Coast Regional Plan 2036 directives relevant to the North Creek CMP

Directive	Actions	Responsibility	Partners
1. Deliver environmentally sustainable growth	1.2	BSC	DPIE
2. Enhance biodiversity, coastal and aquatic habitats and water catchments	2.1 & 2.2	BSC	DPIE, EES
3. Manage natural hazards and climate change	3.1, 3.2 & 3.3	BSC	DPIE, EES

11. Protect and enhance productive agricultural lands	11.1,11.3 11.4 & 11.5	BSC	DPIE, DISRD
12. Grow agribusiness across the region	12.4	BSC	DPIE
13. Sustainably manage natural resources	13.1, 13.2	BSC	DPIE, DISRD
16. Collaborate and partner with Aboriginal communities	16.1,16.2	BSC	DPIE, AANSW, LALC
18. Respect and protect the North Coast's Aboriginal Heritage	18.1	BSC	DPIE, AANSW, EES, LALC

Local Land Services North Coast – Local Strategic Plan 2016-2021

Local Land Services is an integrated organisation charged with the responsibility of ensuring service delivery in the areas of agricultural advisory services, biosecurity, emergency management and natural resource management. The Local Land Services 10-year State Strategic Plan sets the long-term agenda for Local Land Services at state and local levels. Nested beneath the state plan are 11 regional plans, one of which is the North Coast Strategy for 2016. Under each of the broad state-wide goals, regional expected outcomes are listed. Some of the outcomes relevant (either directly or indirectly) to issues facing North Creek catchment are listed in **Error! Reference source not found.** (NCLSP 2016).

Table 34. A summary of the expected strategic outcomes for the North Coast listed under the four state-wide goals

Goal 1: Resilient, self-reliant and prepared local communities	Goal 2: Bio secure, profitable, productive and sustainable primary industries	Goal 3: Healthy, diverse and connected natural environments	Goal 4: Board members who are collaborative, innovative and commercially focussed
Local ownership for social, economic and environmental issues	Adopt innovative policies and practices	Land use aligned with land capability	Participatory decision making
Work with government and industry to develop innovative climate change adaptation approaches	Maintain or improve natural resource base through exercise of NRM practices	Natural environment continues to provide amenity value	Legislative and regulatory responsibilities are met
Make and take responsibility For decisions about NRM, Biosecurity and agricultural productivity.	Adopting policies and practices that deal with adapting to climatic change	Natural resources are managed in a culturally appropriate manner	High level of stakeholder confidence

Ballina Shire Council – Climate Action Strategy 2012 -2020

The Climate Action Strategy complied by BSC identifies both climate mitigation and adaptation strategies at a very broad level. Development of the strategy involved community input, which provided an understanding of the community's expectations regarding the Shire's climate change response. Key strategies relevant to the North Creek CMP include:

Flood and coastal management

- Establish management strategies for identified flood and coastline hazards.
- Incorporate State Government climate change policy into floodplain and coastline management planning.
- Integrate floodplain and coastal management policy into local planning frameworks.

Biodiversity and environmental management

- Strengthen the resilience of the Shire's natural environments to the impacts of climate change.
- Integrate biodiversity management into corporate and land use planning policy.

Regional governance arrangements
The North Coast Delivery, Co-ordination and Monitoring Committee is commissioned with the responsibility to overlook and coordinate the application of the 2036 Regional Plan. The committee is a platform that supports closer working relationships between the NSW Government and North Coast councils. Steering committees from each regional centre, including Ballina, will report to them.

Governance of the Marine Estate is overseen by the Marine Estate Management Authority, which was established in 2012. The Authority developed the Marine Estate Management Strategy 2018-2028 and advises the Minister for Primary Industries and the Minister for the Environment. The strategy co-ordinates all aspects of Marine Estate management under one framework, including local councils.

As the coastal zone is also part of the Marine Estate, the Coastal Management Act 2016 also supports the aims of the *Marine Estate Management Act 2014*. In recognition of the need for expert advice on coastal issues, the NSW government has appointed the NSW Coastal Council, an independent and expert panel, which advises the Minister on coastal issues. The council can perform performance audits on the local council's implementation of its coastal management program.

Local governance arrangements
Reform of the Local Government Act 1993 enabled the Rous County Council to merge with and adopt the responsibilities of smaller county councils in the Northern Rivers region. The Rous County Council is the Flood Mitigation Authority responsible mitigation in the rural environment (not urban areas), this includes the upper and mid reaches of North Creek. The County's natural resource management function relates only to the environmental consequence resulting from the operation of flood mitigation infrastructure on the broader environment. The County is not responsible for other complex management issues relating to estuary ecological health, wetland health and water quality. These responsibilities are shared by Ballina Shire Council and other agencies resulting in a complex governance arrangement.

Attachment F
Water Quality Monitoring Program

alluvium

FINAL REPORT:

North Creek Water Quality Monitoring Plan

Dec 2019

ballina shire council

Document history

Revision:

Revision no.	04
Author/s	Misko Ivezich Alex Sen Lisa Walpole Suzanne Acret
Checked	Tony Weber
Approved	Misko Ivezich

Distribution:

Revision no.	04
Issue date	Dec 2019
Issued to	Suzanne Acret
Description:	Final

Revision no.	03
Issue date	Febuary 2019
Issued to	Suzanne Acret
Description	Draft for comment

Revision no.	02
Issue date	November 2018
Issued to	Suzanne Acret
Description	Draft for comment

Revision no.	01
Issue date	June 2018
Issued to	Suzanne Acret
Description	Draft for comment

Contents

Figures

Tables

1 Introduction

Alluvium Consulting has been engaged by Ballina Shire Council to develop a Water Quality Monitoring Plan (WQMP) as part of the scoping study for the North Creek Coastal Management Program (CMP). Reductions in water quality conditions within the North Creek estuary since European settlement have resulted in a decline in ecosystem health and impacted on fisheries including the once thriving oyster industry.

Poor water quality has been informally attributed to several factors within the catchment. These factors include clearing, altered floodplain drainage, development of agriculture and residential subdivisions within the catchment and sand quarrying activities. However, there have been limited scientific studies within the North Creek catchment sufficiently targeted to help determine the linkages between these factors, other natural catchment processes and the water quality conditions experienced in the estuary. The drivers of impacts (including water quality) on fisheries are currently poorly understood within the North Creek catchment.

This WQMP aims to identify the key drivers of water quality decline within the catchment. It contains an overview of current water quality issues within North Creek, objectives for the WQMP and recommendations and options relating to a water quality monitoring program for implementation.

2 Background

Overview
Water quality within North Creek has been subject to periodic monitoring of some limited parameters since approximately 2013. This has consisted of one datalogger located in the lower estuary and North Creek's inclusion in the 2014 Eco health Program (Ryder et al, 2015).

This monitoring indicates that the water quality within North Creek is generally poor, with high concentrations of bioavailable nutrients throughout and episodes of low pH water and low levels of dissolved oxygen periodically. Despite the tidal nature of the waterway, episodes of poor water quality are believed to persist throughout the catchment following rainfall.

In major flood events, such as the 2001 and 2008 floods, it would be expected that water quality would be poor. However, there appears to be persistent poor water quality within the mid to upper estuary and that small to moderate rainfall events trigger harvest closures and oyster fatalities as a result.

A number of different land uses and activities have been identified as likely sources of nutrients. These include grazing, cropping, horticulture and urbanization (Ryder et al., 2015).

Key points relating to water quality identified in previous studies of North Creek include:

- Agricultural land use is a major source of diffuse pollutant loadings (Hydrosphere 2011)
- A radon mass balance study revealed that North Creek is groundwater dominated in its upper reaches above Ross Lane, primarily due to its small catchment size, extensive drainage network and permanent spring discharge from the Alstonville plateau (Atkins et al. 2013).
- Humic rich and tannin rich waters of the upper catchment combined with high temperatures have been identified as drivers for summer algal blooms (ABER 2008).
- Floodplain drainages have the potential exacerbate deoxygenation of the estuary (EMS, 2011).
- Dissolved oxygen levels decrease progressively upstream. It is likely this is driven by low oxygen wetland and floodplain drainage inputs. DO concentrations are influenced by high dissolved and particulate carbon loads mostly from groundwater inputs, leaf litter fall and summertime phytoplankton blooms (ABER 2008).

- Drains are potential environments for Monosulfidic black ooze (MBO) creation and have the capacity to rapidly deoxygenate water and damage waterway ecology (Hydrosphere 2011).
- Acid Sulfate Soil (ASS) disturbance has resulted in the chronic and acute discharges of acidic water and associated contaminants along drainage channels where ASS occurs (ABER 2008).
- Acid conditions appear to be confined to smaller runoff events, where small volumes of runoff aren't large enough to dilute the impact of acid groundwater inflows (ABER 2008).
- The potential for ASS runoff to affect upper reaches of North Creek estuary during smaller runoff events in the wet season when groundwater levels are relatively high (Hydrosphere, 2011). Much of the upper reaches of North Creek are mapped within the low ASS risk zone.
- In general, pH decreases progressively upstream. This has been noted, with possible explanations, in a number of studies (ABER, 2008 and Hydrosphere 2011). There are two possible reasons for this, either acidic groundwater discharge related to Acid Sulfate Soils being disturbed or acidic groundwater discharge related to acid soils within the catchment.

The Eco-health monitoring program (2014-15) set out to establish baseline water quality monitoring throughout the Richmond River catchment and is the most recent analysis of water quality in the North Creek system. Exceedances of ANZECC trigger thresholds were common for all five sample sites in North Creek. The program revealed high inputs of suspended solids which remain in suspension for the length of North Creek estuary and that the consistently low pH and DO readings potentially relate to drainage modification and the presence of ASS within the catchment.

The soils of the Coolamon and Bangalow Soil Landscapes which characterises the terrain of the upper catchment slopes bear a pH which ranges from 4.5 to 6 (Morand 1994). It is unknown whether the low pH in the estuary is related to acid soils in the upper catchment, ASS in the lower catchment or both. Consequently, a mechanism for identifying the source of low pH within North Creek is suggested in this WQMP.

Rapid Catchment Assessment Tool (RCAT)

In order to identify the potential hot spot areas contributing to water quality issues in North Creek, a Rapid Catchment Assessment Tool (RCAT) has been used to estimate pollutant loads (TSS, TN, TP and e.Coli) from different sub-catchments. A total of 11 sub-catchments were determined based on land use, key geographic features and hydrological drainage. Model results are presented in Attachment A.

The RCAT modelling highlights the potential for significant pollutant generation during runoff events, though given previous studies have also inferred that groundwater sources are dominant, the relationship between surface runoff and groundwater contributions needs to be better defined. The extensive drainage works through the catchment has created predominately perennial waterways which interact with groundwater sources rather than just being conduits of surface runoff. Given that they have periods of low or no flow but still hold water, this allows for the processing of organic compounds which, in the presence of acidic water, can lead to anoxic or even anaerobic conditions.

3 Water quality monitoring plan

3.1 Program objectives

Based on the review of the existing data the following objectives have been identified for the North Creek WQMP:

1. Determine the spatial and temporal variation in water quality parameters throughout the North Creek catchment which can help in the identification of sources of acidity (groundwater, surface water, rain water and ASS disturbance) and organic toxicants (i.e. leaking sewage, agriculture etc.).
2. Determine the relative impact of ambient conditions (i.e. anoxic conditions developing in pooled water within drains from groundwater ingress) or runoff events on water quality.
3. Identify the water quality parameters and flow conditions within the catchment and estuary which are contributing to poor habitat for native estuarine fauna, including oysters.

3.2 Monitoring sites

Main stem of North Creek

At a minimum, monitoring sites should be established at strategic locations along the length of the main drainage network of North Creek. This would require six sites along the estuary, including upstream and downstream of the Ballina Nature Reserve (BNR) to better understand the role of the reserve in impacts on water quality.

The purpose of these locations is to better evaluate variations in water quality parameters along the main drainage to establish spatial and temporal patterns under various weather and climate conditions. Recommended locations are shown in Figure 1 with an overview of each sub-catchment provided in Table 1. The first four primary drainage line sites highlighted in green (from the mouth to Ross Lane), correlate with the 2014 - 2015 Eco-health monitoring sites.

Along main tributaries

In addition to the monitoring sites along North Creek, sites could also be established in the major tributary systems (Figure 1). A total of 11 major sub-catchments were identified through the RCAT modelling. Alternatively, only representative sub-catchments could be selected to avoid monitoring multiple sub-catchments with comparable land use and geology. The representative sub-catchments recommended include:

- The Ballina Nature Reserve – a unique sub-catchment with urban areas discharging to areas of remnant vegetation and long residence times. (Two sample sites would be required to measure the attenuation of pollutants from incoming stormwater from Ballina Heights).
- Ballina – representative of an urban/industrial sub-catchment. RCAT modelling predicted high TP loads.
- East of Knockrow - representative of the grazing and sugarcane sub-catchments which drain the volcanic plateau. RCAT modelling predicted high TN loads.
- Lennox Head – representative of the grazing and sugar cane catchments which drain the coastal margin.
- Skennars Head – Immediately downstream of the intensified urbanisation.

Escarpment

Sampling along watercourses which drain the escarpment and the permanent springs at the base will provide the opportunity to determine how these water sources are contributing to downstream conditions. Aerial imagery suggests that most of these streams are ephemeral. Consequently, monitoring sites may be restricted to only the permanent springs during the dry season.

The permanent springs flowing out of the Alstonville Plateau basalt aquifers provide the opportunity to determine spring water chemistry flowing into North Creek. The precise location of these springs is currently unknown; however, a review of the Bureau of Meteorology's Groundwater Dependent Ecosystem Atlas has identified the likely locations along the escarpment at which these springs may occur (Figure 1). Samples from at least one spring fed site, as well as wet season sampling of flow paths running off the plateau escarpment should be considered as a minimal requirement.

Sampling of the watercourses which channel water off the rapidly developing escarpment in the BNR sub-catchment can provide the opportunity to monitor water quality parameters prior to mixing with the waters within the reserve and should be considered as part of phase 1 of the monitoring program (Section 3.5).

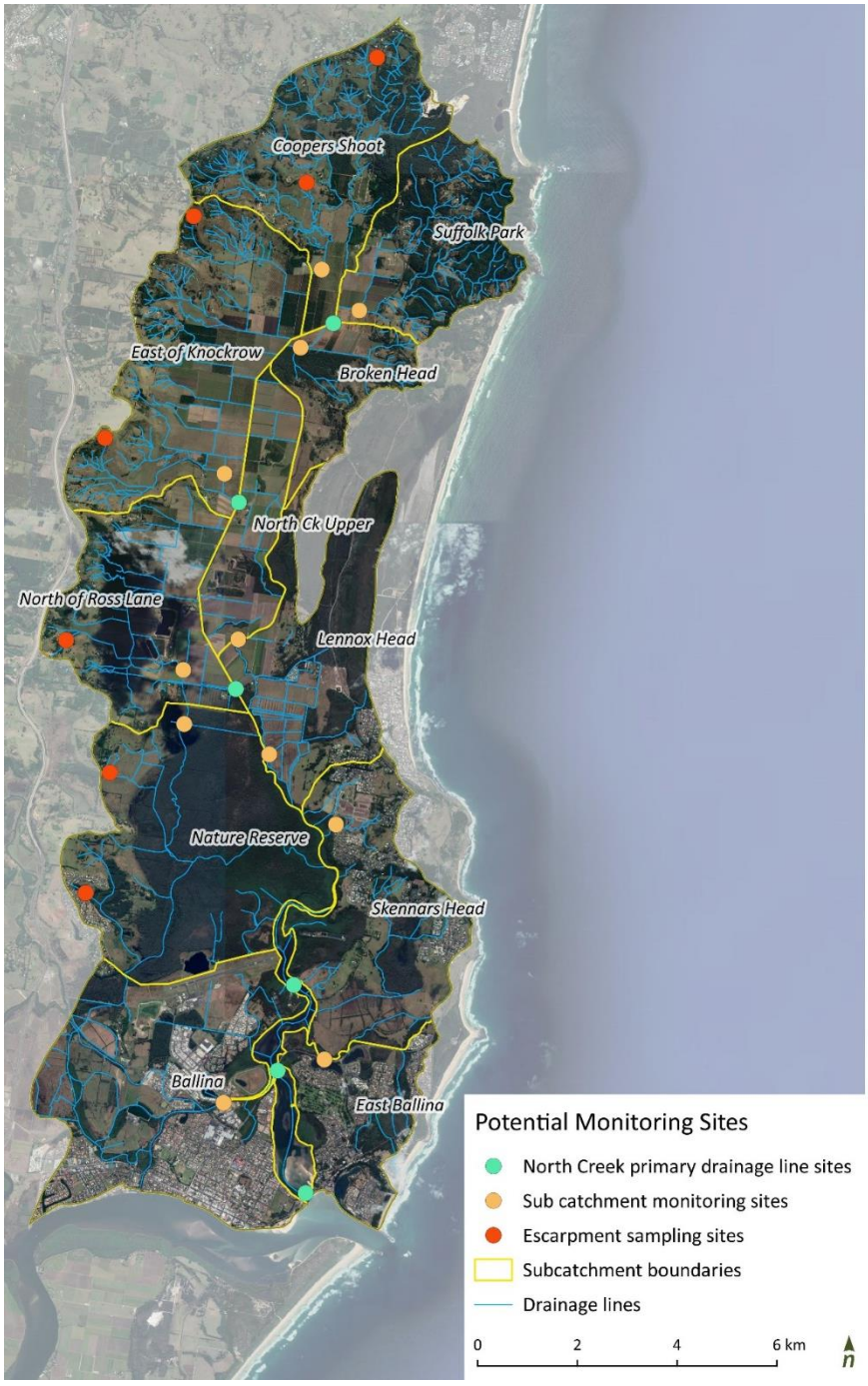


Figure 1 *North Creek primary drainage line sites and potential sub-catchment monitoring sites highlighted in green and orange respectively.*

Table 1 An overview of the qualities of each sub-catchment which may influence water quality monitoring results

Sub-catchment	Description and sampling rationale
Coopers Shoot	Exhibits a mix of land use and soil types within the northern fringe of the Alstonville escarpment holding sugar cane, grazing and significant proportion of macadamia towards the catchment outlet. Sampling of this catchment may provide an indication of the water quality parameter concentrations prior to entering the drained basin. As this catchment contains two soil types, deep red clay loams and shallow sandy loams, the WQ parameter signature may reflect this mix when compared to other, single soil dominated catchments. The escarpment sample points are indicative of the likely areas in which a permanent spring is to be found, sampling of this site aims to understand the water quality contributed by the spring. Wet season sampling of runoff from the escarpment will give an indication of how the acid soils and surrounding land uses contribute to water quality.
Suffolk Park	Predominantly shallow sandy loams with a high degree of native vegetation cover when compared to other escarpment sub-catchments. No macadamias in this sub-catchment and sugar cane fields are located at its outlet. WQ parameters may reflect this mix of land use and soil types.
East of Knockrow	One of the largest sub-catchments with a mix of land uses. Predominantly deep red clay loams on the escarpment and water-logged sandy clays in the basin areas. The northern drainage lines pass through macadamia farms, sugar cane and grazing areas whereas the southern drainage areas do not contain macadamias. Comparative sampling within this catchment may provide the opportunity to observe if macadamia farming correlates with changes in water quality parameters. The escarpment sample points are indicative of the likely areas in which a permanent spring is to be found, sampling of this site aims to understand the water quality contributed by the spring. Wet season sampling of runoff from the escarpment will give an indication of how the acid soils and surrounding land uses contribute to water quality.
Broken Head	Exhibits a mix of dense native vegetation and sugar cane along its main drainage line with flows off the metasediments of Broken Head and the coastal back dunes. In terms of land use and underlying soil it is similar to the Suffolk Park sub-catchment and is therefore not of high sampling priority.
North Creek Upper	This area is bordered completely by the Union and Flood Mitigation Drains with predominantly sugar cane and a smaller area of macadamias and the inactive McGeary's sand mine. The cross-cutting drainage network makes it difficult to select a sampling point which would be reflective of this sub-catchment. Sampling along the flood mitigation drain line downstream of the sand mine may capture any signal from the mine – particularly low pH. There have been anecdotal reports of the presence of black water in this area. This can only be determined if there is another sample point at a suitable location upstream of the mine.
Lennox Head	Contains a mix of land uses, with increasing urbanisation in the upper sections, dense coastal back swamp, sugar cane, intertidal wetland and vacant lots once used for horticulture. Sample site selection within this sub-catchment can help understand the impacts of different land use types.
North of Ross Lane	A catchment with very similar soil and land use characteristics to the East of Knockrow sub-catchment. The main difference is the presence of a sand mine. The mine site is located near the catchment outlet. The sample site is located between the outlet and the mine to capture representative water quality parameters. The escarpment sample point is indicative of the likely area in which a permanent spring is to be found, sampling of this site aims to understand the water quality contributed by the spring. Wet season sampling of runoff from the escarpment will give an indication of the influences the acid soils and surrounding land uses have on water quality prior to sand mining activities.
Nature Reserve	Extensive urbanisation on the escarpment is likely to impact water quality parameters as runoff enters the complex drainage network and flows north from Deadman's Creek to Ross Lane. The sample point in this catchment (near Ross Lane) aims to capture the stormwater flows after they have interacted with the drains within the reserve. The escarpment sample points are indicative of likely areas in which a permanent spring or intermittent creek is to be found, sampling of these sites aims to understand the water quality of the spring water (if a spring is present), or the water quality of runoff from the development or both. Wet season sampling of runoff from the escarpment should also occur.

Skennars Head	Exhibits a mix of increasing urbanisation along sugar, grazing and intertidal wetlands. Development is known to be driving high TSS loads in local drains however the degree to which this input reaches the main creek is unknown. Multiple outlets from this catchment provide the opportunity to monitor inflows which pass through development, acid scalds and pasture areas.
Ballina	The most urbanised sub-catchment of all with many outlets into North Creek, the Richmond River and North Creek canal. Despite the extensive mixing that is likely to occur within these waterways, monitoring of the North Creek canal is recommended. It will provide an indication of how ambient conditions within this highly dynamic area change in relation to changes higher up in the catchment. Recorded changes in these water quality parameters can help the calibration of any future hydrodynamic modelling to determine the relative influence of the Richmond River on water quality in North Creek.
East Ballina	Another highly modified sub-catchment with a range of urbanised areas, modified waterways and fringing intertidal wetlands. One major outlet at Chickiba Creek provides a good opportunity capture representative water quality parameters for the catchment. This is also the location of a 2014-2015 EHMP monitoring site.

3.3 Monitoring options

Three different options for monitoring North Creek are outlined in Table 2. As most monitoring programs are almost always a compromise between the scientific ideal and the financial and logistical constraints, the three options aim to provide varying degrees of insight into the nature of North Creek's water quality. Estimated costs are provided as a range according to the costings provided in Appendix 2 and are based on 2018 costs sourced by Ballina Shire Council.

In order to determine the characteristics of the water delivered from the escarpment, at least two monitoring sites would need to be added to each of the three options below. One for the permanent springs, and another for a primary water course running off the escarpment. These two sampling points would add further cost to each of the options of approximately $7 to $16k per year depending on the final parameters and number of sites chosen (See Table 8 in the Attachment B).

The increased number of monitoring sites in the second and third options listed below provide the opportunity for the development of sub-options which can address the specific characteristics of each sub-catchment. Sample sites may be moved to other locations along the drainage pattern to monitor WQ parameters within flows directly before and after specific land use types rather than at the outlet. This is particularly applicable to the following sub-catchments:

- Coopers Shoot, to monitor water quality prior to entry into the flood plain.
- Skennars Head, to monitor water quality downstream of development areas.
- Ballina Nature Reserve, to monitor water quality downstream of development areas prior to entering the Ballina Nature Reserve.
- North of Ross Lane, to monitor the water quality, namely pH of drain water upstream and downstream of the sand mine.
- Lennox Head, to monitor water quality parameters where the Tuckean Swamp Soil Landscape, a possible source of MBO, is buffered by the Tyagarah Soil Landscape.
- East of Knockrow, where there is the opportunity to monitor water quality before and after macadamia farms and sugar cane with other soil landscape qualities remaining somewhat equal.

With most of these sub-options, the addition of an extra monitoring site at the sub-catchment outlet can then give an indication of how parameters change across specific land use categories. This is particularly applicable to the BNR, where an understanding of the attenuation of stormwater pollutants could be derived.

Table 2 Different options for monitoring in North Creek (Costs subject to change)

Option	Number of sites	Advantages	Disadvantages	Estimated total cost range per year
1) Main stem of North Creek only	6	• Low cost • Easy to access • Understand variations in water quality along North Creek	• Difficult to determine ambient conditions within tributary drains • Difficult to determine relative contribution of sub-catchments and specific land uses	$34,900 (bimonthly sampling of only high priority parameters) to $79,800 (monthly sampling of all parameters) Or $43,000 to $92,000 a year to include escarpment sampling at two extra sites
2) Main stem of North Creek and representative sub-catchments	11	• Understand variations in water quality along North Creek • Some understanding of role of different land uses • Some understanding of ambient conditions	• Some uncertainty surrounding inputs from all sub-catchments • Moderate cost	$44,400 (bimonthly sampling of only high priority parameters) to $115,800 (monthly sampling of all parameters) Or $53,900 to $128,800 a year to include escarpment sampling at two extra sites
3) Main stem of North Creek and all 11 sub-catchments	17	• Understand variations in water quality along North Creek • Understanding of the role of different land uses • Understanding of ambient conditions • Understanding of contributions from all sub-catchments	• High cost	$50,800 (bimonthly sampling of only high priority parameters) to $150,800 (monthly sampling of all parameters) Or $59,800 to $163,800 a year to include escarpment sampling at two extra sites

3.4 Water quality parameters

A list of relevant water quality parameters is provided in Table 3. The parameters have been selected based on a review of the likely groundwater and surface water processes occurring in the North Creek catchment. The relevance and priority for monitoring in the North Creek catchment are also outlined below.

Table 3. Relevant water quality parameters for North Creek

Water quality parameter	Purpose	Priority for monitoring
pH (field measurement)	Identifies areas where acidic drainage may be occurring	High
Temperature (field measurement)	Provides context for the analysis of other results	High
Electrical Conductivity (EC) (field Measurement)	Provides indications of where saline and freshwater areas exist and can also provide indications of groundwater and surface water contributions	High
Dissolved Oxygen (DO) (field measurement)	Identifies low DO areas that may create anoxic conditions and environmental conditions for blackwater and Mono-sulfidic Black Ooze (MBO)	High
Turbidity (field measurement)	Provides an understanding of the light climate in the water column to show how susceptible the waterway may be to algal blooms where conditions are favourable.	High
Chlorophyll A (laboratory sample)	Indication of phytoplankton biomass and nutrient status.	High
Sediment (i.e. Total Suspended Solids-TSS) (laboratory sample)	Shows the mass of sediments and particulates present in the waterway. Can provide an indication of construction activities, high organic matter loads and general surface water runoff pollution. If cost is an issue, this can be removed and NTU can be its proxy if deemed appropriate after phase 1.	High
Nutrients (i.e. Total Nitrogen- TN, Nitrate – NO3, Nitrite – NO2, Ammonia – NH3, Dissolved total Phosphorus – TP, (laboratory sample)	These will provide a solid understanding of the key nutrient stressors in the waterway that can facilitate algal blooms and increase impacts on the fisheries in the estuary.	High
Major and minor ions: Na^+, K^+, Ca^{2+}, Mg^{2+}, HCO_3^-, Cl^-, SO_4^{2-}, and SiO_2 (reactive silica) (laboratory sample)	Major ions provide the basic suite for understanding hydro-chemical processes in surface and groundwater. This includes understanding surface and groundwater hydro-chemical processes and sources. In addition, the analysis of drain water for the Cl/SO_4 ratio can indicate if sulfidic material in the source matrix is being or has been oxidised.	High
Conservative Ions (Li^+ & Br^-) (laboratory sample)	Combined with Cl^- (major ion suite), Li^+ and Br^- comprise the three conservative ion species. These ions can be used to potentially identify discrete surface and groundwater source end members, including seawater, rainwater, groundwater, and sewerage sources. As a result, these ions can be useful for understanding spatial and temporal variability of different sources of discharge/drainage occur throughout the catchment.	High

S_2 ((sulphide - dissolved) (laboratory sample)	S_2 is the redox pair of SO_4. Combined these ions provide an indication of redox conditions, and may help assess influences of ASS and MBO	Medium
Trace metals (i.e. Iron Fe^{3+}, Fe^{2+} and Al, Cu, Zn – dissolved) (laboratory sample)	Understand the contribution of ASS and other groundwater contributions. If possible it is best to differentiate between the ion species Fe3+ and Fe2+ (which are the redox pairs)	Medium
E. coli/enterococci/faecal coliforms (laboratory sample)	Have been linked to poor oyster health	Medium
Pesticides (laboratory sample)	Detection of toxicants in the creek system is possible but identifying the source is difficult given that the pesticide/herbicide is typically applied aerially. If pesticides of concern are found in phase 1 of the sampling program, further analysis of potential sources may warrant soil sampling in phase 2	Medium (passive sampling along main stem/ perennial waterways only)
Dissolved Organic Carbon (DOC) (laboratory sample)	Provides an indication of how much of the organic carbon is dissolved / understanding biological process). DOC can be useful for understanding biological processes, but usually more intensive investigations are needed as the carbon cycle is complex. Given its cost and complexity, it is considered a low priority.	Low
Organic matter (by Loss on Ignition) (laboratory sample)	This analyte will provide an understanding of the overall organic load in the waterway and the amount of particulate matter that is organic. However, if cost is an issue a focus on dissolved N and solutes will suffice. Organic particulate matter will likely be highly variable temporally and spatially	Low

3.5 Sampling regime

Water quality sampling should be undertaken in accordance with AS/NZ 5667:1998. This standard outlines requirements for sampling containers, sample identification, sample preservation, sample transportation and quality control. The final sampling regime will need to consider the available budget and the objectives of the program. It will also need to consider any existing monitoring undertaken by the Rous County Council and the Recycled Waste Water Treatment Plant (RWWTP).

To deliver the best value for money, the sampling program should be delivered in a three phased approach:

- *Developmental*: The initial year of broader scale sampling to establish a baseline understanding of data distribution.
- *Implementation:* a focussed sampling strategy in year two to address the WQMP objectives and to answer any relevant questions raised through analysis of baseline data received in the development phase. This phase may recommend new parameters for monitoring, based on phase 1 results.
- *Review:* Review data against WQMP objectives and revise sampling approach if necessary.

The developmental phase will require higher number of sample sites collected in the first year to establish baseline understanding and identify key contributors of water quality. This will be necessary to determine the relative contribution of escarpment acid soils or Newrybar Swamp ASS are contributing to estuary pH conditions. The development phase should determine key processes and major source of water quality stressors, as well as assess the value/usefulness of the suite of parameters used in the monitoring. This phase should be used to develop an improved conceptual understanding and make any necessary recommendations for future monitoring in subsequent phases. This phase may also determine water quality objectives for

certain parameters that inform the monitoring objectives. This is best performed in line with ANZECC Guidelines for risk-based assessment of water quality. However, sufficient data may not be collected during this stage to inform these water quality objectives, and as a result this work can be continued in the implementation phase.

The implementation phase should include meaningful analysis of the data in a way that informs the WQMP objectives. This is best performed in line with ANZECC Guidelines for risk-based assessment of water quality.

Once the baseline understanding is characterised, a review of the results against the WQMP objectives should enable for a targeted sampling in the years two and three of the program. The review phase should be ongoing and occur intermittently: this phase is an opportunity to continually improve the conceptual understanding of the system, assess the water quality data against objectives, and propose any amendments or changes to the water quality monitoring program over time.

A range of options for the North Creek WQMP are outlined below for consideration.

Integration with existing monitoring
Rous County Council currently resources a data logger in North Creek near the Ballina-Byron Regional Airport. The datalogger provides time series data for water temperature, DO, pH, EC, TDS, water density and water height. This can be closely correlated with rainfall data collected at the airport.

Ballina Recycled Wastewater Treatment Plan also undertakes some monitoring, but this is closely linked to the licensing requirements of the Environment Protection Authority. Parameters sampled would provide good background information but cannot replace a specific and targeted monitoring program focussed on the broader North Creek catchment.

It is likely that the sand mines (active and inactive) are being monitored under the Protection of the Environment Operations Act 1997. These monitoring programs may reduce the need for some of the suggested sample sites and hence reduce overall cost.

Regular sampling
Monitoring could be undertaken at regular intervals (i.e. monthly or quarterly). This would include in-situ monitoring using water quality probes to measure key physico-chemical parameters that can only be measured in the field (i.e. pH, Temperature, Electrical Conductivity, Dissolved Oxygen, Turbidity). In addition, grab sampling will be used for parameters which require laboratory testing (highlighted in Table 3).

Sampling at regular intervals should enable assessment of ambient conditions and base flow water quality conditions and would be useful in identifying long term trends. However, sampling at regular intervals will only provide limited information on catchment and receiving environment response during rainfall. Furthermore, regular sampling would also need to ensure that the tidal signal is accounted for and should avoid ephemeral waterways and drains where possible.

The following points should be considered:

- A reconnaissance survey of all sample locations is required to be check sample site viability. As some may be ephemeral, another location may be required.
- Collection of regular samples should occur during the outgoing tide, to capture the water quality signal from adjacent land.
- ANZECC Guidelines recommend at least 11 samples over a 12-month period for ambient monitoring of most basic water quality parameters.
- Within the deeper reaches of the main trunk of North Creek (>4m), both a surface and bottom sample is necessary to determine water quality due to salt wedge development and stratification.
- A multiprobe sensor for physico-chemical parameters should be employed by a vessel where practical along the main trunk of the estuary, to gather water quality parameter data at 1 m depth intervals.

- A water quality database will be required to ensure appropriate controls on data entry and data integrity.
- ANZECC water quality sampling methods should be followed.
- The data concerning the regulated point sources/releases of water pollution within the catchment (Sand mine, RWWTP) be made available prior to confirming sample locations.

Event-based sampling
To supplement regular sampling, event-based sampling could occur during runoff events. Event-based sampling would provide an indication of the parameter concentrations during runoff events. However, catchment loads cannot be estimated unless a stream gauge is also installed.

There are three options for event-based sampling; grab sampling during the event, autosamplers or rising stage samplers. The autosampler can sample throughout the event but is relatively expensive to set up and operate. The rising stage samplers are lower cost but can only sample a portion of each flow event.

A single grab sample during the event is the cheapest option but will not characterise variations during the event. The event-based sampling can help understand the catchment response to rainfall events and help determine the role of runoff event in pollutant generation and transport. Given the number of sampling sites it is recommended that event-based sampling be grab samples at some stage during the event.

In order to characterise an event with grab samples, at least two samples on the upward limb and three on the downward limb of the hydrograph are necessary. Given that the event response time for 20 to 30mm of rainfall could be as short as 20 minutes for the North Creek catchment, this will be difficult and require a coordinated approach.

Event sampling would consist of two to three sampling runs from the top of the creek down toward the mouth with samples taken at road crossings where it is safe to do so, with notes on whether sampling occurred on the upward or downward limb of the event. Given that it is not practical to sample across all the sites listed in Figure 1 during the event, event monitoring costs are only provided for sampling along the main stem of North Creek.

The following points should be considered:

- Initially, up to four events should be sampled each year, two small (i.e.≈ 20-30 mm) and two large (i.e. > 80 mm).
- The developmental phase should identify if the above sampling frequency is providing the required data to meet the WQMP objectives. This should be determined in accordance with ANZECC Guidelines and should include some consideration of the ephemeral nature of the system, and the temporal change in surface run off versus groundwater discharge.
- Details of the scheduled and unscheduled releases from the RWWTP and sand mine as per their environmental licences should be collected. These releases are likely to coincide with runoff events.
- The location of the event-based sampling should be risk assessed, with extreme events, such as flooding to be avoided.

Microbial source-tracking
Once the developmental phase is complete, the implementation phase should consider whether microbial source tracking can help further discriminate the origin(s) of high E. coli/enterococci/faecal coliforms in North Creek. The methodology applied by UTS and DPIE along the central NSW coastline should be consulted if such an approach is considered to provide further value (Seymour et al. 2019).

3.6 Recommendations

The number of monitoring sites, water quality parameters monitored, and sampling regime will largely be dependent on the available budget and required level of certainty. The total costs of the program will be largely impacted by the number of samples collected and the number of parameters that are monitored. A number of options and their advantages and costs have been outlined in the previous sections. It is recommended that monitoring be undertaken for a minimum of one year (Phase 1) but ideally up to three years to meet the objectives of the program, which essentially seek to understand seasonal variations in water quality in relation to different land uses across the catchment.

Option 2 is recommended for the monitoring program, as it provides a balance between costs and data to meet the objectives of the WQMP. The ambient and event monitoring locations are shown in Figure 2 and summarised in Table 4. It is recommended that all high and medium priority parameters as described in Table 3 are monitored for all the 12 sites listed in Table 4.

Annual costs for both monthly and bimonthly monitoring are provided in Attachment B. If there are budget constraints it is suggested that less frequent monitoring is undertaken (i.e. bimonthly) across more sites (i.e. including representative sub-catchments) as opposed to more frequent monitoring along the main stem of North Creek only. Sampling within the sub-catchments can help identify the source of water quality issues as discussed. Sampling in North Creek alone would still provide insight however tidal processes are likely to mean identifying the sources of water quality issues will be more difficult. In such a case, key physical and chemical parameters could be monitored monthly (i.e. pH/Temp, EC/Salinity, DO, Turbidity, Fe/Al and TN/TP) with the full suite as listed in Table 3 monitored bimonthly.

As mentioned previously, four events should be sampled each year, two small (i.e.≈ 20-30 mm) and two large (i.e. > 80 mm). Event-based monitoring will be critical in determining the relative role of surface water discharges on estuary water quality. Further development of this understanding is of interest to the oyster industry as oyster health is often impacted by small to mid-sized events not just large ones. Achieving event-based sampling in North Creek may open opportunities for research into the water quality parameters which increase the susceptibility of oysters to QX disease.

In conjunction with the water quality monitoring oyster health should also be monitored. This will help determine the water quality parameters in the estuary which increase the susceptibility of oysters to QX disease. This should include monthly biotoxin assessments, fortnightly oyster meat assessments and assessments for QX disease. Oyster health data is currently collected routinely by NSW DPI and through a volunteer program managed by Ozfish. Consultation with these two groups will be necessary to determine cost sharing opportunities and if these assessments can be undertaken as part of the monitoring plan to ensure the monitoring is aligned to events.

The approximate valuation of the primary and commercial production provided in the accompanying scoping study indicates that the estimated costs of the monitoring program combined with the recommended studies are well below the potential annual primary and commercial productivity of the catchment. The CMP for North Creek aims to maximise the social, economic and environmental values within the catchment through evidence-based management. The benefit of this water quality monitoring plan will be that it provides the evidence to ensure that the management actions in this program are appropriately targeted. Without such information expenditure may be in the wrong areas and result in wasted investment that does not properly address the key issues.

Figure 2. *Recommended monitoring approach for the North Creek catchment.*

Table 4. A summary of the recommended sampling approach, for parameter details see Table 3

Sub-catchment	Easting	Northing	Sampling frequency
Cumbalum	554732	6808101	Monthly
Escarpment	554099	6814732	Monthly
Ballina Reserve	552350	6811736	Monthly
Ballina	554827	6819112	Monthly
East of Knockrow	552737	6819748	Monthly
North Creek 1	556198	6806504	Monthly & Event
North Creek 2	555696	6808643	Monthly & Event
North Creek 3	556011	6810149	Monthly
North Creek 4	555026	6815340	Monthly & Event
North Creek 5	555084	6818613	Monthly
North Creek 6	556192	6821535	Monthly & Event
Skennars Head	556768	6812951	Monthly

4 References

Atkins, M., Santos, I., Ruiz-Halpern, S., Maher, D. 2013. Carbon dioxide dynamics driven by groundwater discharge in a coastal floodplain creek, *Journal of Hydrology*

Aquatic Biogeochemical & Ecological Research (ABER) 2008. *Review of water quality data form the Richmond River Estuary* (Draft)

Hydrosphere Consulting, 2011, *Coastal Zone Management Plan for the Richmond River Estuary. Volume 2 Estuary Management Study*.

Morand DT, 1994, *Soil Landscapes of the Lismore-Ballina* 1:100,000 Sheet report, NSW Department of Land and Water Conservation, Sydney

Ryder, D., Mika, S., Richardson, M., Schmidt, J. and Fitzgibbon, B., 2015, *Richmond Eco health Project 2014: Assessment of River and Estuarine Condition*, University of New England, Armidale.

Seymour, J., Williams, N., Siboni, N., 2019, Microbial source-tracking in NSW coastal habitats, Climate Change Cluster, University of Technology Sydney, Sydney

Attachment AA
Rapid Catchment Assessment Tool

Rapid Catchment Assessment Tool

Introduction

In order to identify the potential hot spot areas contributing to water quality issues in North Creek, a Rapid Catchment Assessment Tool (RCAT) has been used to estimate loads from sub-catchment runoff for four pollutants (TSS, TN, TP and e.Coli). An overview of each pollutant is provided in Table 5. A total of 11 sub-catchments were determined based on land use, key geographic features and hydrological drainage.

Table 5 An overview of the four pollutants assessed in the RCAT modelling

Pollutant	What is it a measure of?	Catchment source?	Impact on estuary?
Total Suspended Solids (TSS)	TSS measures the amount of particulate matter suspended in the water column and usually associated with fine sediments. These can be both inorganic (sands, silts and clays) and organic (leaf litter, macroalgae, decaying vegetation).	The generation of particulate matter can happen anywhere in a catchment, but often higher levels are correlated with disturbance, such as land clearing and erosion of exposed soils, animal access in streams and also in-stream (bed and banks) erosion.	Higher TSS values (>10mg/L) can reduce light penetration into the water column and therefore limit the solar radiation received by bottom dwelling organisms, especially seagrasses. In addition, other pollutants, such as heavy metals and petroleum hydrocarbons can be adsorbed onto particulates and then become available once they enter estuaries.
Total Nitrogen (TN)	TN is a measure of the amount of nitrogen (a key nutrient for vegetation and other organism growth) available in both dissolved and particulate forms within the water column.	Typically nitrogen can be associated with both diffuse sources such as fertilisers, animal droppings, vegetation, but also point sources such as sewage treatment and overflows and industrial waste streams.	Nitrogen is an essential nutrient in ecosystems, but as for any nutrient, an oversupply can lead to excessive growth of vegetation and/or algae. This can then lead to “boom/bust” cycles where the excessive growth can die off, decay and re-release nitrogen back into the water column. This can then lead to depletion of oxygen in the water column causing fish death, bad odours and increased nutrient release from bottom sediments, further exacerbating the problem.
Total Phosphorus (TP)	As for TN, TP is a measure of both the dissolved and particulate forms of phosphorus in the water column.	Phosphorus sources can also be very similar to nitrogen, but in addition, it is present in many soils and dissolved phosphorus readily binds	Very much like nitrogen, excess phosphorus can lead to excessive growth of vegetation and algae, but in estuarine systems is usually not

		to particulate matter if present.	the limiting nutrient for growth (usually there is an excess, so growth will be more related to the amount of nitrogen present).
E. coli	Escherichia coli is an indicator organism of faecal contamination, but is non-specific so can indicate human or animal waste (it is found in the gut of warm blooded mammals). E. coli refers to a wide range of bacteria species, some of which can be harmful if ingested.	E. coli are a useful organism to indicate the presence of faecal contamination so sources can be related to sewage, septic tanks, onsite treatment plants, animals, birds and decaying matter.	Within estuaries, E. coli is always likely to be present, but in well flushed systems, levels are typically low. Higher levels usually mean that areas are not suitable for recreational purposes due to the risk of illness from ingestion of waters.

The RCAT tool uses the current proportions of different land use within each North Creek sub-catchment and applies per hectare loads for each land use based on previous studies, annual rainfall, and the estimated proportion of rainfall that leads to runoff from each land use category. The application of the per hectare loads from previous studies involves categorising land use types in North Creek into 19 functional units. These 19 units correspond to broad land use types which have been studied extensively and provide the data by which relative runoff loads can be estimated for North Creek.

For example, the Horticulture category consists of land use types such as 'tree nuts', 'perennial horticulture', 'abandoned land', 'tree fruits' and 'beverage and spice crops', and the Livestock category consists of 'native/exotic pasture mosaic', 'degraded land' and 'grazing native vegetation'. Given that this RCAT model utilises values from previous studies, it is only capable of assigning values to broadly similar land use types (i.e. Horticulture, Livestock Conservation etc) and cannot be used to estimate the contribution from component land-use categories.

An overview of the land uses in each sub-catchment was presented in Table 1. Different land uses result in varying pollutant generation processes. A table of the functional unit breakdown used in the RCAT modelling is provided in Table 6 and summary of each sub-catchment functional unit by percentage is provided in Table 7. The initial results below are shown in total pollutant load per sub-catchment and per hectare load for each parameter (E.Coli, TP,TN & TSS).

Table 6 Functional unit designation for the 2013 North Creek land use spatial layer (OEH 2018)

Functional Unit	North Creek Land Uses (2013)
Commercial	Services, Public Services
Conservation	Environmental forest plantation, National Park, Other conserved area
Horticulture	Sugar, Tree nuts, Perennial horticulture, Abandoned land, Tree fruits, Beverage and spice crops
Industrial	Landfill
Livestock	Native/exotic pasture mosaic, Degraded land, Grazing native vegetation, Poultry farms, Aquaculture
Peri urban	Rural residential with agriculture
Quarry	Quarries
Roads	Roads, Airports/aerodromes, transport and communication
Rural Residential	Farm buildings/infrastructure, Residential and farm infrastructure
Urban	Recreation and culture, Landscape, Urban residential

Vegetation	Residual native cover, Land under rehabilitation
Water	Reservoir/dam, Lake, River - intensive use, Ports and water transport, River, reservoir, Estuary/coastal waters, Sewage, Marsh/wetland

Table 7 A breakdown of the functional unit percentage for each North Creek sub-catchment.

Sub-catchment	Land use	%
Ballina	Urban	29%
	Livestock	20%
	Horticulture	13%
	Vegetation	9%
	Roads	9%
	Industrial	6%
	Commercial	4%
	Water	3%
	Peri Urban	2%
	Conservation	2%
	Landfill	1%
	Rural Residential	1%
	Sewage disposal ponds	1%
Broken Head	Livestock	44%
	Vegetation	26%
	Horticulture	25%
	Peri Urban	5%
	Roads	1%
Coopers Shoot	Livestock	53%
	Vegetation	19%
	Horticulture	15%
	Peri Urban	10%
	Roads	1%
	Quarry	1%
	Conservation	1%
East Ballina	Urban	38%
	Peri Urban	25%
	Vegetation	18%
	Conservation	8%
	Water	5%
	Commercial	3%
	Roads	2%
	Livestock	1%
East of Knockrow	Livestock	54%
	Horticulture	36%
	Rural Residential	9%
Lennox Head	Horticulture	32%
	Livestock	27%

	Vegetation	24%
	Peri Urban	9%
	Conservation	4%
	Roads	1%
	Urban	1%
	Commercial	1%
Nature Reserve	Conservation	39%
	Vegetation	32%
	Livestock	23%
	Horticulture	4%
	Quarry	2%
North Creek Upper	Horticulture	77%
	Livestock	18%
	Vegetation	5%
North of Ross Lane	Horticulture	46%
	Livestock	40%
	Peri Urban	9%
	Vegetation	2%
	Conservation	1%
	Quarry	1%
	Roads	1%
	Urban	1%
Skennars Head	Livestock	44%
	Vegetation	23%
	Peri Urban	22%
	Conservation	7%
	Urban	2%
	Sewage disposal ponds	1%
	Roads	1%
Suffolk Park	Vegetation	35%
	Livestock	33%
	Peri Urban	15%
	Horticulture	12%
	Conservation	4%
	Roads	1%

The RCAT approach aligns well with the current Office of Environment and Heritage (OEH) modelling, which highlights hot spot areas at the catchment level (Figure 3). Validation of the RCAT model results was undertaken using the EHMP data and indicates a reasonable level of accuracy, particularly when looking at relative rather than absolute values.

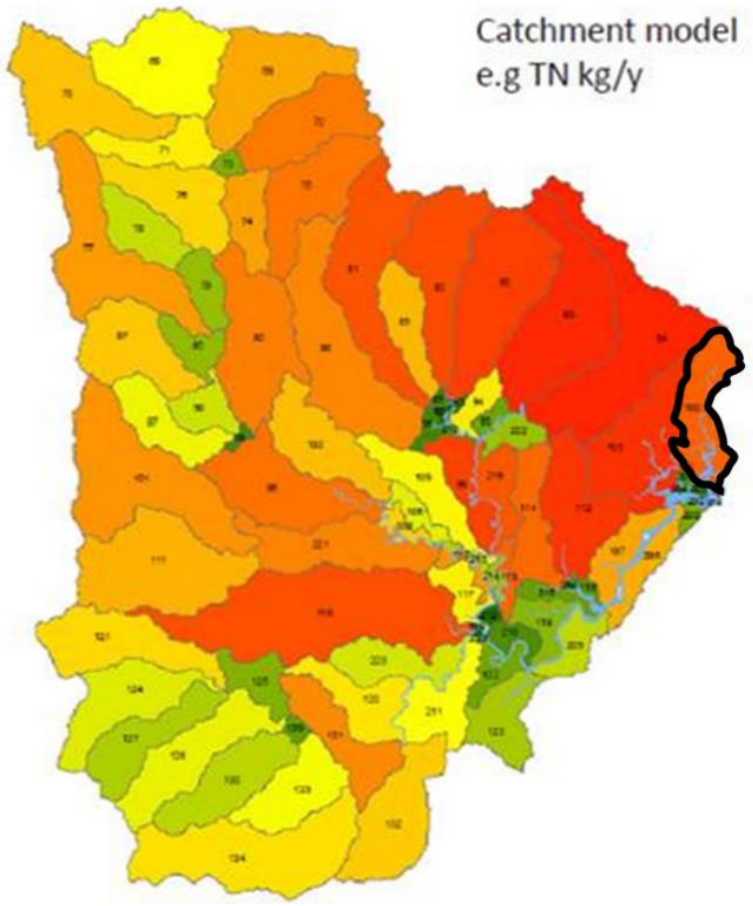


Figure 3 *Hotspot sub-catchments of the Richmond River based on OEH modelling of Total Nitrogen loads with the North Creek catchment highlighted in black.*

Results

E.coli loads

The RCAT model estimated that the greatest total E.coli load is generated within the East of Knockrow sub-catchment, while the highest load per hectare is shared between the East of Knockrow, North Creek Upper and North of Ross Lane sub-catchments (Figure 4). The relative size of the East of Knockrow sub-catchment when compared to the other two sub-catchments contributes to it yielding the greatest total load.

The relatively high E.coli load within these three sub-catchments is attributed to land use being predominantly livestock and horticulture. The load per hectare metric provides an indication of the land use intensity (Figure 4), while the total load indicates the yield from the sub-catchment which is partly governed by the catchment area (Figure 5).

The units used, mpn/y/ha, represent the most probable number (mpn) of viable microorganisms delivered into the waterway per hectare per year (Figure 4) and also in terms of total mpn per year (Figure 5). The RCAT model does not take into consideration the presence of the point source STP plants outlined in orange – as these are now Recycled Wastewater Treatment Plants (RWTP).

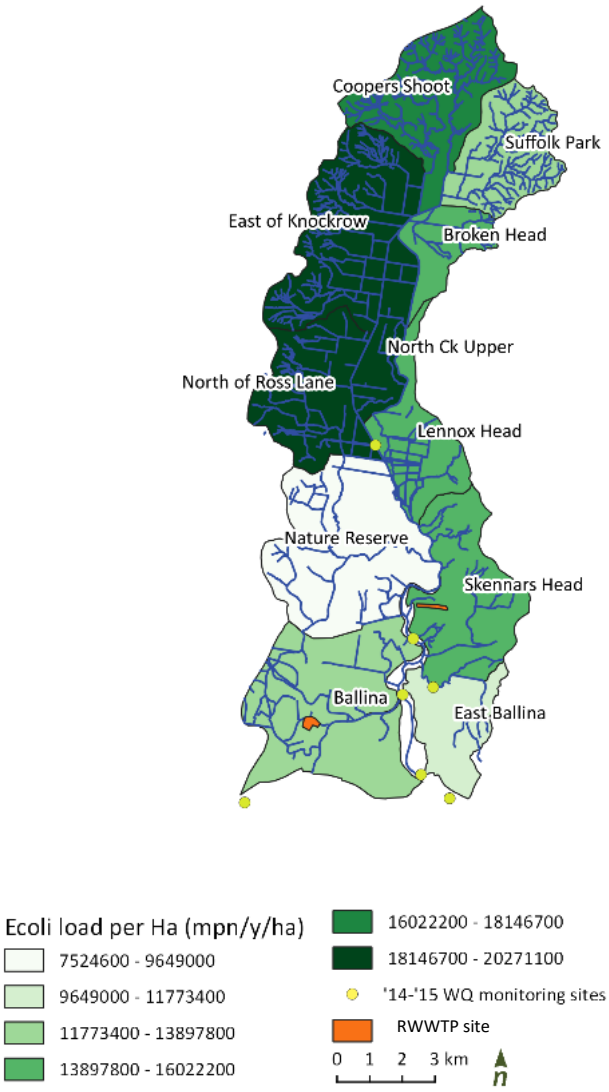


Figure 4 *Estimated E.coli loads in surface runoff per hectare per year for each sub-catchment*

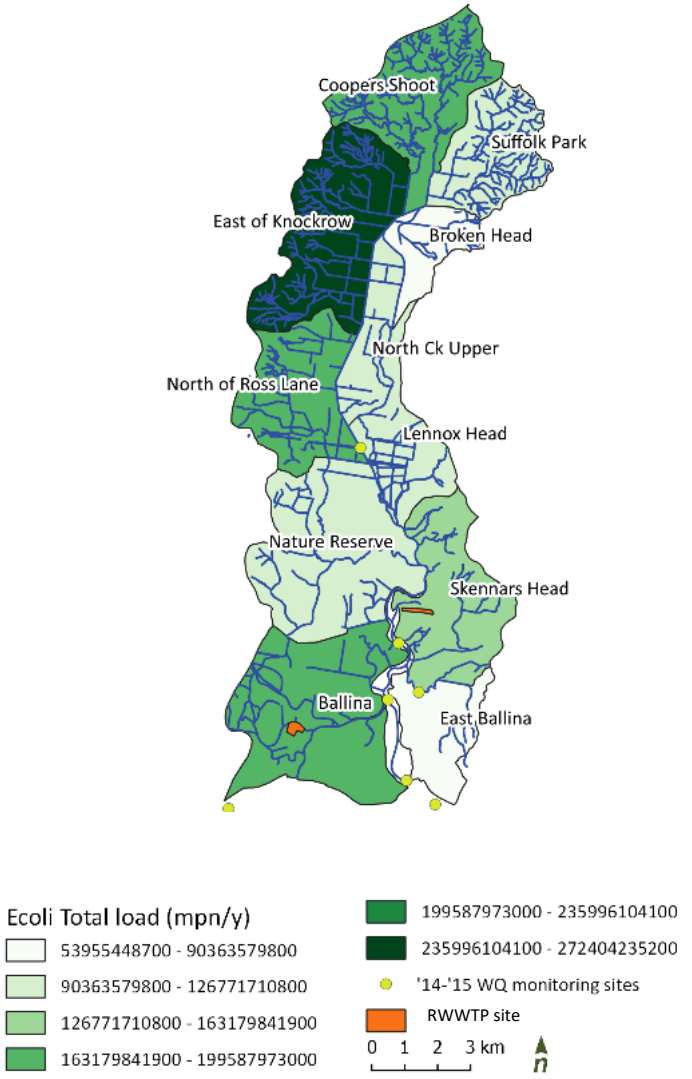


Figure 5 *Estimated total E.coli load from surface runoff per year for each sub-catchment*

Total Nitrogen Loads

Estimated Total Nitrogen (TN) loads for the North Creek catchment are presented in Figure 6 and Figure 7. Figure 6 presents TN loads in terms of kilograms per hectare per year. Figure 7 illustrates TN delivered into the waterway in terms of total kilograms per year.

The RCAT model estimates that the East of Knockrow sub-catchment yields the highest TN loads, with the highest load per hectare shared between the East of Knockrow, North Creek Upper and North of Ross Lane sub-catchments. Livestock and Horticultural land uses are the main contributors of TN in these sub-catchments.

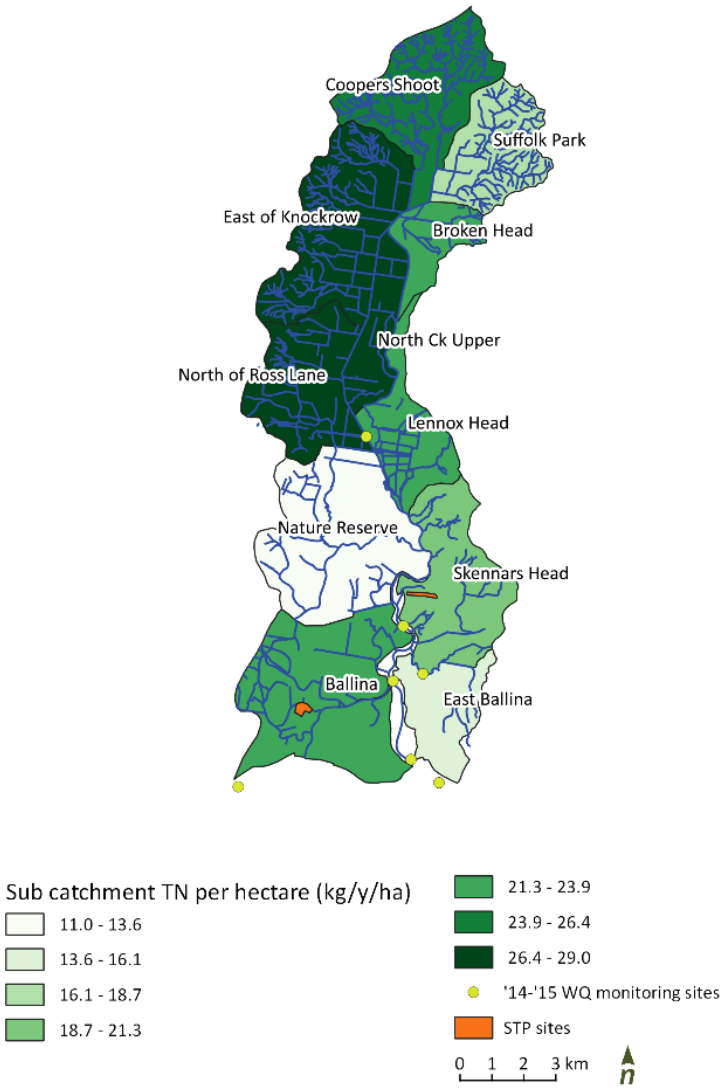


Figure 6 *Estimated total TN loads in surface runoff per hectare per year for each sub-catchment*

Figure 7. *Estimated TN loads in surface runoff per year for each sub-catchment*

The lack of TN discharging from the 'Nature Reserve' sub-catchment is due to the predominance of native vegetation cover in the land use layers despite the presence of urbanisation to the west of the sub-catchment (Ballina Heights/Kinarva). The reality however may be different to what the modelling suggests, as the modified drainage network within the sub-catchment is not considered in the RCAT model. This drainage network may facilitate or even inhibit the conveyance of stormwater and thus influence the attenuation of pollutants.

Total Phosphorus Loads

Estimated Total Phosphorus (TP) loads for the North Creek catchment are presented in Figure 8 and Figure 9. Figure 8 represent the TP delivered into the waterway in terms of kilograms per hectare of land per year. Figure 9 presents TP in terms of total kilograms per year.

It is estimated that the East of Knockrow and Ballina sub-catchments yield the highest TP loads, with North Creek Upper having a relatively high load per hectare given its small foot print and high concentration of Horticulture and Livestock.

All four upper sub-catchments (Coopers Shoot, East of Knockrow, North Creek upper and North of Ross Lane) are estimated to contribute relatively high TP loads. Ballina also contributed a relatively significant load in terms of both total load and per unit area. The dominant land uses for all five areas are Horticulture and Livestock.

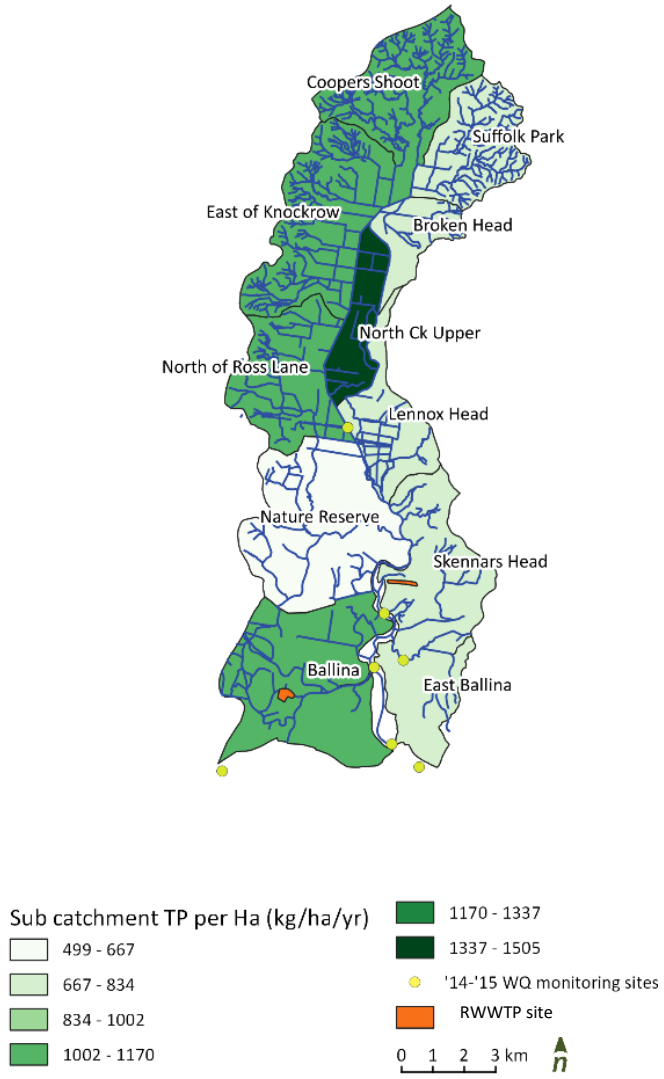


Figure 8 *Estimated TP loads in surface runoff per hectare per year for each sub-catchment*

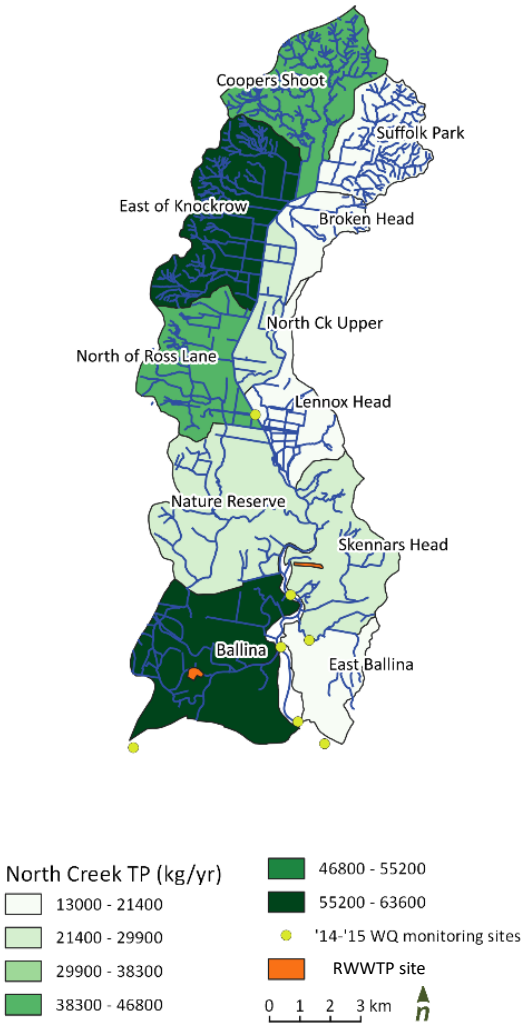


Figure 9 *Estimated total TP loads in surface runoff per year for each sub-catchment*

Total Suspended Sediments

Estimated TSS loads for the North Creek catchment are presented in Figure 10 and Figure 11. Figure 10 illustrates the TSS load delivered into the waterway in terms of kilograms per hectare of land per year. Figure 11 presents TSS in terms of total kilograms per year.

It is estimated that the Ballina sub-catchment yields the highest TSS loads annually and per hectare due to the dominance of urban development. Urban areas have hydraulically efficient drainage infrastructure which results in a high delivery ratio for sediments within the catchment. The upper catchments with primary and secondary land uses being livestock and horticulture are estimated to contribute the highest TSS loads in predominantly rural areas.

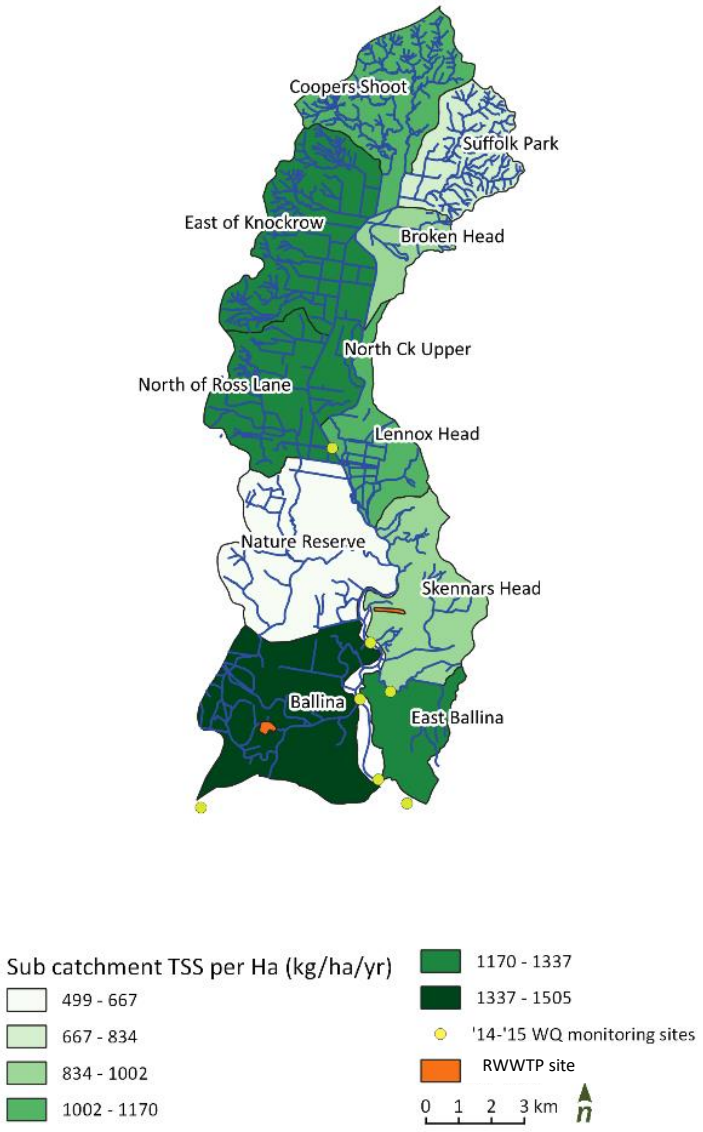


Figure 10 *Estimated TSS loads in surface runoff per hectare per year*

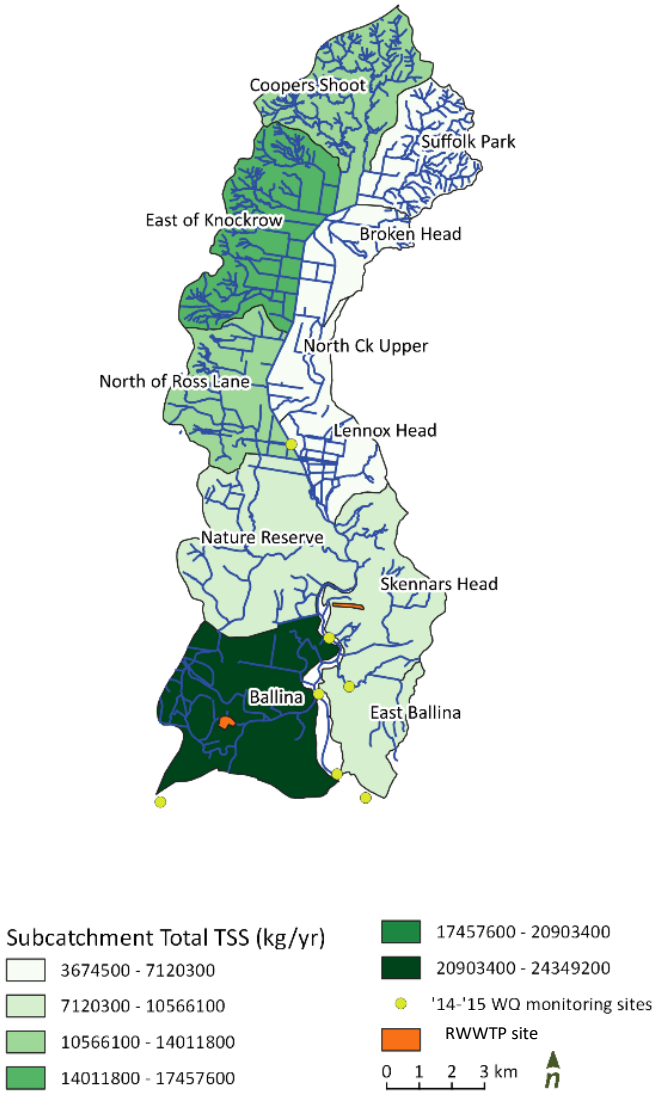


Figure 11 *Estimated total TSS loads in surface runoff per year for each sub-catchment*

Summary

There is significant observational data which suggests that agricultural and urban development, drainage works, and disturbance of ASS has degraded water quality within the North Creek estuary. However, to date there has been limited modelling or monitoring that helps determine the catchment drivers (and their spatial and temporal variations) of pollutant generation. The RCAT modelling helps identify likely risk areas for generation of four common pollutants, namely Total Phosphorus and Nitrogen (TP and TN), Total Suspended Solids (TSS) and E.Coli. The modelling indicates substantial nutrient generation (i.e. TN and TP) is likely to be occurring in the agricultural areas upstream of Ross Lane.

The role and interactions of ambient conditions and runoff events in the North Creek catchment are poorly understood. The RCAT modelling highlights the potential for significant pollutant generation during runoff events, though given a previous study has shown that groundwater sources are dominant, the relationship between surface runoff and groundwater contributions needs to be better defined. The extensive drainage works through the catchment has created predominately perennial waterways which interact with groundwater sources rather than just being conduits of surface runoff. Given that they have periods of low or no flow but still hold water, this allows for the processing of organic compounds which, in the presence of acidic water, can lead to anoxic or even anaerobic conditions.

Given the above, the North Creek WQMP should aim to determine where in the catchment poor water quality is being generated. If possible, the data collected should seek to inform a fuller picture of the reasons for and likely specific impacts of poor water quality, both spatially and temporally. It should also seek to identify the relative role of both groundwater and surface water discharges including the possible influx of acid discharge as a result of acid sulfate soils and/or acid soils.

Attachment BB
Estimated annual costs

Table 8 Estimated annual costs for water quality monitoring within North Creek.

	Samples in main stem of North Creek drainage	Samples in main stem of North Creek and representative sub-catchments	Sample in main stem of North Creek and all sub-catchments
Number of sites	6	11	17
Monthly regular monitoring (high priority parameters only)	$22,800	$31,800	$42,600
Monthly monitoring (all parameters)	$35,000	$63,000	$97,000
Monthly labour cost	$18,000	$24,000	$24,000
Max annual cost	$53,000	$87,000	$121,000
Min annual cost	$40,800	$55,800	$66,600
Bimonthly monitoring (high priority parameters only)	$11,400	$15,900	$21,300
Bimonthly monitoring (all parameters)	$18,000	$33,000	$48,000
Bimonthly labour cost	$9,000	$12,000	$12,000
Max annual cost	$27,000	$45,000	$60,000
Min annual cost	$20,400	$27,900	$33,300
Event monitoring cost (per event - high priority parameters)	$2,250	na	na
Event monitoring cost (per event - All parameters)	$3,200	na	na
Event monitoring labour cost	$2,000	na	na
Max Event monitoring cost (4 events pa- all parameters)	$20,800	na	na
Min event monitoring cost (2 events pa - high priority parameters)	$8,500	na	na
Analysis of results and report	$6,000	$8,000	$9,000
Max total cost per year	$79,800	$115,800	$150,800
Min total cost per year	$34,900	$44,400	$50,800

Ballina Shire Council have provided the costs for sampling based on 2018 information for the parameters identified
Costs for labour (sample collection) are estimated at $2000 per day assuming two people and vehicle/vessel costs.