ATTACHMENTS

COAST, ESTUARY & FLOODPLAIN ADVISORY SUB-COMMITTEE

Thursday 25 February 2021

PORT MACQUARIE HASTINGS COUNCIL

Coast, Estuary & Floodplain Advisory Sub-Committee Meeting

Thursday, 25 February 2021

Items of Business

PORT MACQUARIE HASTINGS COUNCIL

PORT MACQUARIE HASTINGS

JACOBS

North Brother Local Catchments Flood Study

Port Macquarie Hastings Council

Draft Floodplain Risk Management Study and Plan

Revision B

12 February 2020

IA157500

North Brother Local Catchments Flood Study

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Revision	Date	Description	By	Review	Approved
A	1/02/2021	Draft Floodplain Risk Management Study and Plan	L Chong	A Hossain	A Hossain
B	12/02/2021	Draft FRMSP with Council comments	L Chong	A Hossain	A Hossain

Contents

Foreword

The primary objective of the New South Wales Government's Flood Prone Land Policy is to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods, utilising ecologically positive methods, wherever possible. Under the Policy, the management of flood prone land remains the responsibility of local government.

The policy provides for a floodplain management system comprising the following five sequential stages:

1.	**Data Collection**	Involves compilation of existing data and collection of additional data
2.	**Flood Study**	Determines the nature and extent of the flood problem
3.	**Floodplain Risk Management Study**	Evaluates management options in consideration of social, ecological and economic factors relating to flood risk with respect to both existing and future development
4.	**Floodplain Risk Management Plan**	Involves formal adoption by Council of a plan of management for the floodplain
5.	**Implementation of the Plan**	Implementation of flood, response and property modification measures (including mitigation works, planning controls, flood warnings, flood preparedness, environmental rehabilitation, ongoing data collection and monitoring by Council

Port Macquarie Hastings Council is undertaking this study for the North Brother Local Catchments study area to investigate the existing and future flood risks in accordance with the NSW Government's *Floodplain Development Manual*. The study identifies and assesses potential flood mitigation options and guides land use planning and future development on the floodplain in the study area.

This study represents stages 1 to 4 of the management process and has been prepared for Council by Jacobs. This report is the Draft Floodplain Risk Management Study and Plan Report.

Executive Summary

Introduction

Jacobs was engaged by Port Macquarie Hastings Council (Council) to undertake a flood study and floodplain risk management study of the North Brother Local Catchments area. The study area is located on the Mid North Coast of NSW, and includes parts of the villages of Kew, Lakewood, West Haven, Laurieton and Deauville which are situated at the foot of North Brother Mountain. Development in the area has occurred in sometimes unsuitable locations as a result of poor drainage planning, leading to localised nuisance flooding on residential properties at a number of locations on a regular basis. Numerous gullies and watercourses drain from the North Brother Mountain through the developed areas, which over time have been piped, filled, crossed by road embankments or redirected, contributing to the existing flooding problems. Localised flooding in some areas may interact with and be exacerbated by mainstream flooding in Queens Lake, Stingray Creek and Camden Haven River.

This report is the Floodplain Risk Management Study and Plan (FRMSP) which defines the flooding behaviour and its impact on the community, identifies and appraises potential management measures to reduce existing and future flood risk. Based on the study findings, a list of prioritised measures for consideration and implementation by Council has been prepared. Note that this study focusses on overland flooding resulting from runoff from North Brother Mountain and surrounding areas. Riverine flooding is addressed separately in the Camden Haven and Lakes System Flood Study (Worley Parsons, 2013), prepared for Council.

Objectives of the study include:

- Develop and calibrate hydrologic and hydraulic models to estimate flooding conditions for a range of design events and for a climate change scenario.
- Identify flood problem priority areas and identify and assess structural and non-structural mitigation measures to manage flood risk.
- Review existing planning, policy and emergency management for gaps and inconsistencies relating to floodplain planning, then develop proposed amendments to address residual flood risk.
- Prioritise the works and measures, including economic and multi criteria appraisal of options.
- Develop an implementation program for recommended works and measures including timing, responsibility and sources of funding.
- Conduct consultation with the community and key stakeholders throughout the study to obtain information and intelligence for input into the study. Gauges the perceptions of the community on flooding matters. Obtain feedback on the findings and recommendations of the study.

Flood Behaviour

Overland flooding in the steeper parts of the study area, generally upstream of Ocean Drive and Bold Street, is typically a result of runoff from North Brother Mountain concentrating in natural gullies which discharge towards receiving waterways including Queens Lake, Stingray Creek, Camden Haven River and Watsons Taylor Lake. Issues arise when the gullies and flows encounter existing development, which in some instances at the larger gullies have considered the drainage conditions and provided substantial set-back from the gullies such that there is minimal interaction between floodwaters and development.

At most of the smaller gullies and flow paths, attempts have been made to manage the overland flows by use of diversion drains and underground drainage. The natural flow paths have mainly been filled in for development although shallow flow paths may have been retained. The diversion drains and drainage network have limited capacity so begin to surcharge and overflow in relatively frequent flooding events, causing flooding through properties and into buildings with substantial damage. In a number of locations the existing roads form the main flow path for floodwaters.

Most of the overland flow paths cross Ocean Drive and Bold Street, which traverse the foot of the Mountain. The cross drainage culverts are also limited in capacity and prone to blockage by flood debris including rocks

and vegetation, causing overflows over the road. These are two main roads in the study area and traffic is significantly impeded or roads become cut-off during floods. The roads are raised which results in ponding upstream of the road crossings.

The areas downstream of Ocean Drive and Bold Street are mainly low-lying and relatively flat. Development patterns have resulted in a number of low points being formed in roads and through properties, causing overland flows to pond to significant depths. In some areas attempts have been made to provide a continuous overland flow path to the receiving waterways, however, their capacity is also limited which causes hazardous flooding through roads and on properties. Underground and open channel drainage systems are present but are often exceeded. Drainage in these low-lying areas may also be impeded by high water levels in the receiving waters due to floods or storm surge, and mainstream flooding may also affect these areas. These issues are expected to worsen with climate change and sea level rise.

Historic Flooding

Overland flooding was experienced in numerous times in recent history, with events occurring in 2002, 2004, 2008, 2011, 2013, 2015 and 2016, among others. Dates of the reported events are listed below.

- 18 October 2004. 127mm recorded daily depth.
- 25 February 2008.112mm recorded daily depth.
- 24 April 2008 (10% AEP event). 49mm in 45 minutes; 65mm in 60 minutes; 136mm in 24 hours.
- 14 June 2011. 96mm recorded 2-day depth.
- 2 March 2013 (0.2EY) 61mm in 1.5 hours; 152mm in 24 hours.
- 5 January 2016 (20 – 50% AEP) 54mm in 1.5 hours.

Notable flooding reports are from locations including:

- Black Swan Terrace and Waterview Drive. Watercourse is piped through properties. The existing pipe inlet is undersized and the inlet debris screen regularly blocks. Overflows pass through residential yards, with paling fences washed away in previous floods.
- St Joseph's School, Laurieton. Video footage taken of significant flows along walkways between school buildings in the March 2013 event, which was a relatively frequent flood event.
- Ocean Drive. Flooding in numerous locations where a number of flow paths draining off North Brother Mountain cross this main road through the study area. Significant amount of cobblestones and other debris washed from watercourses and deposited on road.
- Flooding to depths of up to 1m in low points in roads at a number of locations in the study area. This was reported at Lilli Pilli Close, Sirius Drive, Mahogany Close and Honeysuckle Avenue, Lakewood; and Pelican Court, West Haven, among others.
- Flooding through Laurieton town centre including Bold Street, Lake Street and Tunis Street.

Flooding at a number of other locations has also been observed in the past.

Assessment of Existing Flooding

Flooding behaviour was defined based on numerical modelling of hydrology and hydraulics, estimating catchment flood flows and the flooding patterns and behaviour. Modelling was undertaken in DRAINS software (hydrology) and TUFLOW software (hydraulics), as documented in the North Brother Local Catchments Flood Study – Final Flood Study Report (Jacobs, 2020).

Overland flow depths on properties are typically up to 0.3m in up to the 1% AEP event. Depths exceed 0.5m in a number of locations in frequent floods such as the 0.2EY event, and exceed 1m in the 5% and 1% AEP events. Areas of deeper flows include main flow paths and drainage low points in a number of roads.

During the PMF event, property and road flooding exceeding 0.5m depth is widespread, with property and road flooding of 1m depth also common. Depths of flooding exceeding 2m occur on approximately 20 properties in the study area.

Overland flooding in the study area is generally a result of intense short-duration rainfall events. As a result, the duration of inundation of roads and built areas is typically short, limited to 1 – 2 hours in up to the 0.5% AEP event. Storage areas such as road sag points in Sirius Drive and Lilli Pilli Close in Lakewood may be inundated for longer durations of up to 3 hours due to constrained capacity of stormwater drainage servicing these areas. Durations of inundation are likely to be up to 4 hours in the PMF event particularly in some flood storage locations, affecting roads including Botanic Drive and Ocean Drive west of Lakewood shopping centre.

A river flooding event may occur shortly after overland flooding in the study area, in which case the low-lying areas of the study area may experience more extensive durations of flooding. River flooding was not assessed in this study.

Flood hazard mapping has been prepared based on the flood modelling outputs to outline safe and unsafe flooding conditions for pedestrians, vehicles and buildings. Flood hydraulic category mapping has also been prepared to describe areas of floodway flows and flood storages, and which will be used to administer development controls by Council depending on the flood behaviour at properties.

Impacts to the Community

The number of buildings affected by above-floor flooding is summarised in Table 1.

Table 1 Number of buildings with above-floor flooding

Event	Residential	Commercial/Non-Residential
0.2EY	161	10
5% AEP	222	16
2% AEP	380	27
1% AEP	492	31
PMF	1,616	83

Above-floor flooding is expected to incur significantly greater flood damages to the building and contents compared to yard (i.e. below floor level) flooding. Figure 5-2 indicates the spatial distribution of properties with above-floor flooding and their relative vulnerability, with properties affected in frequent events such as the 0.2EY event being more vulnerable than those affected only in rarer events such as the 1% AEP event.

A count of properties with very high hazard flooding conditions at the dwelling was undertaken based on the flood hazard mapping, with the review identifying 19 residential properties with a very high flood hazard rating in the 1% AEP event, whereby damage to the building may result due to floodwaters.

Sensitive properties and critical infrastructure have been identified in the catchment. Certain types of properties may require specific evacuation considerations due to the vulnerability of their occupants, such as schools and pre-schools, and aged care facilities. Critical infrastructure impacted by flooding may have effects on the recovery and functioning of the community following a flood event. A number of these properties are affected by high hazard and floodway areas in the 1% AEP event.

Flood damages in the study area is primarily attributed to residential dwellings that are impacted by overland flooding. The flood damages estimates were based on properties selected based on their impact from main areas of flooding, and excludes those affected by localised minor ponding. The residential AAD for the study area is $17.6 million. The non-residential AAD is $1.9 million.

There are 523 residential and non-residential properties that are estimated to experience above floor flooding (not protection level) for the 1% AEP event. In the PMF, 1,699 properties are estimated to experience above floor flooding.

Review of Existing Emergency Planning

The existing local emergency planning arrangements in the study area were reviewed. There is currently no specific flood warning system for flash flooding in the study area. Emergency response and evacuation considerations were reviewed.

Flooding in the study area may generally be considered to be flash flooding in nature with rapid rates of rise, fast catchment hydrologic response, no warning time and short durations of flooding. The study area is interspersed with flow paths which pass through properties and run along roads. Access in and out of flooded properties via these roads during a flood event may be hazardous and pose a risk to residents if they attempt to evacuate to offsite flood-free refuges.

Local evacuation, whereby residents observe flooding and respond by moving to higher ground, may be feasible although it requires awareness of the flooding conditions and flood-free zones. There is also risk of a flood occurring during night time during which the residents may not be awake to observe and respond to flooding.

Given the minor and generally short duration of flooding in the study area in most cases it would be appropriate for residents to shelter in place in the dwelling, although it needs to be recognised that a number of properties may not be suitable in the PMF event due to very high flood hazard.

Assessment of Flood Risk Management Measures

A range of non-structural flood risk management measures were assessed for suitability. Property modification measures reviewed included voluntary house purchase and voluntary house raising but were not considered suitable. Council redevelopment of high hazard properties, as an alternative to voluntary house purchase, has been flagged as a potential option for further consideration by Council. Flood proofing and flood compatible design of properties should be promoted.

Amendments to planning instruments and controls (LEP, existing Flood Policy) were also investigated and recommendations made regarding these measures. A new Overland Flood Policy is recommended to be developed to allow greater flexibility for Council in administering appropriate development controls which are better aligned with overland flooding. Response modification measures which are recommended included flood depth signage on roads, updates to emergency management and planning and flood education and awareness. Development of a flash flood warning system for the study area was considered but is not recommended. Assisting flood-affected sensitive properties with developing a flood management plan is recommended to improve planning and management procedures for flood events.

A number of flood modification options were initially identified from the TUFLOW model results and short-listed in consultation with Council with consideration of the likely improvements to flood behaviour, site constraints, environmental and community benefits and impacts, opportunities for multi-functionality and constructability. The short-listed options include:

- Option 4B – Koonwarra Street to Pelican Court, West Haven drainage upgrades
- Options 6A – Tunis Street flow path flow diversion
- Options 6B-6E – Tunis Street flow path new trunk drainage
- Option 8B – Lake Street culvert crossing debris control structure
- Options 9B – St Joseph's School trunk drainage.

Option 4B and 9B are recommended as High priority options. Option 6B-6E and Option 8B are rated as Medium priority. Option 6A, while providing significant flooding improvements, resulting in worsening of flooding in other

problem areas, and with consideration of likely difficulties in approvals and implementation, was excluded as a recommended option.

Draft Floodplain Risk Management Plan

The Draft Floodplain Risk Management Plan, which outlines an implementation program for the proposed measures, is provided in Table 2. The Plan can be progressively implemented with an anticipated timeframe of 3-5 years for high priority options and 5-10 years for medium priority options. Estimated costs and responsibilities for implementation are indicated. The timing of the proposed works will be dependent on Council's overall budgetary commitments and the availability of funding from external sources. The status remains "Draft" until adoption by Council.

Council and the Flood Risk Management Committee are to provide feedback on the Draft Plan, prior to update and community consultation on the Draft Plan and subsequent adoption of the Draft Plan by Council. Community consultation including public exhibition is to be undertaken on the Draft FRMSP prior to adoption of the Final Plan by Council.

Table 2 Draft Floodplain Risk Management Plan

ID	Measures considered	Responsibility	Initial Cost	Ongoing Cost	Features of the Measure	Recommended Priority Rankings
FM1	**Option 9B** St Joseph's School, Laurieton	Council. Possible co-funding contribution from School	$2,781,000	Council maintenance costs	• Install 2x 3m x 1.2m box culvert in the middle flow path through the School, including upgrade of Ocean Street culvert crossing. Inlet rock debris trap basin required	**High**
FM2	**Option 4B** Koonwarra Street to Pelican Court, West Haven	Council	$2,787,000	Council maintenance costs	• New additional trunk drainage line 2x 2.1m x 1.2m box culverts, intercepting flows at downstream end of channel on Captain Cook Bicentennial Drive villas, cross Ocean Drive and run under The Gateway. Inlet debris trap basin required. • Reprofile grassed verge of access road stub to increase surface outflow capacity from Pelican Court sag	**High**
FM3	**Option 6B – 6E** Tunis Street Overland Flow Path, Laurieton	Council	$12,043,000	Council maintenance costs	• Increase existing diversion channel capacity behind Blackbutt Crescent properties. Widen and remove/maintain vegetation • Construct new diversion channel behind Peach Grove properties north of Tunis Street • Install new 3 x 1.35m trunk drainage line from the easement down Tunis Street to discharge to the river (approximately 740m). Inlet debris trap basin required. • Upgrade and extend drainage in Gow Place to 1.05m dia pipe. Upgrade pit inlets. Install new 900mm pipe connection from the gully to the new trunk drainage line. • Feasibility study is recommended to investigate constructability, constraints and opportunities in greater detail.	**Medium**

ID	Measures considered	Responsibility	Initial Cost	Ongoing Cost	Features of the Measure	Recommended Priority Rankings
FM4	**Option 8B** Lake Street at Seymour Street, Laurieton	Council	$21,000	Council maintenance costs	• Install debris control structure at existing or proposed upgraded culvert inlet	**Medium**
PM1	LEP amendments	Council	Staff costs	N/A	• Amendment of LEP 2011 to include the North Brother local catchments flood mapping on the LEP Flood Planning Map. The current flood prone land mapping and flood planning area mapping does not include this study area. • Further review and refinement of the Overland Flood Planning Mapping may be undertaken by Council prior to adoption and implementation. • The Section 10.7 certificates are recommended to provide flood information for properties such as flood levels and flood planning levels across the lot, in addition to the flood hazard and hydraulic categories present on each lot.	**High**
PM2	Flood Policy Amendments and new Overland Flood Policy	Council	Staff costs	N/A	• A new Overland Flood Policy is recommended to be developed to provide greater flexibility for Council to administer development controls which are better tailored for areas affected by overland flooding only. The Overland Flood Policy would apply to areas where an overland flood study has been adopted, and any other areas deemed applicable by Council. The flood mapping prepared in this North Brother Local Catchments Flood Study including Overland Hydraulic Categories mapping and FPL1 – FPL4 mapping, including should be referenced by the Overland Flood Policy as appropriate.	**High**

ID	Measures considered	Responsibility	Initial Cost	Ongoing Cost	Features of the Measure	Recommended Priority Rankings
					• The Flood Policy should be updated to reference the Overland Flood Policy. • Both flood policies should state that both the mainstream and overland flooding conditions need to be considered for development and re-development of properties. • Design flood events are referred to in the Flood Policy in terms of Average Recurrence Interval (ARI) which is not in line with current floodplain management best practice of referring to events by Annual Exceedance Probability (AEP). Update to the Flood Policy should include reference to AEP terminology and/or definitions on conversion in its glossary (i.e. 5% AEP = 20 year ARI, and 1% AEP = 100 year ARI). • Consider incorporation of the ARR 2019 flood hazard categorisation system into the Flood Policy to reflect the current best practice in defining flood hazard conditions. • "High flood hazard" could be considered as H3 or higher hazard (ARR 2019 hazard categories). The lower threshold for H3 hazard is similar or slightly lower than the high and transitional hazard categories in the Floodplain Development Manual method.	

ID	Measures considered	Responsibility	Initial Cost	Ongoing Cost	Features of the Measure	Recommended Priority Rankings
PM3	Scoping study on a voluntary house purchase/ voluntary redevelopment scheme for very high flood hazard properties	Council	Staff costs	$0K	• Further investigation on feasibility of a voluntary purchase / voluntary redevelopment scheme for very high flood hazard (H5 rating and higher) properties. The scoping study should investigate community interest (affected residents), opportunities and constraints (funding, technical, administrative etc) • Council to investigate and develop resolution of the identified policy and probity issues related to a voluntary redevelopment scheme. • Voluntary redevelopment scheme is to recommend engineering and economic assessments be undertaken for flood-durable development designs to determine feasibility. • Include development controls such as provision of floor levels above PMF level and flood-free emergency access for such developments. • Being a voluntary scheme, current residents may not be in favour of participating.	**Low**
RM1	Develop flood management plan for selected sensitive properties	Council (advocacy only), property operator (funding and implementation), SES (advice)	Cost to be borne by property operator	N/A	• Council should consider consultation with operators of sensitive properties (schools, pre-schools and retirement villages) affected by high hazard flooding regarding management of flood risk on the site. Development of a flood management plan for the sites should be considered. • The plans should contain procedures for monitoring weather and warnings and evacuation of occupants to flood-safe spaces within the property if possible. • Emergency and evacuation procedures shall include a flood risk management procedure.	**High**

ID	Measures considered	Responsibility	Initial Cost	Ongoing Cost	Features of the Measure	Recommended Priority Rankings
RM2	Update of Local Flood Plan	SES	Staff costs	N/A	• It is recommended that Port Macquarie Hastings EMPLAN be updated based on the findings of this study, including intelligence on flood behaviour, impacted and sensitive properties, affected roads etc.	**High**
RM3	Development of flood education and awareness program	Council, SES	$20K	Staff costs	It is recommended that Council develops a flood education program to promote flood awareness and readiness in the community. Measures may include: • Promotion of FloodSafe brochures to help residents understand the flood risk and prepare their property and personal plans for a flooding event. • Promotion of flood proofing measures should also be included in flood education and awareness programs • Section 10.7 certificates to inform property owners about flood risk to their properties • Provide flood mapping on an interactive mapping portal on Council's website for easier viewing • Promotion and support for SES information events • Enhanced messaging on flood risk on Council's floodplain management webpage. The program should be reviewed on a regular (e.g. 5 yearly) basis or after each major flood event.	**Medium**

ID	Measures considered	Responsibility	Initial Cost	Ongoing Cost	Features of the Measure	Recommended Priority Rankings
RM4	Road flood depth signage	Council	$5K per location, five locations	$0K	Install new flood depth signage at selected locations: • Ocean Drive 70m east of Sirius Drive • Ocean Drive 380m east of Fairwinds Avenue • Ocean Drive 30m east of The Gateway • Bold Street sag between Laurie Street and Mill Street • Bold Street sag between Mill Street and Hanley Street.	**High**

Important note about this report

The sole purpose of this report and the associated services performed by Jacobs is to undertake a flood study and prepare a floodplain risk management study and plan for the North Brother Local Catchments study area located in New South Wales in accordance with the scope of services set out in the contract between Jacobs and Port Macquarie Hastings Council (the Client). That scope of services, as described in this report, was developed with the Client.

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the Client and/or from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

Jacobs derived the data in this report from information sourced from the Client, third parties, and/or available in the public domain at the time or times outlined in this report. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report. Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

This report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by Jacobs for use of any part of this report in any other context.

Topographic data used in this study included that sourced from a LiDAR survey and ground survey which were undertaken by third parties. Undertaking independent checks on the accuracy of the data was outside Jacobs's scope of work for this study.

This report has been prepared on behalf of, and for the exclusive use of, Jacobs's Client, and is subject to, and issued in accordance with, the provisions of the contract between Jacobs and the Client. Jacobs accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

1. Introduction

1.1 General

Jacobs was engaged by Port Macquarie Hastings Council (Council) to undertake a flood study and floodplain risk management study of the North Brother Local Catchments area. The study area is located on the Mid North Coast of NSW, and includes parts of the villages of Kew, Lakewood, West Haven, Laurieton and Deauville which are situated at the foot of North Brother Mountain. Development in the area has occurred in sometimes unsuitable locations as a result of poor drainage planning, leading to localised nuisance flooding on residential properties at a number of locations on a regular basis. Numerous gullies and watercourses drain from the North Brother Mountain through the developed areas, which over time have been piped, filled, crossed by road embankments or redirected, contributing to the existing flooding problems. Localised flooding in some areas may interact with and be exacerbated by mainstream flooding in Queens Lake, Stingray Creek and Camden Haven River.

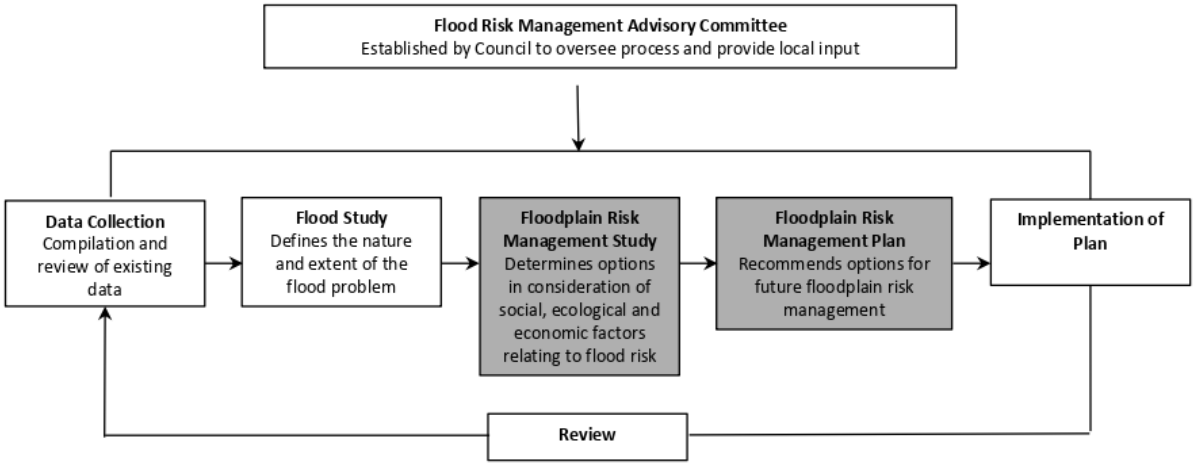
This report is the Floodplain Risk Management Study and Plan (FRMSP) which defines the flooding behaviour and its impact on the community, identifies and appraises potential management measures to reduce existing and future flood risk. Based on the study findings, a list of prioritised measures for consideration and implementation by Council has been prepared. Note that this study focusses on overland flooding resulting from runoff from North Brother Mountain and surrounding areas. Riverine flooding is addressed separately in the Camden Haven and Lakes System Flood Study (Worley Parsons, 2013), prepared for Council.

1.2 Floodplain Risk Management

Council is responsible for managing the existing, continuing and future flood risk for its Local Government Area (LGA). The floodplain risk management planning process, as set out in the *Floodplain Development Manual* (NSW Government, 2005) has a number of steps which are illustrated in Figure 1-1.

The Floodplain Risk Management Advisory Committee for Council was established in 2018 and includes a number of Council Representatives, staff from the Department of Planning Industry and Environment (DPIE, formerly Office of Environment and Heritage), the NSW State Emergency Services (SES), in addition to local stakeholders including community representatives.

Figure 1-1 Floodplain Risk Management Process



1.3 Purpose of this Study

Objectives of the study include:

- Develop and calibrate hydrologic and hydraulic models to estimate flooding conditions for a range of design events and for a climate change scenario.
- Identify flood problem priority areas and identify and assess structural and non-structural mitigation measures to manage flood risk.
- Review existing planning, policy and emergency management for gaps and inconsistencies relating to floodplain planning, then develop proposed amendments to address residual flood risk.
- Prioritise the works and measures, including economic and multi criteria appraisal of options.
- Develop an implementation program for recommended works and measures including timing, responsibility and sources of funding.
- Conduct consultation with the community and key stakeholders throughout the study to obtain information and intelligence for input into the study. Gauges the perceptions of the community on flooding matters. Obtain feedback on the findings and recommendations of the study.

1.4 Structure of this Report

This Draft Floodplain Risk Management Study and Plan (FRMSP) report is structured accordingly:

- Section 2 Study Area – Summary of the physical setting, history of flooding and social, environmental and heritage aspects of the catchment.
- Section 3 Flood Policies and Planning Controls – Summary of relevant State and local government policies and planning framework.
- Section 4 Community Consultation – Summary of consultation activities undertaken for the study.
- Section 5 Existing Flood Environment – Describes flood behaviour and flood hazard. Impacts of flooding on the community including identified flooding locations and high hazard properties, sensitive properties, flood damages.
- Section 6 Local Emergency Planning Context – Overview of existing flood emergency planning, flood warning systems, evacuation and emergency access considerations.
- Section 7 Floodplain Risk Management Measures – Overview of general types of management measures. Identifies, reviews and assesses structural flood mitigation options including hydraulic performance, cost-benefit and multi-criteria analysis.
- Section 8 Non-Structural Measures – Identifies, reviews and assesses non-structural management measures including property, planning and response modification measures.
- Section 9 Draft Floodplain Risk Management Plan – A proposed plan of implementation for recommended floodplain risk management measures.
- Section 10 References – Literature cited in this report.
- Section 11 Glossary – Definition of terms used in this report.

2. Study Area

2.1 Catchment Description

The study area is shown on Figure 2-1 and generally comprises the northern and eastern faces of the North Brother Mountain and the associated urban areas between the foot of the mountain and the adjoining receiving waters.

The study area has an approximate area of 1,852ha, with the North Brother Mountain extending to a height of 490m AHD, dominating the landscape. The terrain is shown on Figure 2-2. The upper reaches of the study area is predominantly the Dooragan National Park, containing the North Brother Mountain itself, below which is situated the Laurieton CBD, various vegetated natural gullies and flow path as well as significant established low and medium density residential, caravan parks and holiday accommodation precincts.

From the North Brother Mountain, stems a number of small, steep and unnamed local catchments which discharge to one of the many waterways surrounding the mountain:

- On the north side of North Brother Mountain is Queens Lake,
- On the east is the Pacific Ocean,
- To the south is Watson Taylors Lake (through which Camden Haven River flows), and
- On the west is the Camden Haven River

The topography within the catchment varies significantly with the upper parts of the catchment being very steep in nature (grades of up to 50%), the mid zone is moderately graded (slopes in the order of 10-15%), and lower areas adjoining the Camden Haven River floodplain being reasonably flat (grades averaging 5%).

Ground cover within the study area also varies considerably and is generally varied in accordance with slope changes. The upper portions of the catchment are heavily forested, with the mid and lower areas consisting of lawns, residential gardens, pavements and roof areas. The relatively short flow path lengths between the foot of the North Brother Mountain and the adjoining downstream receiving waters mean that stormwater flows are characteristically high energy and fast flowing.

The study area experiences overland flooding originating from North Brother Mountain runoff, while areas at lower elevations are also at risk from riverine flooding from the Camden Haven River and lakes system.

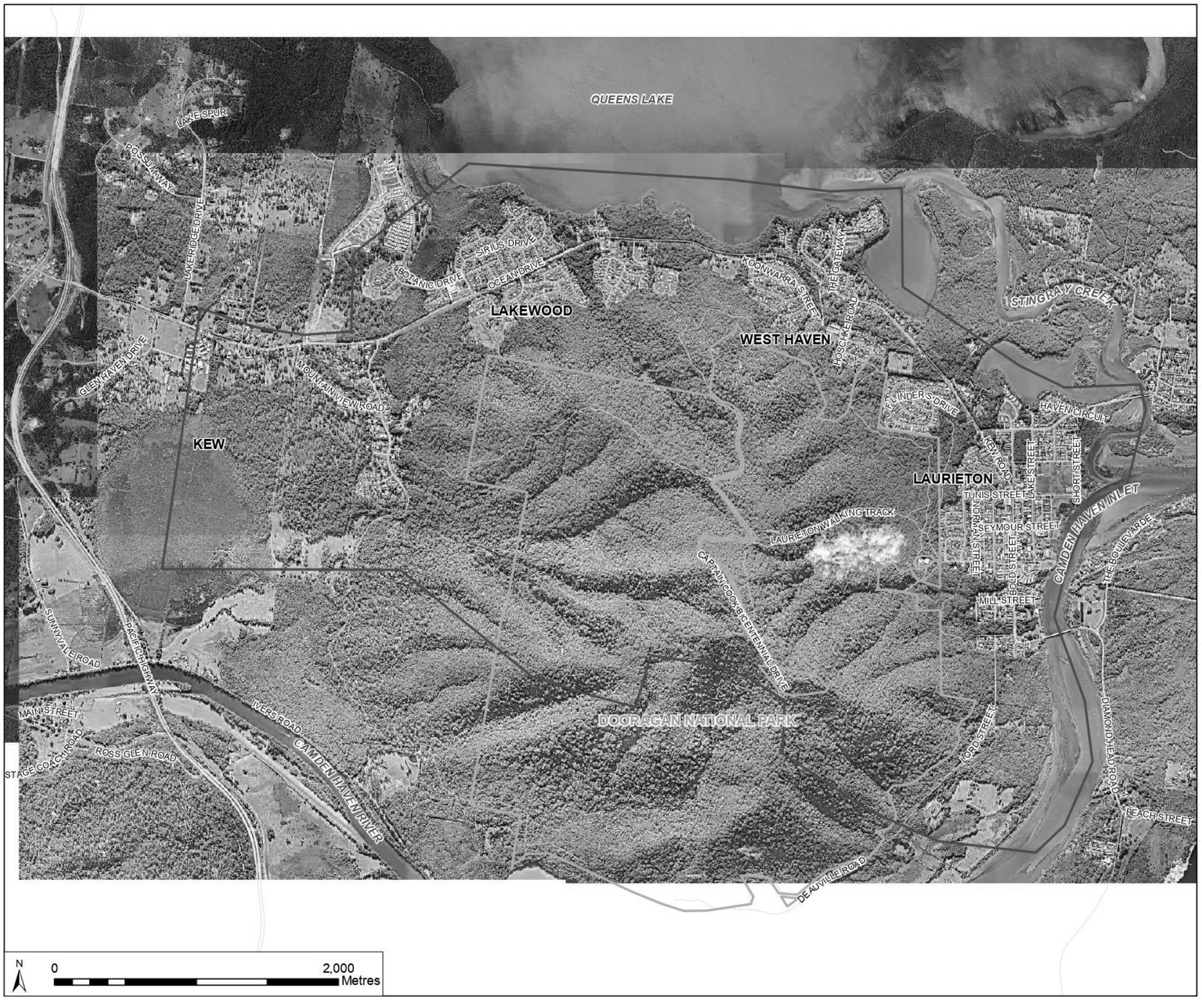
2.2 Existing Land Use and Development

Development of the study area has been occurring from the early 1900's through to the present day with the majority of development having occurred between 1970 - 2000. The construction of associated drainage infrastructure has also primarily dated from this time, with the result being that the majority of watercourses stemming from the North Brother Mountain have either been built over, filled, redirected, piped or crossed by road embankments, often resulting in urban development occurring in unsuitable locations.

Urban development at the foot of the North Brother Mountain is typically bounded by diversion drains and largely natural gullies which direct the large volumes of stormwater runoff generated safely around developed lands and into the downstream waterways. However as mentioned above, development has occurred in some location in close proximity to natural watercourses and man-made surface drainage and is at risk to flooding when the drainage capacity is exceeded.

Development in the study area is predominantly low-density residential, with some higher density developments located in West Haven and Laurieton, including retirement villages. Residential development is ongoing, notably in parts of Lakewood. Commercial areas are located in Lakewood and Laurieton.

Refer to the land use zoning map on Figure 2-3.



Legend

- Study Area
- National Park

GDA 1994 MGA Zone 56
Scale: A3

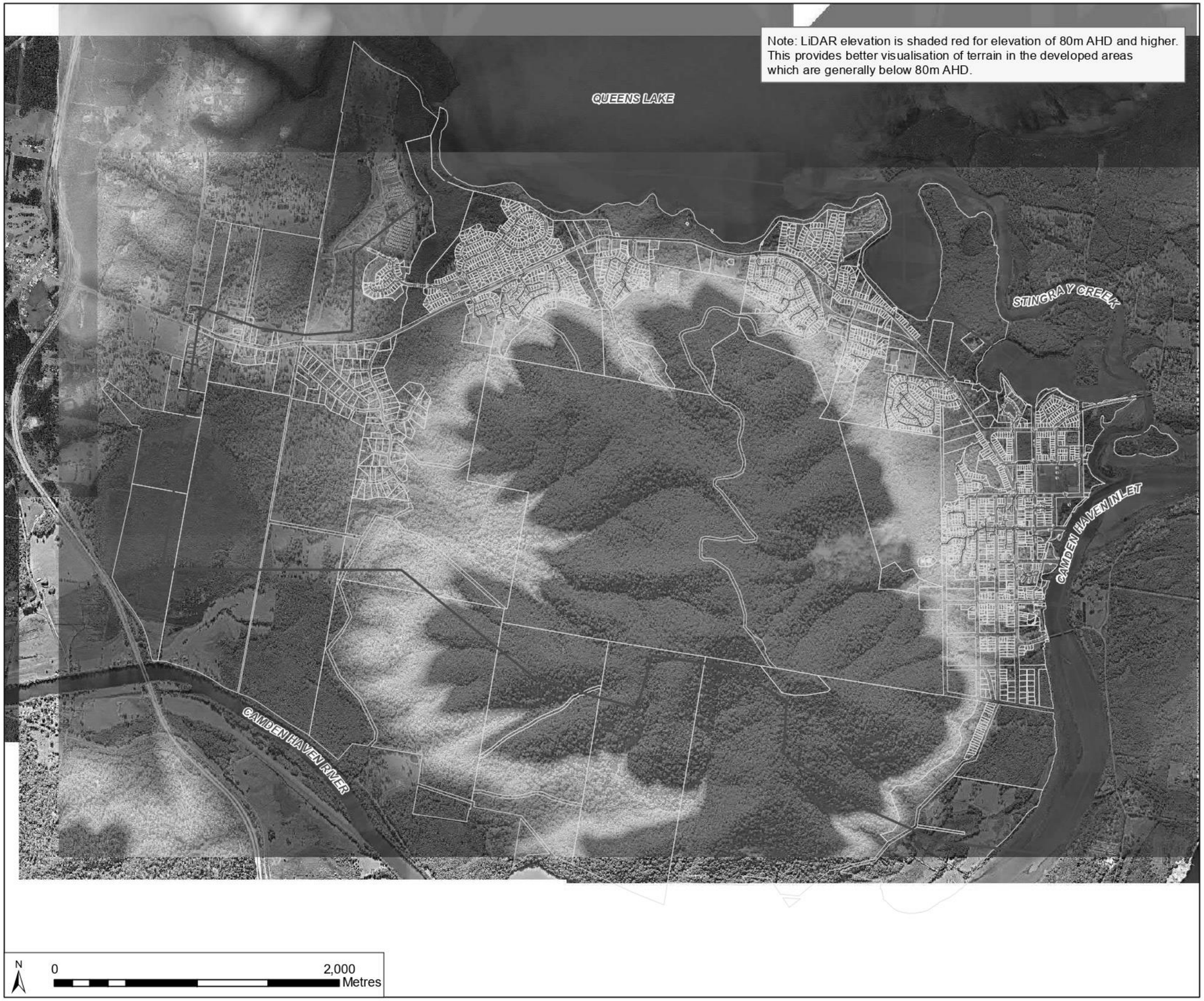
Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	Study Area
PROJECT	North Brother Local Catchments Flood Study
PROJECT #	IA157500
DATE	25/08/2017

FIGURE 2-1



Legend

LiDAR Elevation (m AHD)

High : 80

Low : 0

Culverts

StormwaterPipe

StormwaterPit

Study Area

GDA 1994 MGA Zone 56
Scale: A3

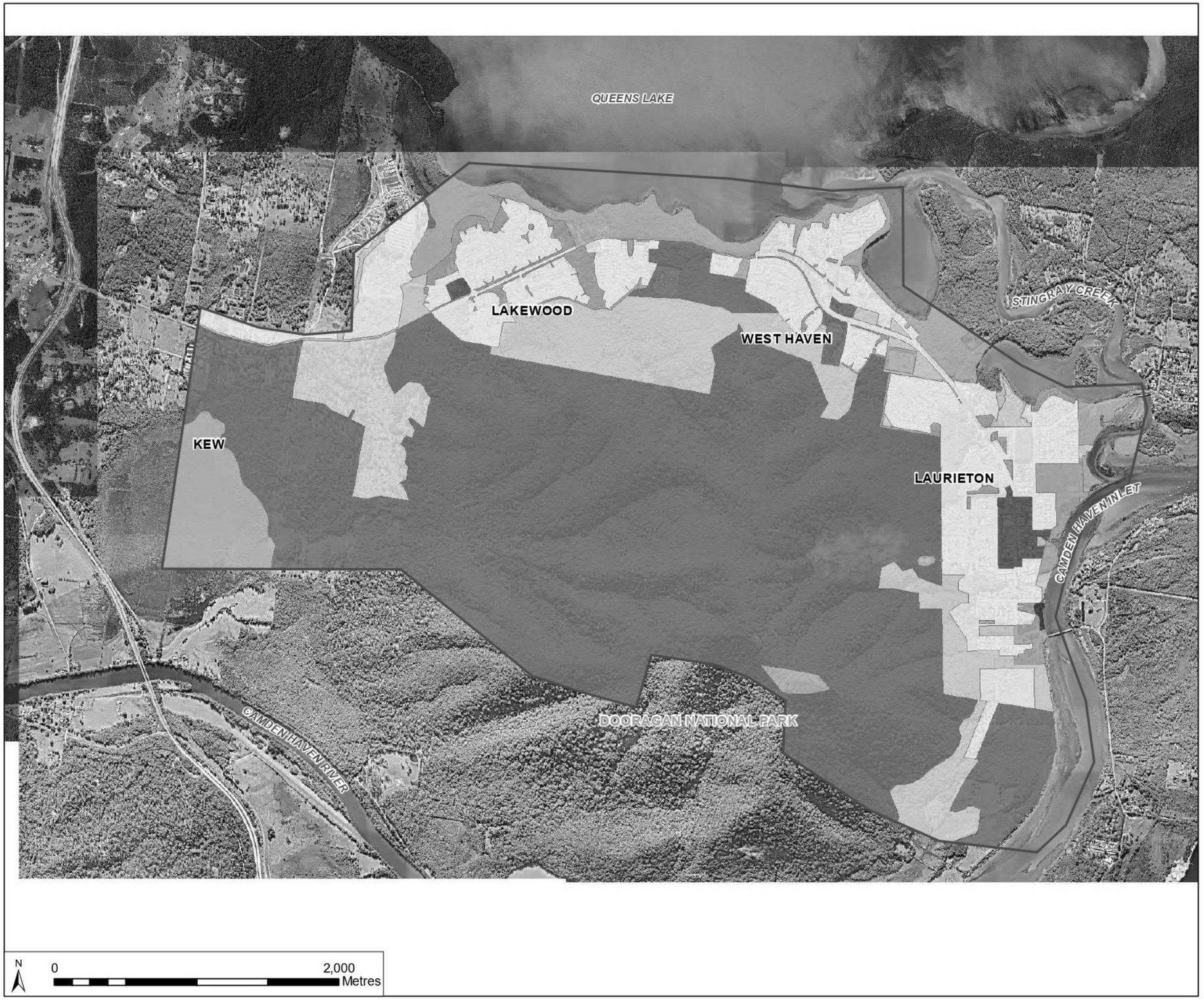
Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	Terrain and Drainage
PROJECT	North Brother Local Catchments Flood Study
PROJECT #	IA157500
DATE	28/01/2021

FIGURE 2-2



Legend

- Study Area

Land Use Zone

- B2 - Local Centre
- B4 - Mixed Use
- E1 - National Parks and Reserves
- E2 - Environmental Conservation
- E3 - Environmental Management
- E4 - Environmental Living
- IN2 - Light industrial
- IN4 - Working Waterfront
- R1 - General Residential
- R2 - Low Density Residential
- RE1 - Public Recreation
- RU1 - Primary Production
- SP2 - Infrastructure

GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	Land Use
PROJECT	North Brother Local Catchments Flood Study
PROJECT #	IA157500
DATE	13/01/2021

FIGURE 2-3

2.3 Flood Behaviour and Drainage

Overland flooding in the steeper parts of the study area, generally upstream of Ocean Drive and Bold Street, is typically a result of runoff from North Brother Mountain concentrating in natural gullies which discharge towards receiving waterways including Queens Lake, Stingray Creek, Camden Haven River and Watsons Taylor Lake. Issues arise when the gullies and flows encounter existing development, which in some instances at the larger gullies have considered the drainage conditions and provided substantial set-back from the gullies such that there is minimal interaction between floodwaters and development.

At most of the smaller gullies and flow paths, attempts have been made to manage the overland flows by use of diversion drains and underground drainage. The natural flow paths have mainly been filled in for development although shallow flow paths may have been retained. The diversion drains and drainage network have limited capacity so begin to surcharge and overflow in relatively frequent flooding events, causing flooding through properties and into buildings with substantial damage. In a number of locations the existing roads form the main flow path for floodwaters.

Most of the overland flow paths cross Ocean Drive and Bold Street, which traverse the foot of the Mountain. The cross drainage culverts are also limited in capacity and prone to blockage by flood debris including rocks and vegetation, causing overflows over the road. These are two main roads in the study area and traffic is significantly impeded or roads become cut-off during floods. The roads are raised which results in ponding upstream of the road crossings.

The areas downstream of Ocean Drive and Bold Street are mainly low-lying and relatively flat. Development patterns have resulted in a number of low points being formed in roads and through properties, causing overland flows to pond to significant depths. In some areas attempts have been made to provide a continuous overland flow path to the receiving waterways, however, their capacity is also limited which causes hazardous flooding through roads and on properties. Underground and open channel drainage systems are present but are often exceeded. Drainage in these low-lying areas may also be impeded by high water levels in the receiving waters due to floods or storm surge, and mainstream flooding may also affect these areas. These issues are expected to worsen with climate change and sea level rise. Culverts and the drainage network are shown on Figure 2-2.

2.4 Historic Flood Events

A number of trouble spots and significant drainage locations were identified by Council based on previous flooding and include:

- Black Swan Terrace, West Haven
- Ringtail Cl, Lakewood
- Lilli Pilli Cl, Lakewood
- Mission Terrace, Lakewood
- Kirmington Terrace, and Pelican Ct, Westhaven
- Flinders Dr Estate, Laurieton
- Bold Street, Laurieton
- Quarry Way, Laurieton
- Lake Street, Laurieton
- St Joseph's School, Laurieton.

In several locations there are localised existing features such as open drains and diversion berms which are not currently performing properly. The heavily-vegetated upper catchments contribute significant volumes of flood debris which impacts on the capacity of the existing drainage and hydraulic structures.

Overland flooding was experienced in numerous times in recent history, with events occurring in 2002, 2004, 2008, 2011, 2013, 2015 and 2016, among others. Council provided a number of photographs and written submissions from residents reporting drainage and flooding problems during historic storm events. Dates of the reported events are listed below. The Annual Exceedance Probability (AEP) of the 2013 and 2016 storm events were estimated by Jacobs from the Council pluviograph data from Camden Haven sewer pumping station.

- 18 October 2004. 127mm recorded daily depth.
- 25 February 2008.112mm recorded daily depth.
- 24 April 2008 (10% AEP event). 49mm in 45minutes; 65mm in 60 minutes; 136mm in 24 hours.
- 14 June 2011. 96mm recorded 2-day depth.
- 2 March 2013 (0.2EY) 61mm in 1.5 hours; 152mm in 24 hours.
- 5 January 2016 (20 – 50% AEP) 54mm in 1.5 hours.

Rainfall data was not available for the 2002 and 2015 events.

Notable flooding reports are from locations including:

- Black Swan Terrace and Waterview Drive. Watercourse is piped through properties. The existing pipe inlet is undersized and the inlet debris screen regularly blocks. Overflows pass through residential yards, with paling fences washed away in previous floods.
- St Josephs's School, Laurieton. Video footage taken of significant flows along walkways between school buildings in the March 2013 event, which was a relatively frequent flood event.
- Ocean Drive. Flooding in numerous locations where a number of flow paths draining off North Brother Mountain cross this main road through the study area. Significant amount of cobblestones and other debris washed from watercourses and deposited on road.
- Flooding to depths of up to 1m in low points in roads at a number of locations in the study area. This was reported at Lilli Pilli Close, Sirius Drive, Mahogany Close and Honeysuckle Avenue, Lakewood; and Pelican Court, West Haven, among others.
- Flooding through Laurieton town centre including Bold Street, Lake Street and Tunis Street.

It is noted that the storm events resulting in the reported flooding and drainage complaints and problems were relatively frequent and smaller magnitude events. Local flooding events of similar frequency and magnitude to planning flood events (i.e. the 1% AEP) or even moderate frequency (e.g. 5% AEP) are yet to be experienced in the study area in recent times.

Figure 2-4 Residents unblocking culvert inlet upstream of Black Swan Terrace properties, April 2008.

Figure 2-5 Overland flows from creek across Ocean Drive, West Haven, April 2008

Figure 2-6 Overland flows, Ocean Drive at Flinders Drive, April 2008

2.5 Social Profile

Social characteristics of the study area are a key consideration for the floodplain risk management study. The Australian Bureau of Statistics (ABS) census 2016 data summarised in Table 2-1 indicates the following information on the population in the study area. The study area constitutes a large portion of the Camden Haven Urban Centres and Localities statistical area, which is assumed to be representative of the study area population.

Table 2-1 Census Data for Camden Haven Urban Centres and Localities (Source: ABS 2016)

Selected Person Characteristic			Dwelling Structure	
Total Persons	~4,500		Separate house	69%
Aged 14 years and under	10.4%		Semi-detached etc	16%
Aged 65 years and over	44.3%		Flat, unit, apartment	6%
Aboriginal/Torres Strait Islander	3.1%		Other dwelling	8.2
Born overseas	11.6%		**Tenure Type by Dwelling Structure**	
Speaks other language, and speaks English not well or not at all	0.2%		Fully owned	56%
Level of highest educational attainment (above 15 years old)			Mortgaged	15%
Above Year 12	36.9%		Rented	22%
Completed Year 11/12	12.0%		Houses – median sale price*	$514K
Completed Year 10	18.0%		**Household Composition**	
Completed Year 9 or below	13.6%		Family households	62%
No educational attainment	0.2%		Single (or lone) person households	36%
Selected Medians & Averages			Group households	2%
Median age	62		**Type of Internet Connection**	
Median total household income ($/weekly)	$773		Internet not accessed from dwelling	27%
Mean mortgage repayment ($/monthly)	$1,400		Internet accessed from dwelling	69%
Mean rent ($/weekly)	$280		**Number of motor vehicles per dwelling:**	
Average household size	2.0		No motor vehicles	8%
Selected Labour Force and Education % of total labour force or % of persons aged 15 years and over			One motor vehicle	49%
Total unemployed	3%		Two motor vehicles	31%
Total labour force	32%		Three or more motor vehicles	11%

* Average of median house sale price for Lakewood, West Haven and Laurieton, January 2021. Source: https://www.propertyvalue.com.au/ . Accessed 11 January 2021.

The census data indicates that:

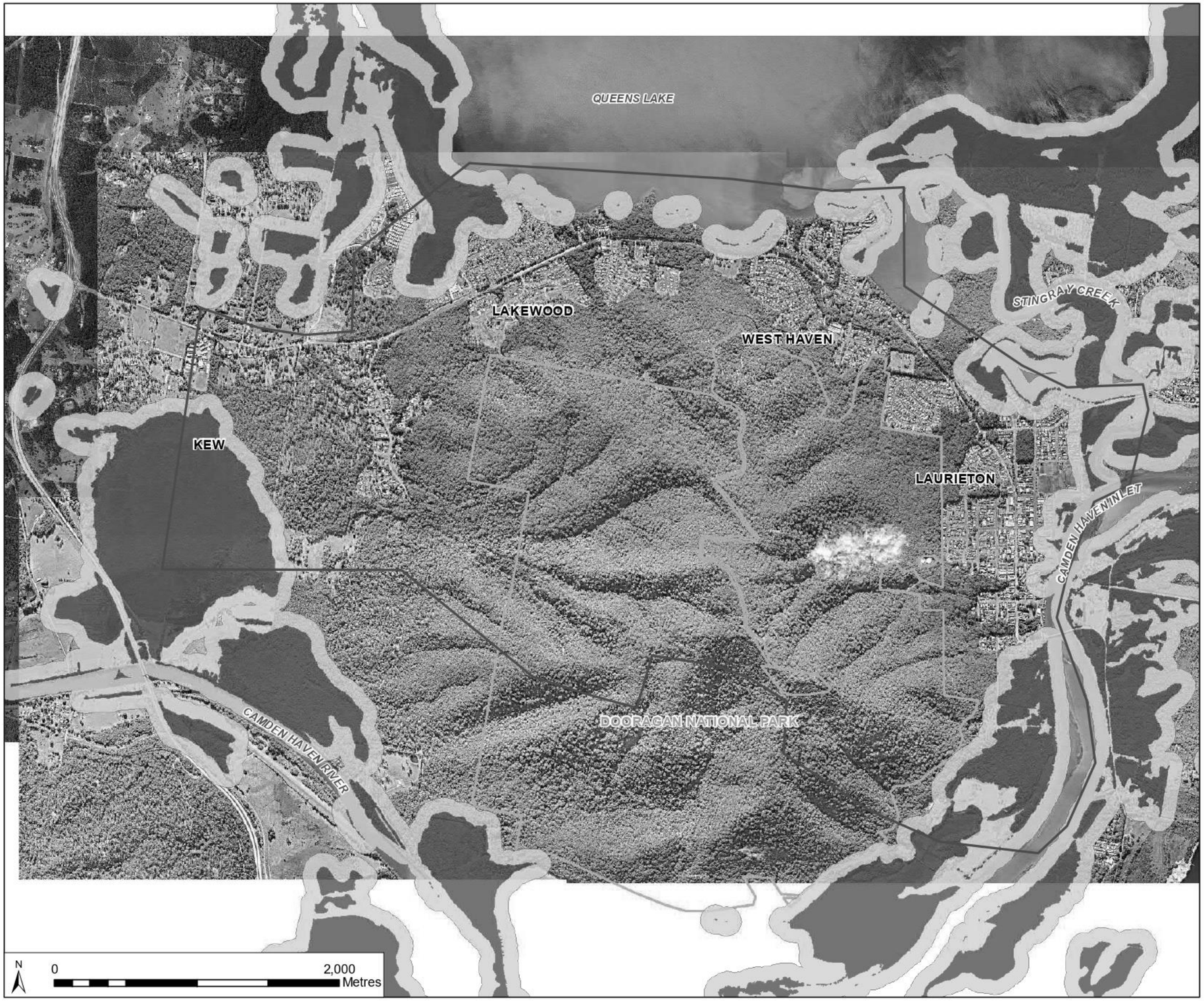
- Very high rates of English being spoken at home and proficiency. This suggests that the use of English in flood warnings and messages, such as brochures and signage, is expected to be adequate.
- 69% of households accessed internet from the dwelling, and 27% with internet access other than from the dwelling, with 96% total households with internet access. It is reasonable to assume that virtually all households also have smartphones which have mobile access to the internet, likely making up the majority of the 27% where internet is not accessed from the dwelling. Therefore, there would be a high rate of accessibility to information on flooding on websites of Council and other agencies such as BOM and SES, including warnings and messages in the lead-up to and during storm events.
- 71% of dwellings are fully owned or mortgaged. Home ownership status may affect the willingness to participate in any proposed property modification measures.
- A relatively high portion of the population are aged 65 years, with a median age of 62 years. Flood emergency, evacuation and recovery needs of older members of the community need to be considered, with aspects including communication of key messages and mobility of individuals.

- The median total household income of $773 per week is below the NSW average of $877 (in 2016). Flood damages to building contents is likely to be similar or slightly lower than the state-wide average. There may be a reduced capacity to recover following a flood event in lieu of insurance.
- 32% of the population are in the labour force, likely reflecting the age demographic and retiree status of the population. Retirees may have a higher likelihood of being home during a storm event (as opposed to workers going to off-site places of employment) and hence may be able to respond immediately during a flood event to minimise property damage.
- About 14% of the population above 15 years old completed year 9 or below, or had no educational attainment. The approach to flood information messaging should be carefully considered, with emphasis on Plain English messages and avoiding reliance on technical information.

2.6 Natural Environment

There are widespread vegetated areas within the study area, both within and outside of Dooragan National Park. Common vegetation communities include wet and dry sclerophyll forests, forested wetlands, wetland swamps, freshwater wetlands and saline wetlands (including mangrove swamps and saltmarshes). These communities are characterised by dominant species including *Eucalyptus pilularis, Eucalyptus seeana, Eucalyptus bancrofti, Eucalyptus robusta Eucalyptus pilularisgloboidea, Lepironia ariticulata, Casuarina glauca, Melaleuca linariifolia, Baumea sp., Aviceniia marina, Sporobolus virginicus,* and others.

Vegetation constraint areas are mapped on Figure 2-7. In the study area, these include areas identified as Coastal Wetlands under the Coastal Management State Environmental Planning Policy 2018 (CM SEPP). CM SEPP was introduced to provide an integrated policy for coastal assets. Under the CM SEPP, areas of 'Coastal Wetlands' and 'Proximity Coastal Wetlands (100m buffer)' have been mapped across the state. The CM SEPP seeks to control development within Coastal Wetland areas for environmental and economic considerations and development consent is required prior to any works being undertaken in the vicinity of listed wetlands. Any development within or near listed wetlands must be considered for the impact it might have on the environment, and whether or not impacts of the proposal are avoidable, before consent is granted.



Legend

- Study Area
- National Park

Coastal Management SEPP 2018

- Coastal Wetlands
- Coastal Wetlands Proximity Area

GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	Vegetation Constraint Areas
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	FIGURE 2-7
DATE 28/01/2021	

2.7 Heritage

An understanding of heritage issues is required in addressing floodplain risk management for the study area. Heritage items provide information on the social and cultural context of the floodplain and their location is an important consideration for floodplain mitigation measures. Any management measures proposed should not unduly impact heritage items or the cultural fabric of the study area, and the presence of heritage items has been considered in the identification and assessment of mitigation options.

A review of the State Heritage Register (SHR) and the Aboriginal Heritage Information Management System (AHIMS) was undertaken. A range of heritage items were identified within the study area including Aboriginal heritage items and a number of non-Aboriginal items. Refer to Table 2-2 and Table 2-3.

Development consent is required prior to altering heritage items; this includes demolishing or moving, altering the building by making structural changes, disturbing or excavating archaeological sites, disturbing or excavating an Aboriginal place of heritage significance, erecting a building on the land or subdividing the land where a heritage item is located.

Table 2-2 Aboriginal Heritage Items in Study Area

Unique ID	Description
30/06/0230	Laurieton 1 – Shells

Table 2-3 Non-Aboriginal Heritage Items in Study Area

Item name	Location	Suburb	Significance	Significance
Laurieton School of Arts	Cnr Laurie and Bold Sts	Laurieton	Port Macquarie-Hastings	State ID 00476
Artillery Piece	Castle Street (corner Bold Street and Kew Road)	Laurieton	Port Macquarie-Hastings	Local
Cemetery	Ocean Drive	Laurieton	Port Macquarie-Hastings	Local
Holy Trinity Church	56 Bold Street	Laurieton	Port Macquarie-Hastings	Local
Laurieton School of Arts Building	58 Bold Street (corner Laurie Street)	Laurieton	Port Macquarie-Hastings	Local
Post Office (Former) and Dwelling House Buildings	5 Laurie Street (corner Lake Street)	Laurieton	Port Macquarie-Hastings	Local

3. Flood Policies and Planning Controls

3.1 Background

This section provides an overview on the NSW flood risk management framework, and existing policies and planning controls applicable to the study area and recommends additional controls to be considered for the study area.

3.2 NSW Flood Risk Management Framework

3.2.1 Objectives and Approach

The primary objective of the NSW Flood Risk Management (FRM) framework, as expressed within the NSW Flood Prone Land Policy (Floodplain Development Manual (FDM) 2005, page 1), is as follows:

"*To reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods, utilising ecologically positive methods wherever possible*."

Within the scope of this report, the relevance of the above objective is primarily to ensure that future redevelopment within the study area does not lead to increased flood risk to property and persons, and that the planning controls proposed to achieve this outcome form part of a consistent and coordinated strategy to reduce flood risk.

3.2.2 NSW FRM Policy and Guidelines

The NSW Flood Prone Land Policy, as identified within Section 1.1 of the FDM, places the primary responsibility for flood risk management on local councils. This provides the opportunity for FRM to be integrated within council's normal planning processes.

The NSW Flood Prone Land Policy and the FDM provide a platform for the management of floodplains following a risk management approach. The FDM provides guidance on how to implement the NSW Flood Prone Land Policy. The FDM requires the level of flood risk acceptable to the community to be determined through a process overseen by a committee comprised of local elected representatives, community members and state and local Government officials (including the SES). This process is shown in Figure 1-1.

The ultimate outcome is the preparation of a Floodplain Risk Management Plan (FRMP), which is a plan formally adopted by a local council in accordance with the NSW Flood Prone Land Policy. FRMPs should have an integrated mix of management measures that address existing, future and continuing risk.

3.2.3 2007 flood planning guideline

On January 31, 2007 the NSW Planning Minister announced a new guideline for development control on floodplains (the "Flood Planning Guideline"). An overview of the new Guideline and associated changes to the *Environmental Planning and Assessment Act 1979* (EP&A Act) and *Environmental Planning and Assessment Regulation 2000* (Regulation) was issued by the Department of Planning in a Circular (PS 07-003) dated 31 January 2007. The Flood Planning Guideline issued by the Minister relates to this package of directions and changes to the EPA Act, Regulation and FDM.

This Flood Planning Guideline provides an amendment to the Floodplain Development Manual (2005). The Guideline confirms that unless there are "exceptional circumstances", Councils are to adopt the 1% AEP plus freeboard as the flood planning level (FPL) for residential development, with the exception of some sensitive forms of residential development such as seniors living housing. The Guideline does provide that controls on residential development above the 1% AEP plus freeboard may be subject to an "exceptional circumstance" justification being agreed to by the Department of Planning, Industry and Environment and the Department of Planning Industry and Environment prior to the exhibition of a Draft LEP or Draft DCP.

The "Guideline on Development Controls on Low Flood Risk Areas – Floodplain Development Manual" defines Standards for Flood Controls for Residential Development. Whilst the flood used to define the residential FPL is a decision of Council, FDM highlights that FPLs for typical residential development would be based around the 1% AEP plus an appropriate freeboard (typically 0.5m).

3.2.4 2020 Draft Updates to Flood Prone Land Package

Significant flood events, like those in Brisbane in 2011 and those more recently in NSW show the importance of managing flood risk up to and beyond the 1% AEP event and considering flood risks up to the probable maximum flood level. This will build resilience in communities located on floodplains and reduce the extent of property damage and potential loss of life from severe to extreme flooding throughout NSW.

The NSW Department of Planning Industry and Environment has been working to update the Flood Prone Land Package (including the 2007 flood planning guideline – refer to Section 3.2.3) which provides advice to councils on considering flooding in land use planning and consists of:

- A proposed amendment to schedule 4, section 7A of the Environmental Planning and Assessment Regulation 2000
- A revised planning circular
- A revised local planning direction regarding flooding issued under section 9.1 of the Environmental Planning and Assessment Act 1979
- Revised Local Environmental Plan flood clauses
- A new guideline: Considering Flooding in Land Use Planning (2020)
- Revoking the Guideline on Development Controls on Low Flood Risk Areas (2007).

The proposed updates promote the effective consideration of flood risk in land use planning, which involves developing an understanding of the full range of flood behaviour up to the Probable Maximum Flood (PMF) and considering this in management of flood risk.

The proposed local planning direction has been revised to remove the need to obtain exceptional circumstances to apply flood-related residential development controls above the 1% AEP flood event.

The proposed updates support the principles of the Floodplain Development Manual and provide advice to local councils on land use planning within flood-prone land. It provides councils greater flexibility in defining the areas to which flood-related development controls apply, with consideration of both defined flood events (used to set flood planning levels) and low probability/high-consequence flooding. In addition, it allows for land requiring controls related to regional evacuation consideration to be identified. The Floodplain Development Manual states that a defined flood event (DFE) of the 1% AEP, or a historic flood of similar scale, plus a freeboard should generally be used as the minimum recommended level for setting residential FPLs. Councils proposing a different FPL are required to demonstrate the merits of this approach through the FRM process.

The consultation period for the updated Flood Prone Land Package concluded on 25 June 2020. Further information is expected from the NSW Department of Planning, Industry and Environment in due course.

3.2.5 Relationship with EP&A Act

The plan-making processes under the EP&A Act, such as for the preparation of Local Environmental Plans (LEPs) and Development Control Plans (DCPs), operate independently of the preparation of FRMPs under the FDM. While these two processes could be overlapped, it has been the usual practice to undertake the processes separately. Ultimately the planning recommendations of the FRMP will need to be reflected in planning instruments and policies brought into force in accordance with the EP&A Act.

Any flood mitigation works recommended as a part of the FRMP may also need to be undertaken in accordance with the EP&A Act, such as obtaining development consent for proposed works in Coastal Wetlands as identified under the Coastal Management SEPP (2018).

3.3 Existing Policies and Planning Controls

The imposition of planning controls can be an effective means of managing flood risks associated with future development (including redevelopment). Such controls might vary from prohibiting certain land uses to specifying development controls such as minimum floor levels and building materials.

In principle, the degree of restriction that is imposed on development due to flooding relates to the level of risk that the community is prepared to accept after balancing economic, environmental and social considerations. In practice, the planning controls that may ultimately be imposed are influenced by a complex array of considerations including state-imposed planning policy and directions, existing local planning strategies and policies and ultimately the acceptability of conditions that could be imposed through the development application process.

The following provides an outline of policy that is potentially relevant because it either directs the FRM planning controls that could be adopted or affects the way flood risk is identified in the planning controls.

3.3.1 State Environmental Planning Policies

State Environmental Planning Policies (SEPPs) are planning policies which deal with Statewide matters of environmental planning significance. They are prepared in accordance with the EP&A Act by the NSW Department of Planning and Environment and approved by the Minister. Clause 1.19 of the Exempt and Complying Development Codes SEPP has been amended so that land identified as 'flood control lot' is no longer excluded from the application of the General Housing Code. Instead, specified development and development standards have been added to the General Housing Code in Clause 3.36 of the Exempt and Complying Development Codes SEPP (2008) for development on flood control lots. The development standards have been designed to ensure that complying development is not allowed on those parts of flood control lots which are defined as being floodways, flood storage areas, a flow path, a high flood hazard area or high flood risk area.

Hydraulic hazard and hydraulic categories across the study area are identified in this study. A number of existing properties are surrounded by floodway and/or high flood hazard areas and during future development assessment and planning the hazard and hydraulic categories maps should be consulted to ensure that developments are not approved on high hazard or floodway areas. Refer to Appendix C for 1% AEP with climate change event flood hazard and hydraulic category mapping, including floodways and flood storages.

Recommendation

The flood hazard and hydraulic categories mapping is to be considered by Council in the planning and approval of proposed developments for flood-affected lots. Proposed developments are not to be approved on high hazard or floodway areas.

3.3.2 Section 9.1(2) Directions

Ministerial directions pursuant to section 9.1(2) of the EPA Act specify matters which local councils must take into consideration in the preparation of LEPs. Direction 4.3, as currently applies, deals specifically with flood prone land and has the following two objectives:

(a) To ensure that the development of flood prone land is consistent with the NSW Government's Flood Prone Land Policy and the principles of the Floodplain Development Manual, 2005.

(b) To ensure that the provisions of an LEP on flood prone land is commensurate with flood hazard and includes consideration of the potential flood impacts both on and off the subject land.

The Direction applies to all councils that contain flood prone land when an LEP proposes to "*create, remove or alter a zone or provision that affects flood prone land*." In such cases, the Direction requires draft LEPs to ensure the following:

1. *A planning proposal must include provisions that give effect to and are consistent with the NSW Flood Prone Land Policy and the principles of the Floodplain Development Manual 2005 (including the Guideline on Development Controls on Low Flood Risk Areas).*

2. *A planning proposal must not rezone land within the flood planning areas from Special Use, Special Purpose, Recreation, Rural or Environmental Protection Zones to a Residential, Business, Industrial, Special Use or Special Purpose Zone.*

3. *A planning proposal must not contain provisions that apply to the flood planning areas which:*

   a. *permit development in floodway areas,*

   b. *permit development that will result in significant flood impacts to other properties,*

   c. *permit a significant increase in the development of that land,*

   d. *are likely to result in a substantially increased requirement for government spending on flood mitigation measures, infrastructure or services, or*

   e. *permit development to be carried out without development consent except for the purposes of agriculture (not including dams, drainage canals, levees, buildings or structures in floodways or high hazard areas), roads or exempt development.*

4. *A planning proposal must not impose flood related development controls above the residential flood planning level for residential development on land, unless a relevant planning authority provides adequate justification for those controls to the satisfaction of the Director-General (or an officer of the Department nominated by the Director-General).*

5. *For the purposes of a planning proposal, a relevant planning authority must not determine a flood planning level that is inconsistent with the Floodplain Development Manual 2005 (including the Guideline on Development Controls on Low Flood Risk Areas) unless a relevant planning authority provides adequate justification for the proposed departure from that Manual to the satisfaction of the Director-General (or an officer of the Department nominated by the Director-General).*

3.3.3 Port Macquarie-Hastings Local Environmental Plan 2011

The Port Macquarie-Hastings Local Environment Plan 2011 (LEP 2011) came in to effect on 23 February 2011. LEP 2011 adopts the Department of Planning, Industry and Environment's model flood planning clause as clause 7.3. The objectives of clause 7.3 Flood Planning are as follows:

- to minimise the flood risk to life and property associated with the use of land,
- to allow development on land that is compatible with the land's flood hazard, taking into account projected changes as a result of climate change,
- to avoid significant adverse impacts on flood behaviour and the environment.

This clause applies to—

- land that is shown as "Flood planning area" on the Flood Planning Map, and
- other land at or below the flood planning level.

Development consent must not be granted to development on land to which this clause applies unless the consent authority is satisfied that the development—

- is compatible with the flood hazard of the land, and
- is not likely to significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties, and

- incorporates appropriate measures to manage risk to life from flood, and
- is not likely to significantly adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses, and
- is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding.

3.3.4 Port Macquarie Hastings Council Flood Policy (2015)

Overview

Council's Flood Policy (adopted 21 October 2015) outlines the considerations to be made by Council in exercising its environmental assessment and planning functions in relation to development in the Port Macquarie Hastings Local Government Area (LGA). It reflects the direction of flood risk management in NSW Government's *Flood Prone Land Policy* and draws on the guidance on this provided in the *Floodplain Development Manual* (2005).

The Flood Policy identifies the development controls to be applied to proposed developments to manage flood risk to occupants and minimise flood damages to the development and flood impacts to adjacent properties. Development controls include flood planning level categories and provisions for different types of development (permissible development types, minimum floor levels), considerations for filling, fencing, boundary adjustments, rezoning and subdivision in the different hydraulic zones in the floodplain. The flood policy draws on the design flood information borne from Council's existing flood studies

Prescriptive Controls

Prescriptive controls that apply to a particular Flood Risk include:

- Floor Level
- Flood Proofing
- Flood Impact on Other Properties
- Site Access and Flood Evacuation Requirements.

The Flood Policy provides requirements for different types of development in relation to these prescriptive controls. These requirements vary depending on the hydraulic classification and flood hazard conditions on the property.

Hydraulic Classifications

The flood policy provides definitions for the different hydraulic classifications of the floodplain, including floodway, flood storage and flood fringe areas. It outlines the type and nature of development which is allowed according to the hydraulic classifications on the property. Generally, new development is not allowed in floodway areas. There may be circumstances in which certain types of limited or Minor Development (including infill development, redevelopment, replacement development or minor extensions) could proceed, subject to a range of considerations.

Flood Hazard

The flood policy provides guidance on how proposed developments are to comply with the prescribed development controls and provisions. One of these is consideration of the flood hazard on the property. The flood hazard categorisation system adopted in the flood policy differs from the hazard categorisation system recommended in Australian Rainfall and Runoff 2019, which is based on recent research and which is presented in *Australian Disaster Resilience Handbook 7. Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia* (AIDR, 2017a) and *Guideline 7-3 Flood Hazard* (AIDR, 2017b). The flood hazard mapping prepared in this study for the North Brother Local Catchments follows the ARR 2019 system.

Flood Planning Levels

The Flood Policy defines the adopted flood planning levels for various types of proposed development. Council has adopted a 0.5m freeboard across the whole LGA, including both mainstream and overland flood areas. The different flood planning level categories define the minimum levels for floor levels, flood proofing, flood impacts to other properties and site access (e.g. roads) and evacuation routes for different types of development.

Table 3-1 Flood Planning Level (FPL) Categories

Category Proposed	FPL Category Description
FPL1	20 year ARI (i.e. 5% AEP) Flood level (No allowance for Climate Change, No Freeboard)
FPL2	100 year ARI (i.e. 1% AEP) Flood level + Climate Change Allowance (No Freeboard)
FPL3	100 year ARI (i.e. 1% AEP) Flood level + Climate Change Allowance + 500mm Freeboard
FPL4	Probable Maximum Flood (PMF)

Compatibility with overland flooding

The flood studies which have been completed and adopted by Port Macquarie-Hastings Council are focussed on mainstream and riverine flooding since this is the main flood threat to the Port Macquarie-Hastings LGA. Hence, Council's Flood Policy has been developed to be geared towards mainstream flooding. A number of aspects and development controls within the Flood Policy may be incompatible with the nature of overland flooding and it may be difficult for proposed developments to comply with the existing development controls. These aspects include:

- Reliable site access for new residential developments: The Flood Policy states that Council will only support development where "*Effective Warning Time and reliable access is available for evacuation. Developments will be required to demonstrate that evacuation through low hazard conditions during the early warning period of a Flood is achievable. A minimum 8 hours Effective Warning Time must be available to a particular site*", and "*Safe Reliable Evacuation must be provided from the site to land above the PMF, preferably to an approved Flood Evacuation Centre* " For overland flooding such warning time is not available (usually the warning time is less than 1 hour and often it is effectively nil). Therefore, it is recommended to update the Flood Policy to provide exemptions or modified conditions for development of properties subject to overland flooding. Further, due to the dispersed nature of overland flows, evacuation routes which are flood-free in the PMF may not be available.
- Area above FPL2 for property boundary adjustments: "*As far as practical each lot must have a minimum area of 400m^2 (residential/large lot residential/urban) or 1,000m^2 (rural) at or above FPL2*". This may not be possible on numerous properties, which are otherwise sited away from main flow paths and watercourses, due to often dispersed and shallow nature of overland flows.

Amendments to the Flood Policy which allow improved compatibility with overland flooding should be considered and are discussed in Section 8.1.3.3.

3.3.5 Section 10.7 Certificates

When property is sold in NSW, the vendor must attach to the sale contract a copy of a planning certificate for the property issued by the local council under section 10.7(2) of the EP&A Act. When the Council has secured an FRMP, information will be included on the planning certificate. Section 10.7(2) Certificates advise whether development on the land or part of the land is subject to the Council's flood related development controls, which apply to land below the FPL. Certificates should not be understood to advise that land above the adopted FPL is flood free, as land above the FPL can flood in rare flood events.

4. Community Consultation

4.1 Initial Consultation

Community consultation was undertaken throughout this study, including distribution of newsletters and media releases and the hosting of a website on Council's webpage to announce the commencement and provide background on the study.

4.2 Community Survey

A community survey was mailed out to residents with the study newsletter during the flood study stage in October 2017, asking residents for information on previous flooding events that they experienced in the study area, refer to Appendix A for the survey. A total of 302 responses were received. The responses assisted the project team in identifying the most significant flooding events in recent history which would be suitable for model calibration and verification. Observations including noted flood depths, flow patterns and durations of flooding were reported. Residents also submitted photographs and videos of flooding during the events. Views on flood management measures were also collected and considered.

4.3 Public Exhibition

The Draft Flood Study Report was placed on public exhibition during May – June 2019 following review and comment from the Port Macquarie Hastings Council Coast, Estuary & Floodplain Advisory Sub-committee. Written submissions from the community on the flood study were addressed by Council and Jacobs.

This Draft Floodplain Risk Management Study and Plan report will be placed on public exhibition during the first half of 2021, following endorsement by the floodplain risk management advisory sub-committee.

4.4 Community Information Sessions

Two community information sessions were held at Laurieton Library in August 2018 during the model development and calibration stage. Residents were invited to view flood mapping for the model calibration and provide feedback on the results and other general concerns relating to flooding in the study area. Approximately 40 residents attended over the two sessions. The modelling was updated based on several resident comments for the final model calibration runs and design flood estimation.

An additional two community information sessions were held at Laurieton Library in June 2019 during the public exhibition of the Draft Flood Study Report. Feedback and queries from the community were responded to on the flood study outcomes. Approximately 50 residents attended over the two sessions.

Further community information sessions during the floodplain risk management study phase of the project did not proceed due to COVID-19 travel and gathering restrictions and general COVID-19 risk management considerations by the Council's project team. Instead, Council undertook targeted consultation with key stakeholders and landowners during this project stage in relation to flood management options.

4.5 Floodplain Risk Management Advisory Committee

The Port Macquarie Hastings Council Coast, Estuary & Floodplain Advisory Sub-committee is comprised of councillors, council officers, key stakeholders including SES and community representatives. The committee has provided feedback on key aspects and outcomes of this study, including on the flood study, selection of flood management options for detailed assessment and this Draft Floodplain Risk Management Study and Plan report.

5. Existing Flood Environment

5.1 Description of Flooding Conditions

5.1.1 Flood Depth

Flooding behaviour was defined based on numerical modelling of hydrology and hydraulics, estimating catchment flood flows and the flooding patterns and behaviour. Modelling was undertaken in DRAINS software (hydrology) and TUFLOW software (hydraulics), as documented in the North Brother Local Catchments Flood Study – Final Flood Study Report (Jacobs, 2020). Flood depth mapping based on the modelling results is presented in Appendix B for the 1% AEP, 1% AEP with climate change and PMF events. Refer to the flood study report for mapping of other flood events.

Overland flow depths on properties are typically up to 0.3m in up to the 1% AEP event. Flood depths exceed 0.5m in a number of locations in frequent floods such as the 0.2EY event, and exceed 1m in the 5% and 1% AEP events. Areas of deeper flows include main flow paths and drainage low points in a number of roads.

During the PMF event, property and road flooding exceeding 0.5m depth is widespread, with property and road flooding of 1m depth also common. Depths of flooding exceeding 2m occur on approximately 20 properties in the study area.

The flood depth mapping shows relatively high depths of ponding on the upstream sides of many buildings. In most cases this is due to the model terrain not allowing free drainage of water around the buildings. In real life, the ground surface around buildings is usually graded to allow water to drain off and not form trapped points. There may also be property stormwater drainage present which is not included in the model. Some care therefore needs to be taken in the review of the flood depth mapping.

5.1.2 Duration of Flooding

Overland flooding in the study area is generally a result of intense short-duration rainfall events. As a result, the duration of inundation of roads and built areas is typically short, limited to 1 – 2 hours in up to the 0.5% AEP event. Storage areas such as road sag points in Sirius Drive and Lilli Pilli Close in Lakewood may be inundated for longer durations of up to 3 hours due to constrained capacity of stormwater drainage servicing these areas.

Durations of inundation are likely to be up to 4 hours in the PMF event particularly in some flood storage locations, affecting roads including Botanic Drive and Ocean Drive west of Lakewood shopping centre.

Note that the duration of flooding for depths greater than 0.3m, at which stage floodwaters become impassable for most passenger vehicles, is generally limited to approximately 1 hour duration in most roads.

A river flooding event may occur shortly after overland flooding in the study area, in which case the lower-lying areas of the study area may experience more extensive durations of flooding. River flooding was not assessed in this study.

5.1.3 Flood Hazard

Flood hazard mapping was prepared for the 1% AEP event for current climate conditions and for the 1% AEP event under the adopted climate change scenario (increased rainfall intensity by 10% and with 0.9m sea level rise). Recent research has been undertaken into the hazard that flooding poses and the vulnerability of the public and assets when interacting with floodwaters. A combined flood hazard classification is presented in *Australian Disaster Resilience Handbook 7. Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia* (AIDR, 2017a) and *Guideline 7-3 Flood Hazard* (AIDR, 2017b) based on this research, and is illustrated in Figure 5-1. The flood hazard categories according to the AIDR definition are:

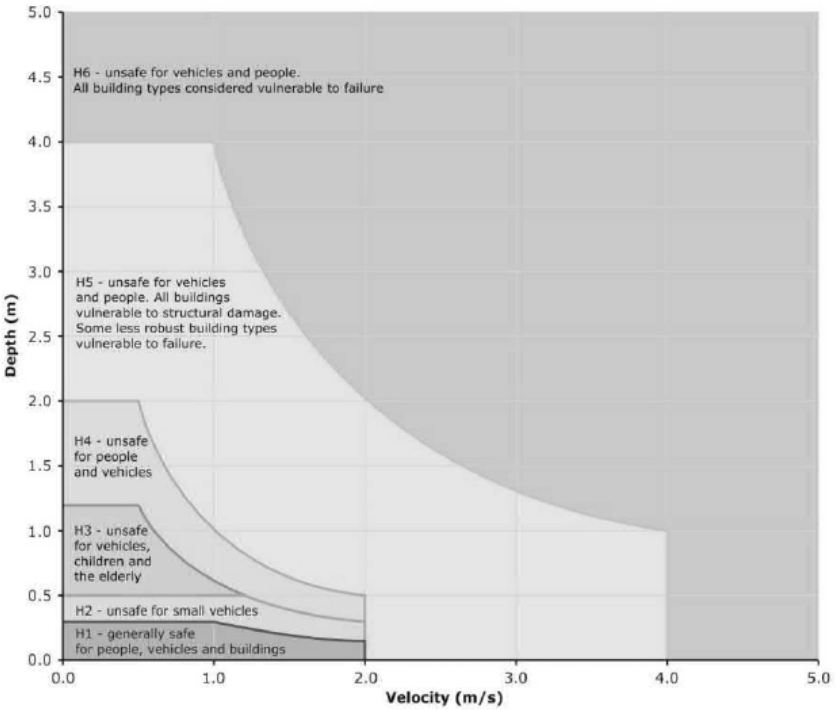
- H1 – Generally safe for people, vehicles and buildings;
- H2 – Unsafe for small vehicles;

- H3 - Unsafe for vehicles, children and the elderly;
- H4 - Unsafe for people and vehicles;
- H5 - Unsafe for people and vehicles. Buildings require special engineering design and construction; and
- H6 – Unsafe for people or vehicles. All buildings types considered vulnerable to failure.

The flood hazard classification is more discrete and provides guidance on flood hazard thresholds to different members of the community (e.g. children and elderly) and different assets (small versus larger vehicles, standard versus specialised engineered buildings). The AIDR flood hazard definition potentially provides a more suitable guideline for assessing flood hazard on the floodplain from an emergency management perspective.

Flood hazard mapping is presented in Appendix B for the 1% AEP with climate change event.

Figure 5-1 General flood hazard vulnerability curves, Australian Institute for Disaster Resilience (AIDR) definition. Reproduced from Figure 6 in *Guideline 7-3: Flood Hazard* (AIDR, 2017b)



5.1.4 Provisional Hydraulic Categories Mapping

Three flood hydraulic categories identified in the *Floodplain Development Manual* (NSW Government, 2005). These are also defined in Council's Flood Policy (2015):

- Floodway, where significant discharge of water occurs during floods and blockage could cause redirection of flows. Generally characterised by relatively high flow rates; depths and velocities;
- Flood storage, characterised by relatively deep areas of floodwater and low flow velocities. Floodplain filling of these areas can cause adverse impacts to flood levels in adjacent areas; and
- Flood fringe, areas of the floodplain characterised by shallow flows at low velocity.

There is no firm guidance on hydraulic parameter values for defining these hydraulic categories, and appropriate parameter values may differ from catchment to catchment. For example, the minimum threshold flows and depths which might define a floodway in an overland flow catchment may be markedly lower than those for a large lowland river due to the different scale of flooding. The category definition adopted in the

Hastings River Flood Study (PBP, 2006) and Hastings River Floodplain Risk Management Study (Worley Parsons, 2012) was initially considered for this study. For the Hastings River the floodways were defined as areas in the 1% AEP flood with flows greater than 2m, velocities greater than 0.5m/s and velocity x depth greater than $1m^2/s$. This does not agree with the flooding conditions in the North Brother study area, where 1% AEP flows are generally less than 1.5m deep. Hence, an alternative hydraulic category system is required.

Howells et. al. (2003) suggest that consideration of flow depths, velocities and velocity x depth of flood flows can be used to help define the hydraulic category areas. Various combinations of flow, depth and velocity were trialled for appropriate threshold values for the hydraulic categories. For the purposes of this study, the hydraulic categories were defined as per the criteria in Table 5-1, which were selected following trials of different criteria values and categorisation methods. These criteria are consistent with those adopted by a number of other councils in NSW for overland flooding. Note that the hydraulic category areas have been prefixed with "Overland Flow", to distinguish them from the mainstream flooding hydraulic category mapping.

Table 5-1 Hydraulic Categories Criteria – Overland Flow

Hydraulic Category	Criteria
Overland Flow Floodway	Area within the flood extent where: • Velocity x Depth > $0.3m^2/s$ AND • Velocity > 0.5m/s AND • Depth > 0.15m. Overland Flow Floodway areas have generally been retained for main overland flow path areas Localised areas initially classed as "floodway" have generally been downgraded to "Flood Storage".
Overland Flow Flood Storage	Remaining area within overland flow 1% AEP flood extent where Depth > 0.15m
Overland Flow Flood Fringe	Remaining area within overland flow 1% AEP flood extent where Depth > 0.05m, outside the Overland Flow Floodway and Flood Storage areas.

The provisional hydraulic categories mapping is presented in Appendix C for the 1% AEP event with climate change, with the climate change scenario mapping used in Council's Flood Policy to identify areas where various flood planning controls are applicable. Preparation of the mapping considered maintaining a continuous floodway strip (where appropriate) and removing/reclassifying isolated areas which currently meet the floodway criteria to either flood storage or flood fringe categories. This was achieved by manual inspection and adjustment of the mapped hydraulic category areas. Similarly, filtering out of small patches of flood storage and flood fringe from the mapping was undertaken.

Floodway areas are generally located within the natural watercourses and flow paths, although there are a number of roads which contain floodways throughout the study area. Floodways pass through properties on Black Swan Terrace, Koonwarra Street, Pelican Court, Elouera Place, Flinders Drive, St Joseph's School, Peach Grove, Gow Place, Kew Road and in Laurieton between Quarry Place and Bold Street, among others. There are 273 lot parcels with floodway areas on the lot. These include national park, open space and other public spaces which have not been filtered from the lot count.

Note that the flood hydraulic categories extents are generally similar between the 1% AEP event with climate change mapping (as presented in Appendix C) and the hydraulic categories mapping for the 1% AEP event with existing climate, due to a relatively modest (10%) difference in rainfall intensity and overland flows for most parts of the study area. There are differences in extent in in low-lying areas due to the inclusion of 0.9m sea level rise in the tailwater conditions, whereby the 1% AEP plus climate change mapping outlines are more extensive.

5.2 Summary of Flood Problem Areas

Flooding hot spots are identified in the flood study, confirming problem areas previously identified by Council. The hot spots are summarised in Table 5-2 below. Critical areas with consideration of high flood depths, velocities or hazard are highlighted with orange cell or text shading. In summary, the identified critical locations include:

- Black Swan Terrace, West Haven.
- Kirmington Terrace, Koonwarra Street, Captain Cook Bicentennial Drive villas and Ocean Street property and Pelican Court, West Haven.
- Bold Street, Laurieton
  - Laurieton Hotel and adjoining areas
  - Harbourside Crescent villas.
- Lake Street property, Laurieton. Corner Seymour Street.
- St Joseph's School, Laurieton.
- Lilli Pilli Close, Lakewood (road flooding).
- Sirius Drive, Honeysuckle Avenue and Mahogany Close, Lakewood (road flooding).
- Ocean Drive between Fairwinds Avenue and Mission Terrace (road flooding).
- Pelican Court, West Haven (road flooding).
- Waterview Crescent, Kirmington Terrace and Koonwarra Drive, West Haven (road flooding).
- Bold Street between Laurie Street and Mill Street (road flooding).
- Lord Street at Seymour Street, Laurieton (road flooding).

Table 5-2 Description of Flooding Hot Spots

Location	Description
Property flooding	
Black Swan Terrace, West Haven	Flow depths on properties up to 0.5m in the 0.2EY event and up to 0.7m in the 1% AEP event. Swift flows of 2m/s. Flood hazard up to H5 rating in the 1% AEP event.
Ringtail Cl, Lakewood	Overflows from open channel onto properties with flooding in backyards to depths 0.2 – 0.3m in the 1% AEP event. Relatively low flooding impact.
Lilli Pilli Cl, Lakewood	Flooding in backyards to depths of 0.3 – 0.5m in the 1% AEP event from open drain overflows. Flooding in cul-de-sac to depths up to 0.8m. Also significant flooding of car park around Lakewood shopping centre.
Mission Terrace, Lakewood	Overflows with depths of 0.1 – 0.3m in the 1% AEP event from cul-de-sac onto downhill property. Overflows from the overland flow path running through properties on the uphill side of the road with depths up to 0.2m.
Kirmington Terrace to Pelican Court, West Haven	Flows through properties on low side of Koonwarra Street of 0.3m in the 0.2EY event and exceeding 0.5m in the 1% AEP event. Velocities up to 2m/s in the 1% AEP event. Flood hazard up to H4 (some localised H5) rating in the 1% AEP event.

	Flow depths 0.5m in the 0.2EY event and up to 0.8m in the 1% AEP event on Captain Cook Bicentennial Drive villas and Ocean Drive property, at dwellings. Flood hazard up to H4 rating in the 1% AEP event. Flood depths of 0.6 – 0.8m in the 0.2EY event within Pelican Court roadway and pedestrian walkway. Depths up to 0.6m at dwellings in 1% AEP event. Flood hazard up to H4 rating on properties and H5 on roadway in the 1% AEP event. Groundwater springs occur in this area but are not directly related to the surface water flood risk. These springs appear to be a spatially random occurrence.
Flinders Dr Estate, Laurieton	Overflows from drainage easement swale onto properties with depths to 0.3m in the 0.2EY event and 0.5m in the 1% AEP event. Overflows from Reliance Crescent sag point onto properties to depths of 0.2m in the 0.2EY event and 0.4m in the 1% AEP event.
Bold Street area, Laurieton	Significant flows through Laurieton Hotel with H4 hazard rating. Trapped drainage point on western side of commercial properties with significant depths, though local drainage may be present which would mitigate the flood depths. Overflows down fire trail at Norman Street/ Mill Street affecting properties with depths up to 0.3m in the 1% AEP. Overflows onto units on Harbourside Crescent from trunk drainage channel to depths exceeding 0.5m in the 1% AEP event, with H5 hazard rating.
Quarry Way, Laurieton	Overflows from flow diversion drain to depths of 0.5m in the 1% AEP event on properties. The drain is reported to be affected by significant debris blockage.
Lake Street, Laurieton	Flood depths up to 1m in the 1% AEP event affecting dwelling on the corner of Lake Street and Seymour Street. Overflows from Lake Street onto properties between Ocean Drive and Castle Street to depths of 0.3m in the 1% AEP.
St Joseph's School, Laurieton.	Swift flows in overland flow paths to depths of 0.8m and velocities exceeding 2m/s in the 1% AEP event. Flows between buildings are 0.4m in the 0.2EY event and 0.6m in the 1% AEP event, with velocities up to 2m/s. Flood hazard rating of H4 in pedestrian walkways and H5 in overland flow paths in the 1% AEP event.
Properties adjacent to Stingray Creek and Camden Haven River, Laurieton	Numerous properties on low-lying land at risk of oceanic inundation during storm surge events. Estimated depths on the flood mapping expected to be conservative due to likely attenuation of ocean inflows through the river mouth.
Blackbutt Crescent and Peach Grove, Laurieton	Overflows from flow diversion drain to depths of 0.5m in the 1% AEP event on properties. The drain cross-sectional profile and capacity significantly reduces near its discharge point onto Peach Grove at Tunis Street. Flows into the drain originate from natural watercourse further uphill, which is significantly affected by rubble and debris blockage.
Elouera Place, West Haven	Overflows from watercourse and diversion drain. Depths over 0.3m in the 0.2EY event and 0.5m in the 1% AEP event.

Sirius Drive, Honeysuckle Avenue and Mahogany Close, Lakewood	Flood depths on properties 0.3 – 0.5m in the 1% AEP event, built up from road ponding areas.
Sirius Drive and Oak Close, Lakewood	Depths 0.3 – 0.4m and velocities 1m/s in the 1% AEP event.
Sandpiper Close	Overflows from concrete channel along Ocean Drive. Depths 0.3 – 0.4m and velocities 1m/s in the 1% AEP event.
Properties on lower side of Ocean Drive, 200m east of Hoschke Road, West Haven	Road low point overflows onto properties with depths of 0.5m and velocities of 1m/s in the 1% AEP event.
Roads	
Ocean Drive west of Lakewood shopping centre	5% AEP event flood depths of 0.4m 1% AEP event flood depths of 0.5m, H3 hazard rating
Botanic Drive, Lakewood	1% AEP event flood depths of 0.4m, H2 hazard rating
Lilli Pilli Close, Lakewood	5% AEP event flood depths of 0.6m 1% AEP event flood depths of 0.7m, H3 hazard rating
Ocean Drive east of Lakewood shopping centre	5% AEP event flood depths of 0.3m 1% AEP event flood depths of 0.35m, >H4 hazard rating
Sirius Drive, Honeysuckle Avenue and Mahogany Close, Lakewood	0.2EY event flood depths of 0.6 – 0.7m 1% AEP flood depths 1m, H3 hazard rating
Ocean Drive between Fairwinds Avenue and Mission Terrace	0.2EY event flood depths of 0.5m 1% AEP event flood depths of 0.7m, >H4 hazard rating
Ocean Drive and Mission Terrace intersection	0.2EY event flood depths of 0.4m 1% AEP event flood depths of 0.6m, H3 hazard rating
Ocean Drive near Waterview Crescent	5% AEP event flood depths of 0.2 – 0.3m 1% AEP event flood depths of 0.3m, low hazard rating but long section of flooding
Ocean Drive near Pelican Court	5% AEP event flood depths of 0.3m 1% AEP event flood depths of 0.4m, H3 hazard rating
Pelican Court, West Haven	0.2EY event flood depths 0.6m 1% AEP event flood depths of 1m, H5 hazard rating
Waterview Crescent, Kirmington Terrace and Koonwarra Drive, West Haven	0.2EY event flood depths of 0.2m with 2m/s velocity; max 0.6m depths (low velocity) 1% AEP event flood depths up to 0.7m, H5 – H6 hazard rating
Ocean Drive east of Hoshcke Road	0.2EY event flood depths of 0.4m 1% AEP event flood depths of 0.5m, H3 hazard rating
Ocean Drive east of Flinders Drive	5% AEP event flood depths of 0.3m 1% AEP event flood depths of 0.4m, H3 hazard rating
Kew Road/Bold Street near Tunis Street, Laurieton	1% AEP event flood depths of 0.5m, H2 hazard rating
Bold Street between Laurie Street and Mill Street	0.2EY event flood depths over 0.5m 1% AEP event flood depths 0.6 – 0.8m, H5 hazard rating

Bold Street north of Hanley Street, Laurieton	0.2EY event flood depths of 0.3m with 1m/s velocity 1% AEP event flood depths up to 0.5m, H3 hazard rating
Lord Street at Seymour Street, Laurieton	0.2EY event flood depths of 0.5m 1% AEP event flood depths up to 0.7m, H3 hazard rating
Flinders Drive, Laurieton Tunis Street, Laurieton Rosewood Court and Mission Terrace, Lakewood Diamentina Way, Lakewood	H5 hazard rating on steep sections of road (1% AEP event)

5.3 Above-Floor Property Flooding

A floor level survey was undertaken in October 2019 for selected properties in the study area, which were identified based on presence of high hazard flooding at the dwelling in the 1% AEP event. The minimum habitable floor level was surveyed at a total of approximately 270 buildings. Floor levels for the remaining 2,000 (approximately) properties in the study area were estimated based on an assumed 0.2m height above the maximum ground level at the dwelling.

Above-floor flooding in the 0.2EY, 5%, 2% and 1% AEP and PMF flood events is mapped on Figure 5-2. The buildings shown on the map were selected as those affected by main flow paths and bodies of flooding, and exclude those affected by minor ponding. This selection process was done for each flood AEP and was also used in the flood damages assessment (see Section 5.7). The numbers of buildings affected in each flood event are summarised in Table 5-3.

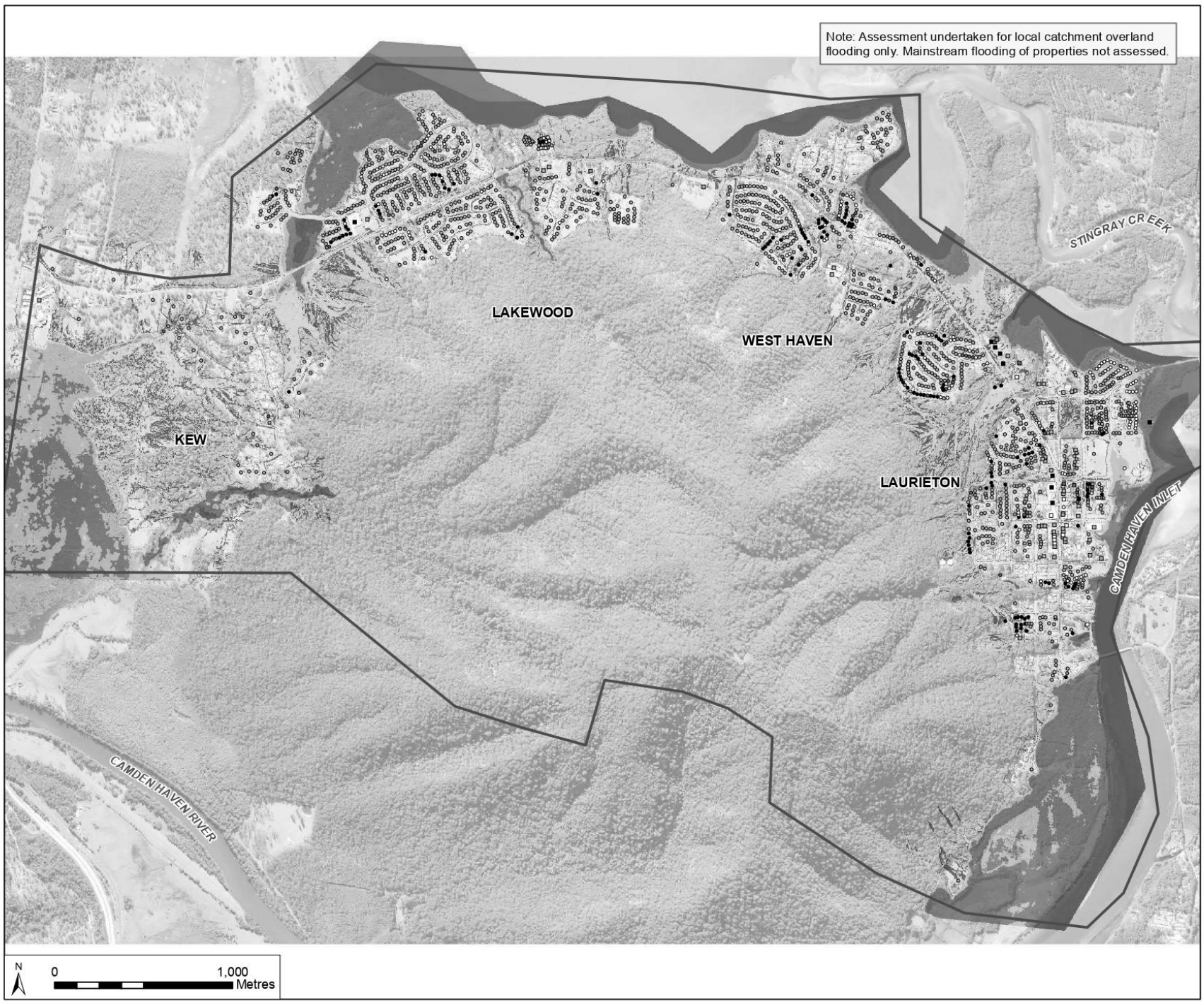
Table 5-3 Number of buildings with above-floor flooding

Event	Residential	Commercial/Non-Residential
0.2EY	161	10
5% AEP	222	16
2% AEP	380	27
1% AEP	492	31
PMF	1,616	83

Above-floor flooding is expected to incur significantly greater flood damages to the building and contents compared to yard (i.e. below floor level) flooding. The map indicates the spatial distribution of properties with above-floor flooding and their relative vulnerability, with properties affected in frequent events such as the 0.2EY event being more vulnerable than those affected only in rarer events such as the 1% AEP event.

5.4 Very High Hazard Residential Properties

A count of properties with very high hazard flooding conditions at the dwelling was undertaken based on the flood hazard mapping in Appendix B, with the review identifying 19 residential properties with a flood hazard rating of H5 or H6 in the 1% AEP event, whereby damage to the building may result due to floodwaters. The properties are located within the flood problem areas as discussed in Section 5.2 and may be candidates for management measures including voluntary purchase and redevelopment by Council, as discussed further in Section 8.1.1 and Section 8.1.4, respectively.



Legend

Design Flood when Floor Becomes Inundated

- 0.2EY
- 5% AEP
- 2% AEP
- 1% AEP
- PMF

Property Type

- Residential
- Non-residential

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area

GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

JACOBS

TITLE	Above-Floor Flooding at Dwellings
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	FIGURE 5-2
DATE 3/12/2019	

5.5 Sensitive Properties and Critical Infrastructure

Sensitive properties and critical infrastructure have been identified in the catchment. Certain types of properties may require specific evacuation considerations due to the vulnerability of their occupants, such as schools and pre-schools, and aged care facilities. Critical infrastructure impacted by flooding may have effects on the recovery and functioning of the community following a flood event.

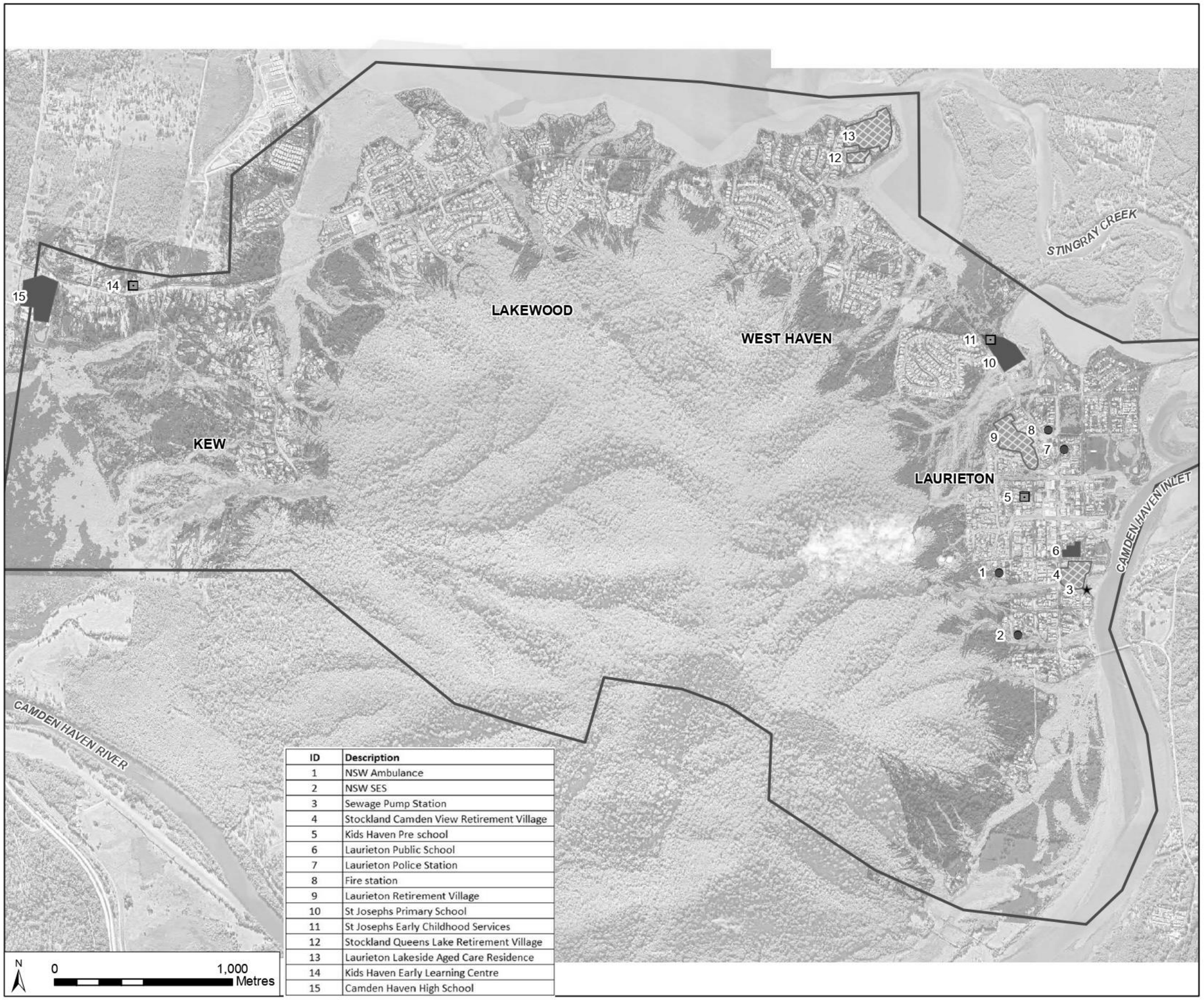
The sensitive properties and critical infrastructure are mapped on Figure 5-3. The flood hazard in the PMF event is mapped on the figure. Note that centrally-operated facilities are listed. Properties which include apartments, villa estates etc. have not been identified.

The sensitive properties and critical infrastructure identified as being directly affected by overland flooding are summarised in Table 5-4 with the flood hazard on each site indicated. Note that the list is based on the overland flood modelling in this study, and a number of sites are impacted by mainstream flooding which is not assessed.

Table 5-4 List of flood-affected sensitive properties and critical infrastructure

Name	Overland Flow Flood Hazard* (Existing case, no climate change)		Hydraulic Category (1% AEP, climate change)
	1% AEP	PMF	
Sensitive Properties			
Stockland Camden View Retirement Village	Mostly H1/H2 Up to H5	H6	Flood Fringe/Flood Storage/Floodway
Kids Haven Pre School	H1	H1	Flood Fringe
Laurieton Public School	H1	H4	Flood Fringe
Laurieton Retirement Village	Mostly H1 – H2 Localised H3	H6	Mostly Flood Fringe/Flood Storage. Some Floodway areas
St Joseph's Primary School	Mostly H1/H2 Up to H5	H5-H6	Flood Fringe/Flood Storage/Floodway
St Joseph's Early Childhood Services	Mostly H1/H2 Up to H4	H5	Flood Fringe/Flood Storage/Floodway
Stockland Queens Lake Retirement Village	Mostly H1/H2	H4	Mostly Flood Fringe. Some Flood Storage areas
Laurieton Lakeside Aged Care Residence	Mostly H1	Mostly H1- H3	Flood Fringe
Kids Haven Early Learning Centre	H1	H1	Flood Fringe
Camden Haven High School	Mostly H1	Mostly H1, up to H4 in low-lying southern part of school	Mostly Flood Fringe
Critical Facilities and Infrastructure			
NSW Ambulance Laurieton	H1	H3	Flood Fringe/Flood Storage
NSW SES Camden Haven unit	H1	H3	Flood Fringe
Laurieton Police Station	H1	H2	Flood Fringe
Fire station Laurieton	H3	H4	Flood Fringe/Flood Storage
Laurieton sewage pumping station	H4	H6	Flood Storage/Floodway

* Note, overland flood hazard indicated. Some properties are also affected by mainstream flooding.



ID	Description
1	NSW Ambulance
2	NSW SES
3	Sewage Pump Station
4	Stockland Camden View Retirement Village
5	Kids Haven Pre school
6	Laurieton Public School
7	Laurieton Police Station
8	Fire station
9	Laurieton Retirement Village
10	St Josephs Primary School
11	St Josephs Early Childhood Services
12	Stockland Queens Lake Retirement Village
13	Laurieton Lakeside Aged Care Residence
14	Kids Haven Early Learning Centre
15	Camden Haven High School

Legend

- Child Care Centre
- Critical Infrastructure
- Emergency Services
- School
- Aged Care Facility
- Study Area

Flood Hazard Category

- H1 - Generally safe for vehicles, people and buildings.
- H2 - Unsafe for small vehicles.
- H3 - Unsafe for all vehicles, children and the elderly.
- H4 - Unsafe for all people and all vehicles.
- H5 - Unsafe for all people and all vehicles. Buildings require special engineering design and construction.
- H6 - Unsafe for Vehicles and people. All building types considered vulnerable to failure.

GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

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TITLE	Sensitive Properties and Critical Infrastructure
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	FIGURE 5-3
DATE 9/12/2019	

5.6 Provisional Overland Flood Planning Areas

Council's Flood Policy (refer Section 3.3.4) sets four different flood planning levels (FPLs) for applying different development controls on floor levels and minimum flood free areas, etc., depending on the flood hydraulic category of the land and the type of development. Overland flood planning areas have been mapped in accordance with the definitions in the Flood Policy.

Manual review and processing of the flood depth mapping (Appendix B) has been undertaken to infill areas in the flood mapping which are blank due to building footprints, and remove very shallow flows and isolated areas of ponding which would not be considered "flooding". This has been done to provide a sanitised set of mapping layers suitable for Council's town planning processes. The extents of the FPL1 – FPL3 areas are limited by the extent of the FPL4 area (which is based on the PMF). Flood related development controls would typically not be implemented for areas above and outside the PMF The category definitions and mapping treatments are summarised in Table 5-5, and are mapped in Appendix C.

Since properties outside of the defined FPL areas are still susceptible to sheet flow runoff, it would be prudent to apply a minimum floor level height to all properties of 0.15m above the finished ground level. This is consistent with Building Code of Australia (ACBC, 1996) for drainage purposes for slab-on-ground dwellings.

Table 5-5 Overland Flood Planning Level (FPL) Categories

Category Proposed	Overland FPL Category Description	Mapping Treatments
Overland FPL1	20 year ARI (i.e. 5% AEP) Flood level (No allowance for Climate Change, No Freeboard)	• Very shallow flooding and isolated ponding deleted • Gaps in the mapping occupied by building footprints infilled as appropriate • FPL3 level is limited in elevation by the PMF level (i.e. the PMF may be less than 500mm higher than the 1% AEP plus climate change flood level) • All FPL areas limited in extent by FPL4 • Mainstream flooding is considered to be dominant in low-lying areas. The Mainstream FPL3 is shown on the mapping to indicate that the mainstream Flood Policy and FPLs are applicable in those areas.
Overland FPL2	100 year ARI (i.e. 1% AEP) Flood level + Climate Change Allowance (No Freeboard)	
Overland FPL3	100 year ARI (i.e. 1% AEP) Flood level + Climate Change Allowance + 500mm Freeboard.	
Overland FPL4	Probable Maximum Flood (PMF)	

5.7 Flood Damages Assessment

5.7.1 Overview

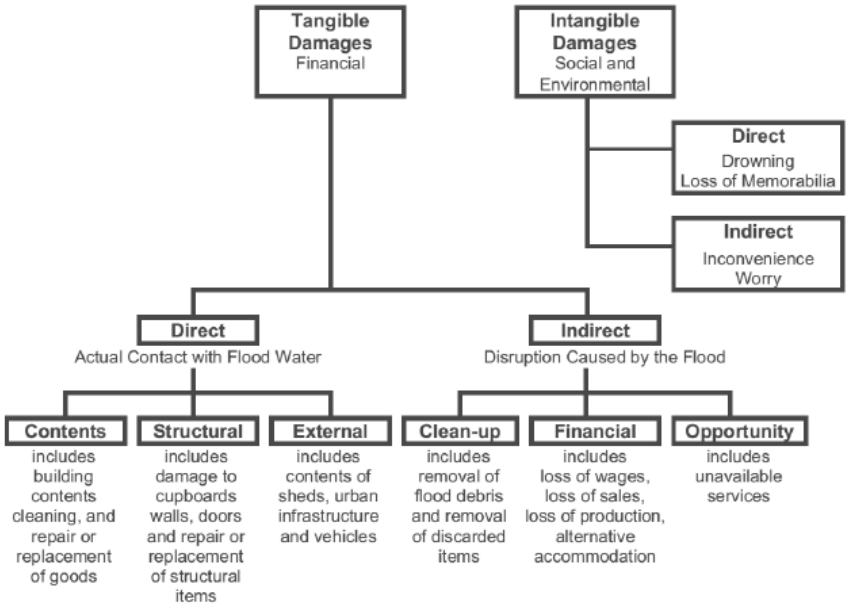
Flood events may cause damage to property with significant costs to property owners and insurers. The damage may occur due to floodwaters affecting the building façade and interior (weatherboard exterior, gyprock interior walls, carpets), electrical wiring and building contents and other property outside the dwelling (vehicles, contents of sheds and garages, etc). Structural damage to the dwelling can also occur due to extreme flood hazard conditions.

The cost of flooding is estimated to identify the magnitude of the event to a community, and subsequently provide a benchmark for the viability of potential measures for mitigating the impacts of flooding. This section describes the estimation of flood damage costs in the study area, focussing on residential and commercial properties.

5.7.2 Flood Damages Categories

The type of damages associated with floods is shown in Figure 5-4 (*Floodplain Development Manual, NSW Government 2005*). The cost of damage caused by floods may include tangible and intangible components. Tangible damage costs include the direct material damage and rebuilding costs to existing homes, property and infrastructure, and also the indirect costs associated with the social disruption of the floods, such as: clean-up; lost income during and after the flood event; and the cost of alternative accommodation for people displaced by the floods. A monetary value can be readily placed on the direct damages, which are the focus of this assessment.

Figure 5-4 Types of Flood Damage



Other social and environmental damages to which a monetary value cannot readily be placed are intangible damages, which include emotional stress of the flood event, injury and loss of life. While these damages cannot readily be incorporated into an economic feasibility assessment of mitigation options, it is still important to consider the potential for these intangible damages, particularly if there is an elevated risk of loss of life.

5.7.3 Estimation of Direct Tangible Flood Damage Costs

5.7.3.1 Property Information

Residential and commercial properties were identified and characterised based on knowledge and site observations of the study area.

Residential house types in the study area are generally a mixture of one and two storey houses, in addition to a number of villa and apartment complexes. In floodplains with deep flooding (riverine floodplains) two storey houses would experience a second increment of flood damages as floodwaters rise and affect the second storey. While some properties in the low-lying areas adjacent to the rivers and lakes would be affected by

riverine flooding, the focus of this study is on overland flows from the local catchments, affecting up to the first storey of the house only. For the purposes of this assessment all houses were assumed to be single storey.

Flood damages are estimated based on flood level in relation to building floor level, with the damages increasing as the flood levels increase. The floor levels of approximately 270 buildings, selected based on high hazard flooding in the 1% AEP event, were surveyed. The floor levels of remaining buildings were estimated based on LiDAR ground levels plus and assumed 0.2m above the highest ground level at the building.

Affected buildings for the flood damages assessment were selected based on interpretation of overland flood extents from the flood mapping, to include only those properties affected by main flow paths and significant ponding shown on the mapping so as not to overestimate the flood damages. The affected properties were selected for each event assessed in the flood damages estimation, i.e. the 0.2EY, 5%, 2% and 1% AEP and PMF events. This approach was taken so as not to overestimate the flood damages.

5.7.3.2 Residential Property Damages

Residential flood damages guidelines and a calculation spreadsheet was developed by the NSW Office of Environment and Heritage (OEH, 2016b). The calculation spreadsheet includes a representative stage-damage curve derived for typical house types in the study area to estimate structural, contents and external damage. The amount of damage is based on the flood inundation depth, for a suite of annual exceedance probability events ranging from the 20% AEP event up to the PMF. These values are then summed to provide a total damage for each flood event analysed. The AEP of the PMF in the study area is assumed to be 1 in 10,000,000.

The stage-damage curves assume some flood damages for flood levels below the floor level. A minimum damage value of $12,060 (2019 dollars) is assumed to occur at a level 0.5m below the floor level. This approach accounts for flood damages to parts of the dwelling and property below the floor level and ensures that damages are not underestimated.

Various input parameters are used to define the flooding and location characteristics which derive a location specific damage curve. The parameters adopted for the study area are presented in Table 5-6. Unless otherwise stated, default parameters have been used (as recommended in the *Residential Flood Damage Guidelines* (OEH, 2016b)).

The DECCW stage-damage curves within the spreadsheet are derived for late 2001, and have been updated using an Average Weekly Earnings (AWE) factor to the current day values. AWE is used to update residential flood damage curves rather than the inflation rate measured by the Consumer Price Index (CPI). The most recent AWE value from the Australian Bureau of Statistics (ABS, 2019) at the time of the assessment was November 2018, however, this resulted in a multiplication factor on 2001 dollars of 2.37, which was significantly out of step from the factor value derived from November 2017 AWE of 1.76 and from previous recent years. On this basis, a factor of 1.9 was assumed for up to August 2019 to keep in trend with AWE increases for the years prior to November 2017.

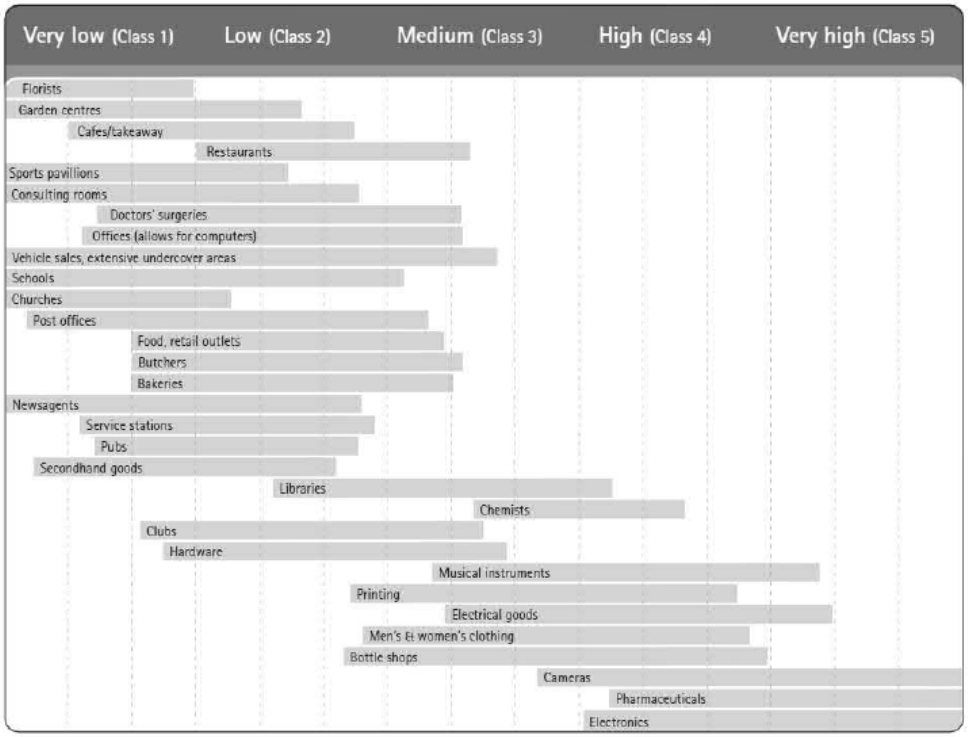
Table 5-6 Input parameters for damage calculations

Parameter	Value	Comment
Regional Cost Variation Factor	1.0	Appropriate value for a major city (Sydney) and surrounds. Similar value assumed for major regional city.
Post flood inflation factor	1.15	
Typical duration of immersion	1 hour	
Building damage repair limitation Factor	0.85	Represents short duration flood (<12 hours) where some materials can recover from short periods of flooding and may not need replacement
Typical free-standing house size	240m²	
Contents damage repair limitation Factor	0.75	Guidelines suggest a value of 0.75 for short duration floods
Effective warning time (hrs)	0	Only marginal improvement in damages cost when effective warning time is increased to 1 hour as a sensitivity assessment
Level of flood awareness	Low	Flood warning times are nil, and it is assumed that residents are typically not aware of potential damage of flood waters and the measures to minimise damages (e.g. elevated storage of goods).

5.7.3.3 Commercial Property Damages

No information on commercial property flood damage costs in NSW was found during a literature search. The most relevant information obtained was published in the Queensland Government Natural Resources and Management Department's *Guidance on the Assessment of Tangible Flood Damages* (2002). This document contains flood damage curves for commercial properties over a range of property footprint areas and degrees of susceptibility to flooding and is based on information published in *ANUFLOOD: A Field Guide* (Centre for Resource and Environmental Studies (Australian National University), 1992). Different types of commercial and non-residential properties were assigned a susceptibility rating, as illustrated in Figure 5-5.

Figure 5-5 Damage categories for commercial properties (reproduced from *Guidance on the Assessment of Tangible Flood Damages* (Qld. Government, 2002)



The stage-damage data were factored up by a value of 1.9 from late 2001 dollars to current values based on Average Weekly Earnings (AWE), similar to the approach adopted for the residential flood damages.

An additional multiplication factor of 1.6 was applied based on guidance in *Rapid-Appraisal Method (RAM) for Floodplain Management* (Victorian Government Natural Resources and Environment, 2000), which suggests that the ANUFLOOD values are underestimated and should be increased by 60%.

A total of 89 commercial and non-residential premises/buildings which are potentially flood-affected were identified. Detached buildings on non-residential properties were assessed individually e.g. on school grounds. Individual shops within an overall commercial building complex were also assessed separately where possible. The results of the commercial and non-residential property flood damages assessment are provided in Section 5.7.3.5.

5.7.3.4 Damages to Utilities and Infrastructure

Utilities and infrastructure in the study area which are susceptible to flooding may include roads and other public infrastructure such as sewage pumping stations, electrical transformer boxes, etc.

The potential cost of damage to roads is difficult to estimate for the study area, as the nature of flooding in a significant portion of study area is typically due to relatively shallow, short-duration flows, although road damage is possible for roads conveying higher velocity flows.

The roads damages guidance published in the references cited in this study are based on longer-duration mainstream flooding damages and hence are likely to overestimate the flood damages to roads in the study area. Hence these costs have not been included in this assessment.

5.7.3.5 Damage Assessment Results

The most convenient way to express flood damage for a range of flood events is by calculating the Annual Average Damage (AAD). The AAD is equal to the total damage caused by all floods over a long period of time divided by the number of years in that period. The AAD for the existing case then provides a benchmark by which to assess the merit of flood management options.

The AAD value is determined by multiplying the damages that can occur in a given flood by the probability of that flood actually occurring in a given year and then summing across a range of floods. This method allows smaller floods, which occur more frequently to be given a greater weighting than the rarer catastrophic floods.

Table 5-7 summarises the residential damages and the commercial and non-residential damages. The residential and commercial property flood damages include direct damages to property such as structural, external and contents damage, and indirect damages such as clean up costs and accommodation/ loss of rent costs. Infrastructure damage, vehicular damage and intangible damages are not included.

The OEH (2016b) guidelines recommend that the adopted freeboard in the flood planning level (0.5m) be considered in the flood damages estimation. This gives the "Protection Level" which reduces the floor level relative to the flood levels in the calculations which are adopted as the damages estimates. Calculations of damages based on floor level (no freeboard adjustment applied) are also provided as a sensitivity check.

The flood damages here are "potential flood damages", which may be reduced with increased flood awareness and preparedness in the community. The Net Present Value of the flood damages assumes a 7% discount rate over a 50 year life, as per the OEH (2016b) guidelines. The damages are in 2019 dollar values

Table 5-7 Estimated Tangible Flood Damages due to Overland Flooding

Event	Based on Floor Level*		Based on Protection Level (Floor Levels minus Freeboard)*	
	Number of properties flooded above floor level	Estimated Flood Damage	Number of properties flooded above protection level	Estimated Flood Damage
Residential				
20% AEP	161	$18.9M	344	$40.3M
5% AEP	222	$25.6M	429	$50.8M
2% AEP	380	$42.7M	679	$80.6M
1% AEP	492	$54.1M	839	$100.0M
PMF	1,616	$193.9M	2,062	$274.5M
AAD		**$8.9M**		**$17.6M**
Commercial/Non-Residential				
20% AEP	10	$1.0M	34	$4.4M
5% AEP	16	$1.5M	44	$6.1M
2% AEP	27	$2.3M	59	$8.3M
1% AEP	31	$2.5M	63	$8.9M
PMF	83	**$12.9M**	98	$22.7M
AAD		**$0.5M**		**$1.9M**

* Damages estimate based on Protection Level is to be adopted. Estimate based on floor level used as a sensitivity check.

5.7.4 Summary

Flood damages in the study area is primarily attributed to residential dwellings that are impacted by overland flooding. The estimates based on Protection Level are adopted. The flood damages estimates were based on properties selected based on their impact from main areas of flooding, and excludes those affected by localised minor ponding. The residential AAD for the study area is $17.6 million. The non-residential AAD is $1.9 million.

There are 523 residential and non-residential properties that are estimated to experience above floor flooding (not protection level) for the 1% AEP event. In the PMF, 1,699 properties are estimated to experience above floor flooding.

While flood damage estimates for the study area are indicative only, they are useful in the evaluation of flood management options, aimed at reducing flood damage estimates while being economically viable to implement.

6. Local Emergency Planning Context

6.1 Local Flood Plan

Having a local flood plan is important for the community and State Emergency Service (SES) and other emergency services to be prepared when there is a flood. The plan would outline preparedness measures and the response to flooding in the area. The strategies and personnel responsible for their implementation would be detailed along with the plan for recovery afterwards. A local flood plan may prove to be a valuable resource in times of flood in order to coordinate a strategy to reduce flood risks.

The Port Macquarie-Hastings Local Emergency Management Plan (EMPLAN) applies to the study area and identifies the range of hazards as having risk of causing loss of life, property, utilities, services and/or the community's ability to function within its normal capacity. The EMPLAN focusses on mainstream flooding as the primary source of flood risk in Port Macquarie-Hastings local government area, including the Laurieton Sector, which includes the study area. Impacts to properties and population, emergency response categorisation of the floodplain and evacuation arrangements (access routes, evacuation centres) are reported for mainstream flooding. Overland or flash flooding is not currently recognised in the EMPLAN for the study area.

6.2 Flood Warning Systems

There is currently no flood warning system relevant to overland flooding specific to the study area. Given the study area terrain, catchment response time to rainfall events is very short and overland flooding is expected to occur shortly after the start of a storm event with a short time to peak (generally much less than an hour, and potentially nearly immediate flash flood response). Hence, a catchment specific flood warning system is not considered an appropriate option for implementation.

General sources of real time information currently available during the event of a flood are:

- Bureau of Meteorology (BOM)
- State Emergency Service (SES).

BOM issues forecasts and warnings of possible flood events across Australia in the form of generalised flood warnings (Flood Watch) that flooding is occurring or is expected to occur in a particular region, including flash flooding and riverine flooding. Severe Thunderstorm Warnings and Severe Weather Warnings are also issued when significant weather is expected to occur in certain areas, and which may cause flash flooding. Detailed Severe Thunderstorm Warnings are issued for specific thunderstorms which are occurring in metropolitan areas including locations expected to be affected and the time of affectation. These warnings are relevant to the study area and are posted on BOM's website www.bom.gov.au/warnings/nsw. These warnings are also disseminated via social media by BOM and community groups, and announced on local radio stations. Some insurance companies also relay Severe Thunderstorm Warnings and Severe Weather Warnings by SMS to their customers located in the area affected.

BOM also issues Flood Warnings of minor, moderate or major flooding in areas where specialised warning systems have been implemented, including the Camden Haven system for mainstream flooding. These are not directly relevant to overland flooding in the North Brother study area, as a flash flooding event may occur preceding, or independently from a riverine flood event. Conversely, a riverine flood could also occur with no related flash flood event.

SES uses information provided by the BOM and assists in communication flood warnings and recommendation on what action communities should take before, during and after flood events.

6.3 Assessment of Community Flood Awareness

Responses from the community questionnaire indicated that about half of the respondents had previously experienced flooding of property/businesses or on roads, noting that recent historical flood events were frequent

to moderate frequency (up to 10% AEP) events. About 75% respondents have an awareness of flooding in the study area.

There was awareness of potential damage to building contents and property from floodwaters, with a number of respondents reporting damage experienced during previous flood events, including significant damages exceeding $50,000 at several properties. Awareness regarding potential flood hazard posed to people and property from rare to extreme flooding events was not gauged in the questionnaire. There were a few respondents who felt that their properties were not at risk of flooding.

6.4 Flood Evacuation and Emergency Access Considerations

Flooding in the study area may generally be considered to be flash flooding in nature with rapid rates of rise, fast catchment hydrologic response, no warning times and short durations of flooding. The study area is interspersed with flow paths which pass through properties and run along roads. Affected roads are summarised in Table 5-2. Some are affected by hazardous flow conditions in events as frequent as the 0.2EY event. Access in and out of flooded properties via these roads during a flood event may be hazardous and pose a risk to residents if they attempt to evacuate to offsite flood-free refuges.

The minimum response time for emergency services to coordinate and undertake a response is in the range of one hour, by which time the flood is likely to have passed due to the short duration and flashy nature of flooding. Hence coordinated evacuation to flood refuges is not a practical solution.

Local evacuation, whereby residents observe flooding and respond by moving to higher ground, may be feasible although it requires an awareness of the flooding conditions and flood-free zones. There is also risk of a flood occurring at night during which the residents may not be awake to observe and respond to flooding.

Given the minor and generally short duration of flooding in the study area, in most cases, it would be appropriate for residents to shelter in place in the dwelling, although it needs to be recognised that a number of properties may not be suitable in the PMF event due to very high flood hazard (refer to Section 5.4).

7. Floodplain Risk Management Measures

7.1 Overview

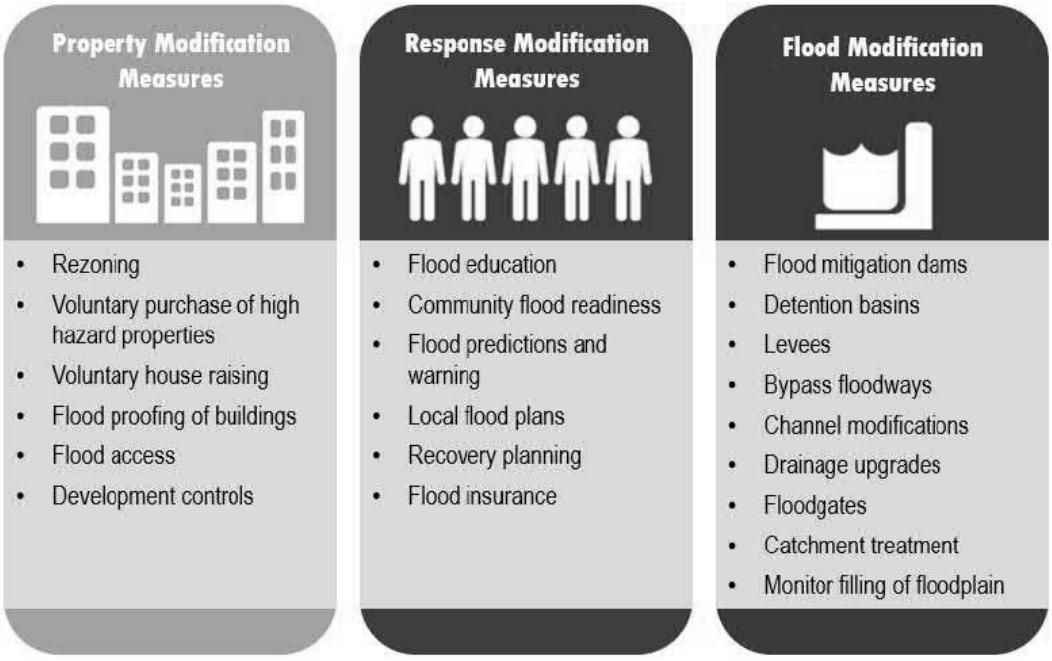
One of the objectives of this Floodplain Risk Management Study is to identify and compare various floodplain risk management options to deal with existing and future flood risk in the study area, considering and assessing their social, economic, ecological and cultural impacts and their ability to mitigate flood impacts.

The *Floodplain Development Manual* (NSW Government, 2005) describes floodplain risk management measures in three broad categories as described below:

- Property modification measures involve modifying existing properties (for example, house-raising) and/or imposing controls on new property and infrastructure development (for example, floor height restrictions);
- Response modification measures involve modifying the response of the population at risk to better cope with a flood event (for example improving community flood readiness); and
- Flood modification measures involve modifying the behaviour of the flood itself (for example, construction of a levee to exclude floodwaters from an area or flood retarding/detention basins to store floodwaters and reduce peak outflows).

Examples of measures falling under the three categories are outlined in Figure 7-1. Some of these measures may or may not be appropriate in a particular catchment, depending on factors such as the flooding behaviour and patterns of development.

Figure 7-1 Floodplain Risk Management Measures *(Source: Floodplain Development Manual, 2005)*



7.2 Considerations in Options Identification and Prioritisation

In determining the nature and priority of potential options for further detailed assessment, the following factors have been considered:

- The identified mitigation options are aimed at improving flooding conditions due to local catchment flooding. Riverine flood levels exceed the local catchment flood levels by a substantial amount particularly in the 1% AEP event and inundate low-lying areas of the study area. The local catchment flood mitigation options in these areas should be designed not to worsen the susceptibility of these areas to riverine flooding. For example, substantial lowering of berms may allow overtopping of river floodwaters in more frequent events.
- Design river tailwater conditions due to elevated ocean levels are up to 2.1m AHD in the 1% AEP event. Some low-lying areas on properties and roads have a ground level of approximately 2.6m AHD and would be difficult to drain via underground pipes.
- The effectiveness of mitigation options during future climate change scenario is to be considered. The design river tailwater conditions due to elevated ocean levels would increase to 3.0m AHD in the 1% AEP event in a climate change scenario, with 0.9m of sea level rise.
- The design riverine flood levels are 2.3 – 2.4m AHD in the 5% AEP event and 2.9 – 3.0m AHD in the 1% AEP event in the current climate. The flood levels in a climate change scenario are expected to increase by up to 0.8m in the 1% AEP event as a result of 0.9m sea level rise and 10% increase in rainfall (Patterson Britton and Partners, 2013).
- Given the low elevation of a number of identified sites for potential mitigation, it is expected that the effectiveness of the mitigation options would be reduced if local overland flooding coincided with a mainstream flood peak. Some contingency will be incorporated into the options modelling with adoption of elevated, but not peak, river tailwater levels.

7.3 Selection of Options for Detailed Assessment

A description and qualitative evaluation of identified works-based flood modification options at 16 locations was provided in the Working Draft Options Report, dated 9 December 2019. The identified options aim to mitigate flooding at the locations summarised in Table 5-2, in particular property flooding. A short-list of six combinations of options were selected by Council and the committee, and have been analysed in the TUFLOW model for the 0.2EY, 5%, 2% and 1% AEP events and the 1% AEP with climate change event to assess the improvements to flooding conditions. Existing underground utilities were considered in the configuration of the options based on Dial Before You Dig searches.

The assessed options are described, and their modelled performance is summarised for the 0.2EY, 5% and 1% AEP events in the following sections.

7.3.1 Black Swan Terrace, West Haven

Council commissioned, separately from this study, a design for an improved trunk drainage pipe inlet arrangement and high-flow diversion to the street. Additional works in the street including raising of the road verge and driveways are proposed. Details of the design were provided following completion of the final Flood Study Report (Jacobs, 2020), hence it has not been incorporated into the design flood modelling and mapping. Since the design development of mitigation works at this location are already well-advanced, further mitigation options are not proposed in this study.

The pre-developed conditions at Black Swan Terrace have been retained in the mitigation case modelling. Post-development hydraulic modelling for this option is being undertaken by others on behalf of Council. Flow conditions in Koonwarra Street, downstream of the works, are not expected to be significantly changed as a result of the proposed works, hence omission of the proposed works from the mitigation case modelling should not affect the assessment of other mitigation options.

7.3.2 Koonwarra Street to Pelican Court, West Haven

This area is identified as a critical flood problem area with significant flooding of properties in Koonwarra Street, Captain Cook Bicentennial Drive villas, Ocean Drive and Pelican Court. The flood hazard is high to very high (H4, some H5) on properties and on roads in the 1% AEP event. The area is highly affected in frequent events such as the 0.2EY event.

Flooding originates from three separate overland flow paths, including one from Black Swan Terrace, a second near Kirmington Terrace and a third from near Hoschke Road. Flow paths 1 and 2 converge in Koonwarra Street and then flow path 3 converges at Pelican Court. Overland flows are about 15m^3/s in flow paths 1 and 2 in total in the 1% AEP event downstream of Koonwarra Street, and 20m^3/s in combined flow paths 1, 2 and 3 in Pelican Court. Existing pipe flows in Pelican Court are 3m^3/s in the 1% AEP event in addition to the overland flows. The existing pipes in the network run full in the 0.2EY event. Flow paths 1 and 2 affect a number of properties throughout this area.

Flow path 3 directly affects two dwellings on Ocean Drive (numbers 384 and 386) near Hoschke Road in addition to contributing to flows in Pelican Court. It includes a 2m wide drainage channel through properties on the higher side of Ocean Drive, draining to a 2.4m x 0.9m box culvert under Ocean Drive, which is the main flow constraint. The culvert conveys 3.7m^3/s in the 1% AEP while another 3.7m^3/s overflows over Ocean Drive. it discharges to the formed swale on the low side of the road before the flows enter Pelican Court.

Floodwaters pond in Pelican Court and flow overland via an access road in addition to through properties to discharge to Queens Lake.

7.3.2.1 Option 4B

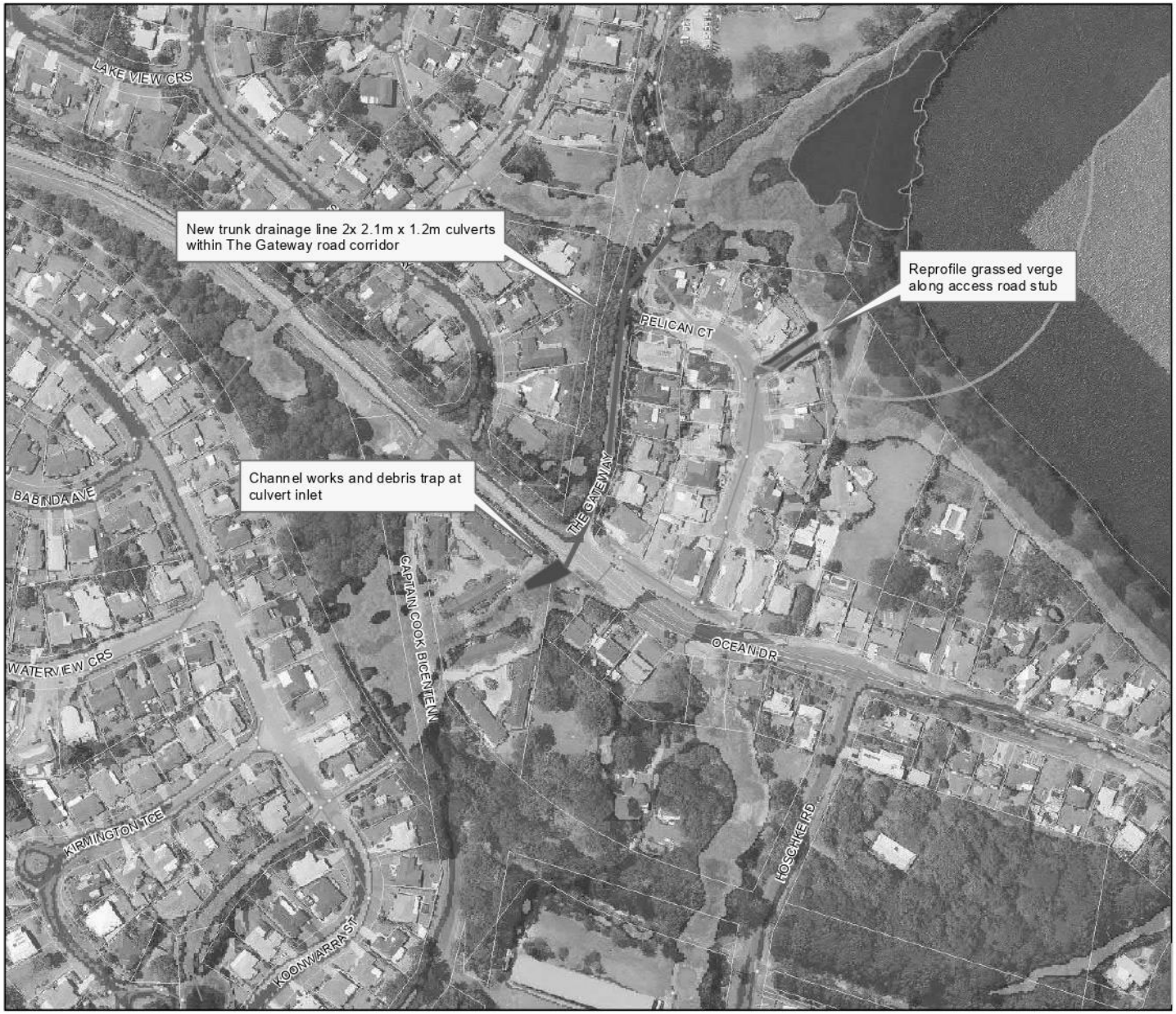
Description

Option 4B consists of new additional trunk drainage line 2x 2.1m x 1.2m box culverts, intercepting flows at downstream end of channel on Captain Cook Bicentennial Drive villas, cross Ocean Drive and run under The Gateway and discharge to receiving waterway to the north of Pelican Court. This proposed culvert capacity would be approximately 11m^3/s which would reduce the total overland flow in Pelican Court by about 50% in the 1% AEP event. An inlet basin/rock debris trap similar to that proposed at Black Swan Terrace may be required. Additionally, reprofiling of the grassed verge along the access road stub between 7 and 9 Pelican Court to allow higher rate of outflow from the Pelican Court sag point would be undertaken. Refer to Figure 7-2 for illustration of the option.

Constraints assessment

- Existing underground utilities in Ocean Drive and The Gateway (Telstra, Optus, NBN, power, stormwater).
- Substantial number of trees in western verge of The Gateway, require removal if running new trunk drainage in the verge.
- Limited space to widen existing channel running through Captain Cook Bicentennial Drive villas.
- Existing power pole on Ocean Drive may require relocation.
- Minimal space for rock debris trap at new trunk drainage inlet structure. Requires more detailed site assessment for potential rock debris loads. There are a number of informal traps upstream (e.g. road crossings) and a discontinuous flow path running off the mountain, so rock debris loads may be low.
- Works would be in the vicinity of CM SEPP Coastal Wetlands and may require approval under Part 4 of the EP&A Act 1979 as designated development, subject to any provisions and exemptions to Council given that Council would be the proponent.

Based on the site constraints, it is assumed that the new trunk drainage line would run under the western side of The Gateway in order to minimise the number of underground services which need to be crossed or protected.



Legend

- Stormwater Pit/Node
- Pipes and Culverts

Coastal Management SEPP 2018

- Coastal Wetlands
- Coastal Wetlands Proximity Area

1% AEP Existing Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0

0 25 50 100 Metres

JACOBS

Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

GDA 1994 MGA Zone 56

TITLE
Option 4B Koonwarra Street to Pelican Court, West Haven

PROJECT
North Brother Local Catchments Flood Study

PROJECT # IA157500

MAP # FIGURE 7-2

DATE 12/02/2021

Hydraulic performance

Flood impact maps, showing the change in flood levels, are presented in Figure 7-3 to Figure 7-5 for the 0.2EY, 5% and 1% AEP events, respectively. The hydraulic performance of Option 4B is summarised in Table 7-1.

Table 7-1 Hydraulic performance of Option 4B

Event AEP	Changes in flood conditions
0.2EY	• Pelican Court – flood levels reduced by -0.2 to -0.4m in roadway and alleyway. Localised reductions only on properties up to -0.1m. • Ocean Drive property - flood levels reduced by -0.4m • Reduced flood hazard from very high (H5) to mostly low (H1, H2) in Pelican Court, some moderate H3 in alleyway.
5% AEP	• Pelican Court – flood levels reduced by -0.3 to -0.5m in roadway and alleyway. Reductions on properties typically to -0.1m, up to -0.3m on four properties. • Ocean Drive property - flood levels reduced by -0.4m • Reduced extent of very high flood hazard (H5) in Pelican Court.
1% AEP	• Pelican Court – flood levels reduced by -0.4 to -0.5m in roadway and alleyway. Reductions of up to -0.4m on 12 properties. • Ocean Drive property - flood levels reduced by -0.5m • Reduced flood hazard on Ocean Drive from up to very high (H5) to low (H2). Note that road may be cut-off in other locations. • Reduced extent of H3-H5 hazard in Pelican Court.
1% AEP plus climate change	Similar performance to 1% AEP event, in terms of reductions in flood levels in mitigated versus existing development case (with climate change). No reduction in performance due to sea level rise.

Summary

Options 4B is effective at reducing flood levels and flood hazard (magnitude and extent) on Ocean Drive and Pelican Court including up to 20 dwellings.

Legend

Change in Flood Level (m)

- < -0.5
- -0.5 - -0.3
- -0.3 - -0.1
- -0.1 - -0.01
- -0.01 - 0.01
- 0.01 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- > 0.5

Change in Flood Extent

- Was Wet Now Dry
- Was Dry Now Wet

0 25 50 100 Metres

JACOBS

Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

GDA 1994 MGA Zone 56

TITLE
Option 4B
Change in Flood Level
0.2EY Event

PROJECT
North Brother Local Catchments Flood Study

PROJECT # IA157500

MAP # FIGURE 7-3

DATE 21/01/2021

Legend

Change in Flood Level (m)

- < -0.5
- -0.5 - -0.3
- -0.3 - -0.1
- -0.1 - -0.01
- -0.01 - 0.01
- 0.01 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- > 0.5

Change in Flood Extent

- Was Wet Now Dry
- Was Dry Now Wet

0 25 50 100 Metres

JACOBS

Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

GDA 1994 MGA Zone 56

TITLE
Option 4B
Change in Flood Level
5% AEP Event

PROJECT
North Brother Local Catchments Flood Study

PROJECT #	MAP #
IA157500	FIGURE 7-4
DATE	
21/01/2021	

Legend

Change in Flood Level (m)

- < -0.5
- -0.5 - -0.3
- -0.3 - -0.1
- -0.1 - -0.01
- -0.01 - 0.01
- 0.01 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- > 0.5

Change in Flood Extent

- Was Wet Now Dry
- Was Dry Now Wet

0 25 50 100 Metres

JACOBS

Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

GDA 1994 MGA Zone 56

TITLE
Option 4B
Change in Flood Level
1% AEP Event

PROJECT
North Brother Local Catchments Flood Study

PROJECT # IA157500

MAP # FIGURE 7-5

DATE 21/01/2021

7.3.3 Tunis Street Overland Flow Path, Laurieton

This overland flow path originates above Blackbutt Crescent and Peach Grove, where a natural gully overflows into a constructed diversion channel which skirts around properties on Blackbutt Crescent and conveys flows through an easement to Peach Grove at Tunis Street. There is an existing low capacity pipe (375mm diameter) draining the flows in the easement to the existing drainage system. Flows in excess of the overland flow path spill out onto properties on Peach Grove and contribute to flooding at the main complex at Laurieton retirement village, although flooding at this complex is exacerbated by partially-trapped drainage low points.

The main flow path splits around Gow Place and Norman Street/Tunis Street intersection, with the northern branch flowing through the Laurieton retirement village villas and exiting around Kew Road at Castle Street, and the southern branch draining to the sag point on Bold Street at Tunis Street, and then joining a separate flow path through commercial and residential properties on Bold Street to McLennan Street.

The main stormwater drainage line consists of up to 900mm diameter pipe in Tunis Street, draining to the river.

Peak overland flows in these flow paths are summarised in Table 7-2.

Table 7-2 Peak flood flows at Tunis Street overland flow path

Location	Event AEP		
	0.2EY	5% AEP	1% AEP
Upstream of Peach Grove	5.2	9.4	14.1
Tunis Street at Peach Grove	3.5	6.2	9.2
Gow Street branch	1.8	3.2	5.0
Tunis Street and natural gully at Lord Street	2.1	4.1	7.1

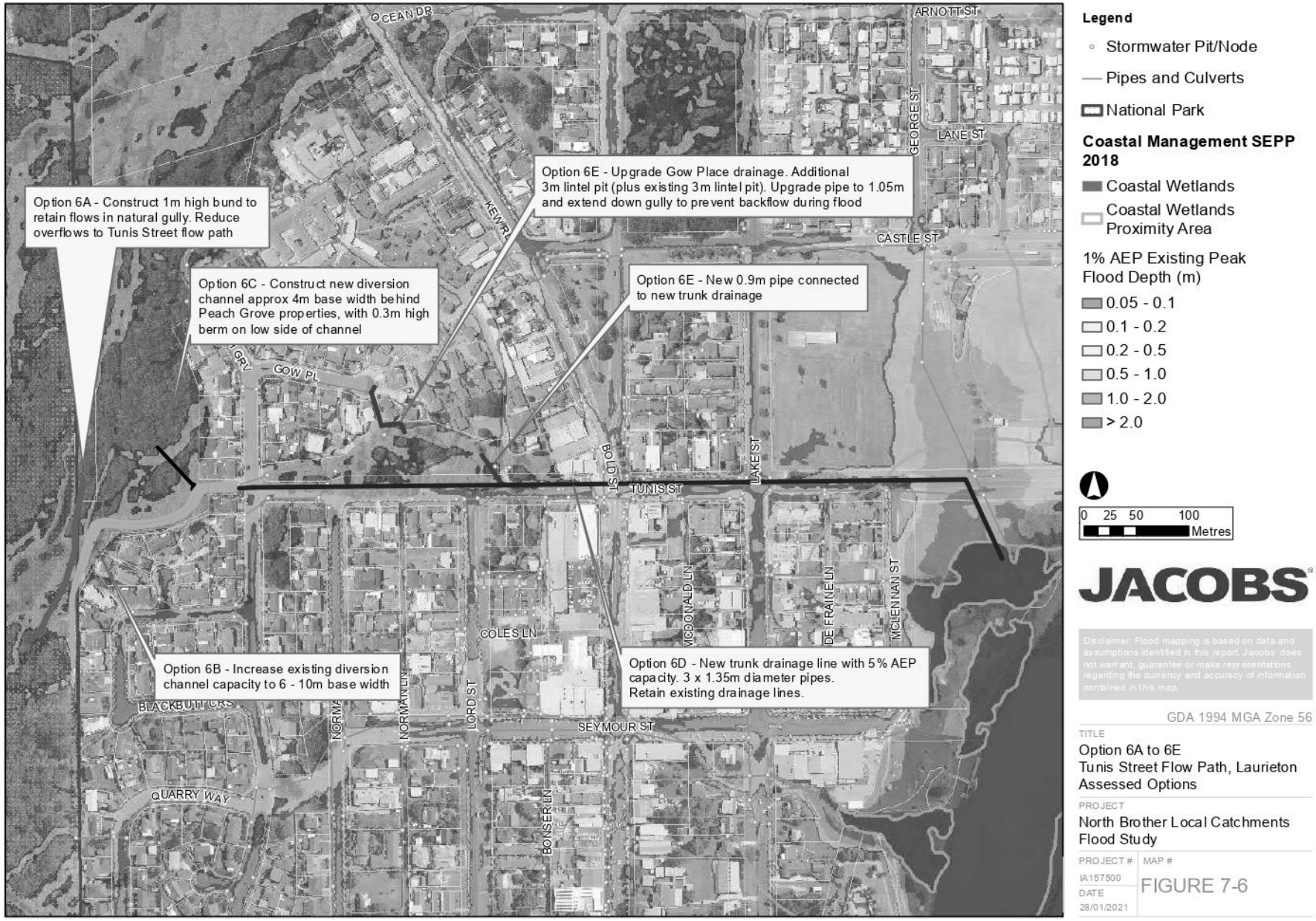
7.3.3.1 Option 6A

Description of Options

Option 6A was assessed individually:

- Option 6A – construct/raise a 160m long berm, up to 1m high above existing ground levels, between the natural flow path and the diversion channel above Blackbutt Crescent to reduce overflows into the diversion channel and hence reduce flows through the properties downstream. However, this option is expected to increase the flows being directed toward St Josephs School.

Refer to Figure 7-6 for illustration of Option 6A. The figure also describes Options 6B to 6E, refer to Section 7.3.3.2 for details.


Option 6A - Construct 1m high bund to retain flows in natural gully. Reduce overflows to Tunis Street flow path
Option 6C - Construct new diversion channel approx 4m base width behind Peach Grove properties, with 0.3m high berm on low side of channel
Option 6E - Upgrade Gow Place drainage. Additional 3m lintel pit (plus existing 3m lintel pit). Upgrade pipe to 1.05m and extend down gully to prevent backflow during flood
Option 6E - New 0.9m pipe connected to new trunk drainage
Option 6B - Increase existing diversion channel capacity to 6 - 10m base width
Option 6D - New trunk drainage line with 5% AEP capacity. 3 x 1.35m diameter pipes. Retain existing drainage lines.
OCEAN DR
ARNOTT ST
GEORGE ST
LANE ST
CASTLE ST
KEWELL
GOW PL
BOLD ST
TUNIS ST
LAKE ST
COLES LN
MCDONALD LN
DE FRAINE LN
MCLENNAN ST
NORMAN LN
LORD ST
SEYMOUR ST
BONSER LN
QUARRY WAY
BLACKBUTT CRS
Legend
Stormwater Pit/Node
Pipes and Culverts
National Park
Coastal Management SEPP 2018
Coastal Wetlands
Coastal Wetlands Proximity Area
1% AEP Existing Peak Flood Depth (m)
0.05 - 0.1
0.1 - 0.2
0.2 - 0.5
0.5 - 1.0
1.0 - 2.0
> 2.0
0 25 50 100
Metres
JACOBS
Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.
GDA 1994 MGA Zone 56
TITLE
Option 6A to 6E
Tunis Street Flow Path, Laurieton
Assessed Options
PROJECT
North Brother Local Catchments
Flood Study
PROJECT #
IA157500
MAP #
FIGURE 7-6
DATE
28/01/2021

Constraints assessment

- Option 6A would need to be constructed within the national park area, likely requiring removal of a large number of trees for the proposed bund in addition to site access for construction plants.
- The option would be constructed on a natural berm which appears to be formed from flood-flow deposits of rock rubble and other material. Geotechnical conditions may be challenging.
- Periodic maintenance of the proposed bund would be required.

Hydraulic performance

Flood impact maps, showing the change in flood levels, are presented in Figure 7-7 to Figure 7-9 for the 0.2EY, 5% and 1% AEP events, respectively. The hydraulic performance of Option 6A is summarised in Table 7-3.

Table 7-3 Hydraulic performance of Options 6A

Event AEP	Changes in flood conditions
0.2EY	• Reductions in flood levels of -0.05 to -0.1m on Gow Place properties and Laurieton retirement village villas. • Localised reductions of up to -0.4m on Peach Grove properties. • Minor reductions of up to -0.05m on residential and commercial properties on and to the east of Ocean Drive. • Widespread minor increases of +0.02m on St Josephs School grounds.
5% AEP	• Reductions in flood levels of -0.05 to -0.2m on Gow Place properties and Laurieton retirement village villas, some localised areas greater than -0.02m. Reductions of -0.03m at Laurieton retirement village main facility. • Localised reductions of up to -0.4m on Peach Grove properties. One property experiences minor increases of less than +0.02m. • Minor reductions of up to -0.06m on residential and commercial properties on and to the east of Ocean Drive. • Widespread increases of +0.03 to +0.07m on St Josephs School grounds.
1% AEP	• Reductions in flood levels of -0.05 to -0.2m on Gow Place properties and Laurieton retirement village villas, some localised areas greater than -0.02m. Reductions of -0.1m at Laurieton retirement village main facility. • Localised reductions of up to -0.4m on Peach Grove properties. One property experiences minor increases of less than +0.02m. • Minor reductions of up to -0.06m on residential and commercial properties on and to the east of Ocean Drive. • Widespread increases of +0.03 to +0.07m on St Josephs School grounds.
1% AEP plus climate change	Similar performance to 1% AEP event, in terms of reductions in flood levels in mitigated versus existing development case (with climate change). No reduction in performance due to sea level rise.

Summary

While there are minor to modest (up to -0.2m) reductions in flood levels on a large number of residential properties, these are offset by minor increases (+0.03 to +0.07m) on St Joseph's School. An engineered berm in the national park is likely to result in vegetation impacts and requires consultation with NPWS. A permanent access track would be required for ongoing maintenance.

Legend

Change in Flood Level (m)

- < -0.5
- -0.5 - -0.3
- -0.3 - -0.1
- -0.1 - -0.01
- -0.01 - 0.01
- 0.01 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- > 0.5

Change in Flood Extent

- Was Wet Now Dry
- Was Dry Now Wet

0 25 50 100 Metres

JACOBS

Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

GDA 1994 MGA Zone 56

TITLE
Option 6A
Change in Flood Level
0.2EY Event

PROJECT
North Brother Local Catchments Flood Study

PROJECT #	MAP #
IA157500	FIGURE 7-7
DATE	
21/01/2021	

Legend

Change in Flood Level (m)

- < -0.5
- -0.5 - -0.3
- -0.3 - -0.1
- -0.1 - -0.01
- -0.01 - 0.01
- 0.01 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- > 0.5

Change in Flood Extent

- Was Wet Now Dry
- Was Dry Now Wet

0 25 50 100 Metres

JACOBS

GDA 1994 MGA Zone 56

TITLE
Option 6A
Change in Flood Level
5% AEP Event

PROJECT
North Brother Local Catchments Flood Study

PROJECT #	MAP #
IA157500	FIGURE 7-8
DATE 21/01/2021	

Legend

Change in Flood Level (m)

- < -0.5
- -0.5 - -0.3
- -0.3 - -0.1
- -0.1 - -0.01
- -0.01 - 0.01
- 0.01 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- > 0.5

Change in Flood Extent

- Was Wet Now Dry
- Was Dry Now Wet

0 25 50 100 Metres

JACOBS

Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

GDA 1994 MGA Zone 56

TITLE
Option 6A
Change in Flood Level
1% AEP Event

PROJECT
North Brother Local Catchments Flood Study

PROJECT # IA157500

MAP # FIGURE 7-9

DATE 21/01/2021

7.3.3.2 Option 6B+6C+6D+6E

Description of Options

The following options were assessed in combination (Options 6B+6C+6D+6E):

- Option 6B – increase the existing diversion channel capacity behind Blackbutt Crescent properties to reduce overflows onto properties, achieved by a combination of widening the existing channel to a base width of 6 – 10m (current base width 3 – 5m, top width 5 – 8m), raising the banks (e.g. block retaining wall along the property boundaries) and clearing of vegetation in the channel.
- Option 6C – construct new diversion channel 3m base width and 1m deep behind Peach Grove properties north of Tunis Street to direct flows south to the easement at the end of Tunis Street. This is outside of the national park. Form a bund on the lower side of the channel to increase capacity.
- Option 6D – install new trunk drainage line from the easement down Tunis Street to discharge to the river (approximately 740m). A new line consisting of 3 x 1.35m diameter pipes has been assessed, having a system capacity of approximately 5% AEP (about 9.5m^3/s) and would reduce the 1% AEP overland flows through downstream properties by about 67%. A rock debris trap/basin would need to be constructed at the trunk drainage inlet to reduce the inlet blockage risk.
- Option 6E – upgrade drainage in Gow Place cul-de-sac to reduce overflows through properties and the retirement village villas. The existing drainage consists of a 450mm pipe which drains through an easement and discharges to open space between Gow Place and Tunis Street. There is an existing 3m lintel pit inlet plus smaller approximately 1m lintel inlets. Replacing one of these smaller inlets with a second 3m lintel is proposed. The existing 450mm pipe is proposed to be upgraded to 1.05m pipe and extended to discharge further down the gully to prevent backflow into the cul-de-sac. A 900mm pipe connection from the gully to the new trunk drainage line is proposed.

Constraints assessment

- Option 6B - Works would need to be undertaken on the edge of the national park land for a 100m section of the upgraded channel. The channel is assumed to be grassed and would need to be maintained to ensure limited vegetation growth.
- Option 6C - The channel is assumed to be grassed and would need to be maintained to ensure limited vegetation growth.
- Option 6D – There are numerous existing underground utilities (Telstra, Optus, NBN, power, stormwater) under Tunis Street and adjoining streets. Approximately 10 crossings of the utilities are identified and would need to be protected. It is assumed that the existing utilities are at sufficiently shallow depth to enable the new trunk drainage to be laid beneath. Trench construction methods are assumed for the whole alignment. Deep trenching (up to 3m) with temporary shoring is likely to be required for sections of the alignment. Pipe jacking installation could be considered in the section between Lord Street and Lake Street (about 200m) to allow the road access to remain open (e.g. Coles loading dock), although construction cost would be significantly greater. Design and construction will need to minimise traffic impacts including delivery truck access to Coles Supermarket loading dock. A rock debris trap/basin would need to be constructed at the trunk drainage inlet to reduce the inlet blockage risk.
- Works would be within and in the vicinity of CM SEPP Coastal Wetlands and may require approval under Part 4 of the EP&A Act 1979 as designated development, subject to any provisions and exemptions to Council given that Council would be the proponent.

A structural assessment was undertaken for Option 6D due to the space constraints related to this option. Relevant findings are summarised below:

- The existing buildings are single storey and are likely to have shallow foundations. The construction zone of construction access & excavation for the proposed 3x 1.35m diameter pipes would need to extend approx. 3m to 5m from the edge of the new pipes to limit effect to the existing buildings. For open cut sections this construction zone would take up most of the two lanes of Tunis Street and footpaths i.e. 11m to 15m wide. Appropriate traffic diversions would be required.

- Vibration due to construction activities can be a concern and a detailed structural inspection of the existing buildings should be conducted to assess if some areas of the existing buildings are more susceptible to such vibration. The construction techniques can then be chosen to limit effects in these vibration sensitive zones.
- The soils in this location are likely to be high acid-sulphate. Trial pitting and geotechnical investigation and interpretation should be carried out by to confirm risks and mitigation measures.

Overall, it is considered feasible to construct 3x 1.35m diameter stormwater flood control pipes underground along Tunis Street. The width and depth of excavation for the pipes would be considerable taking up most of Tunis Street and footpaths. Controls would need to be put in place for environmental considerations and for the structural integrity of existing buildings during construction. Consideration could be given to the option for 2x larger pipes to limit the width of excavation and zone of construction activities. The other alternative would be for rectangular box culverts where open cut & cover excavation might be considered – this may offer some advantages in terms of width of excavation but would require a substantial structural cover slab to withstand the vehicular loadings.

Hydraulic performance

Flood impact maps, showing the change in flood levels, are presented on Figure 7-10 to Figure 7-12 for the 0.2EY, 5% and 1% AEP events, respectively. The hydraulic performance of Option 6B+6C+6D+6E is summarised in Table 7-4.

Table 7-4 Hydraulic performance of Options 6B+6C+6D+6E

Event AEP	Changes in flood conditions
0.2EY	• Reductions in flood levels of up to -0.3m on Gow Place properties and Laurieton retirement village villas, including substantial reductions in flood extent. • Reductions in flood levels of up to -0.4m on Peach Grove properties including reductions in flood extent. • Minor reductions of up to -0.05m on residential and commercial properties on and to the east of Kew Road/Bold Street.
5% AEP	• Reductions in flood levels of up to -0.3m on Gow Place properties and Laurieton retirement village villas, including substantial reductions in flood extent. • Reductions in flood levels of up to -0.5m on Peach Grove properties including reductions in flood extent. • Reductions of -0.05 to -0.1m on residential and commercial properties on and to the east of Ocean Drive, with some localised reductions of -0.2m. • Removal of areas of very high hazard (up to H5) in road and on properties between Peach Grove and to the east of Kew Road/Bold Street.
1% AEP	• Reductions in flood levels of up to -0.4m on Gow Place properties and Laurieton retirement village villas, including some reductions in flood extent. • Reductions in flood levels of up to -0.5m on Peach Grove and Blackbutt Crescent properties including reductions in flood extent. Localised reductions of up to -0.7m. • Reductions of -0.1 to -0.2m on residential and commercial properties on and to the east of Ocean Drive. • Removal of areas of very high hazard (up to H5) in road and on properties between Blackbutt Crescent/Peach Grove and to the east of Kew Road/Bold Street.
1% AEP plus climate change	Generally similar performance to 1% AEP event, in terms of reductions in flood levels in mitigated versus existing development case (with climate change). Slight reduction in performance due to sea level rise in low elevation areas below 3m AHD, where the

	reductions fall from -0.07m in the current climate case to -0.01m in the climate change scenario.

Summary on performance

The combined option 6B+6C+6D+6E provides substantial reductions in flood levels, extents and hazard as a result of significant drainage capacity upgrades. There are minor reductions in flood levels in low-lying areas as a result of sea level rise in the climate change scenario.

Legend

Change in Flood Level (m)

- < -0.5
- -0.5 - -0.3
- -0.3 - -0.1
- -0.1 - -0.01
- -0.01 - 0.01
- 0.01 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- > 0.5

Change in Flood Extent

- Was Wet Now Dry
- Was Dry Now Wet

0 25 50 100 Metres

JACOBS

Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

GDA 1994 MGA Zone 56

TITLE
Option 6B+6C+6D+6E
Change in Flood Level
0.2EY Event

PROJECT
North Brother Local Catchments Flood Study

PROJECT # IA157500

MAP # FIGURE 7-10

DATE 21/01/2021

Legend

Change in Flood Level (m)

- < -0.5
- -0.5 - -0.3
- -0.3 - -0.1
- -0.1 - -0.01
- -0.01 - 0.01
- 0.01 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- > 0.5

Change in Flood Extent

- Was Wet Now Dry
- Was Dry Now Wet

0 25 50 100
Metres

JACOBS

Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

GDA 1994 MGA Zone 56

TITLE
Option 6B+6C+6D+6E
Change in Flood Level
5% AEP Event

PROJECT
North Brother Local Catchments Flood Study

PROJECT # IA157500

MAP # FIGURE 7-11

DATE 21/01/2021

Legend

Change in Flood Level (m)

- < -0.5
- -0.5 - -0.3
- -0.3 - -0.1
- -0.1 - -0.01
- -0.01 - 0.01
- 0.01 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- > 0.5

Change in Flood Extent

- Was Wet Now Dry
- Was Dry Now Wet

0 25 50 100 Metres

JACOBS

Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

GDA 1994 MGA Zone 56

TITLE
Option 6B+6C+6D+6E
Change in Flood Level
1% AEP Event

PROJECT
North Brother Local Catchments Flood Study

PROJECT # IA157500

MAP # FIGURE 7-12

DATE 21/01/2021

7.3.4 Lake Street at Seymour Street, Laurieton

The corner property at this location receives overland flows and trunk drainage flows from the Quarry Way flow path. There is an open channel and flow path through this property, where the dwelling is surrounded by high hazard flooding to depths of over 1m in the 1% AEP event. The floodwaters pond behind the raised road crest in Lake Street before overflowing over the road and around the southern side of the Laurieton United Services Club. It is identified as being affected by above-floor flooding.

The drainage at this location includes 2x 1.5m x 0.75m box culverts at the inlet at the downstream end of the channel through this property, turning into 2x 1200mm pipes crossing Lake Street, which then increase to 2x 1500mm pipes on the low side of the road and discharging to a channel on the southern side of the Services Club.

7.3.4.1 Option 8B

Description of Options

Option 8B was selected for assessment. The culvert inlet is currently unscreened and has been modelled as 50% blocked due to likely debris blockage. A large-faced debris screen or other debris controls are proposed to retrofit the existing culvert inlet to reduce the risk of blockage. The debris screen is assumed to be effective and has been represented with a reduced blockage factor of 10%.

Refer to Figure 7-13 for illustration.

Constraints assessment

Works would be in the vicinity of CM SEPP Coastal Wetlands and may require approval under Part 4 of the EP&A Act 1979 as designated development, subject to any provisions and exemptions to Council given that Council would be the proponent.

Inspection and maintenance after significant storm events are required to increase reliability.

Hydraulic performance

Flood impact maps, showing the change in flood levels, are presented on Figure 7-14 to Figure 7-16 for the 0.2EY, 5% and 1% AEP events, respectively. The hydraulic performance of Option 8B is summarised in Table 7-5.

Table 7-5 Hydraulic performance of Options 8B

Event AEP	Changes in flood conditions
0.2EY	• Minor reductions of -0.03m on private property dwelling and Laurieton United Services Club side entrance. • Reductions of up to -0.1m on Lake Street
5% AEP	• Reductions of -0.08m on private property dwelling and -0.13m at Laurieton United Services Club side entrance. • Reductions of up to -0.1m on Lake Street • Minor increases of less than -0.02m on some private properties and parts of club property due to reduced drainage capacity of local stormwater drainage branches.
1% AEP	• Reductions of -0.1m on private property dwelling and Laurieton United Services Club side entrance. • Reductions of up to -0.1m on Lake Street. • Minor localised increases of less than -0.02m on some private properties due to reduced drainage capacity of local stormwater drainage branches.
1% AEP plus climate change	Similar performance to 1% AEP event, in terms of reductions in flood levels in mitigated versus existing development case (with climate change). No reduction in performance due to sea level rise.

Summary on performance

Option 8B provides minor to modest improvements (up to -0.1m) in flooding conditions with benefits confined to one residential property. The spatial extent of the reductions in flood levels at the Services Club are limited to the western side entrance on Lake Street, while there are no changes in flood levels along the main northern side of the club building. The effect of the proposed inlet debris screen is constrained by the limited capacity of the existing culverts crossing the road.

While the debris screen proposed as Option 8B provides at best modest improvements to flooding conditions to property and the road, it could be considered by Council as a low-cost measure to reduce the risk of severe blockage of the culvert inlet at this and other locations in the study area.


SEYMOUR LN
MCDONALD LN
SEYMOUR ST
DE FRAINE LN
LAKE ST
Option 8B - Install large-faced debris screen on inlet. Currently unscreened
Legend
Stormwater Pit/Node
Pipes and Culverts
Coastal Management SEPP 2018
Coastal Wetlands
Coastal Wetlands Proximity Area
1% AEP Existing Peak Flood Depth (m)
0.05 - 0.1
0.1 - 0.2
0.2 - 0.5
0.5 - 1.0
1.0 - 2.0
> 2.0
0 10 20 40
Metres
JACOBS
Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.
GDA 1994 MGA Zone 56
TITLE
Option 8B Lake Street at Seymour Street, Laurieton Assessed Options
PROJECT
North Brother Local Catchments Flood Study
PROJECT # IA157500
MAP # FIGURE 7-13
DATE 28/01/2021

Legend

Change in Flood Level (m)

- < -0.5
- -0.5 - -0.3
- -0.3 - -0.1
- -0.1 - -0.01
- -0.01 - 0.01
- 0.01 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- > 0.5

Change in Flood Extent

- Was Wet Now Dry
- Was Dry Now Wet

0 10 20 40
Metres

JACOBS

Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

GDA 1994 MGA Zone 56

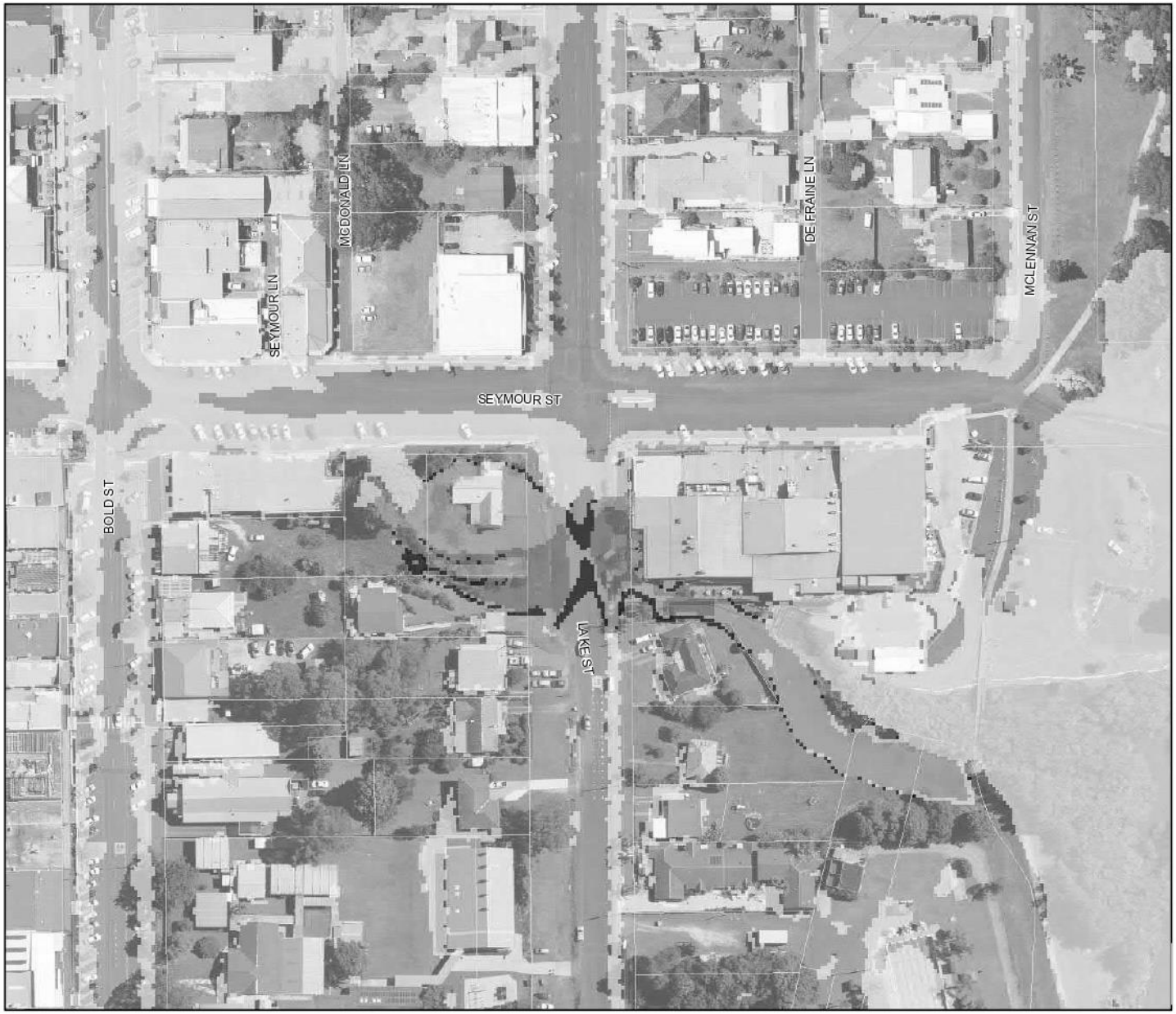
TITLE
Option 8B
Change in Flood Level
0.2EY Event

PROJECT
North Brother Local Catchments Flood Study

PROJECT # IA157500

MAP # FIGURE 7-14

DATE 21/01/2021



Legend

Change in Flood Level (m)

- < -0.5
- -0.5 - -0.3
- -0.3 - -0.1
- -0.1 - -0.01
- -0.01 - 0.01
- 0.01 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- > 0.5

Change in Flood Extent

- Was Wet Now Dry
- Was Dry Now Wet

0 10 20 40
Metres

JACOBS

Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

GDA 1994 MGA Zone 56

TITLE
Option 8B
Change in Flood Level
5% AEP Event

PROJECT
North Brother Local Catchments Flood Study

PROJECT # IA157500

MAP # FIGURE 7-15

DATE 21/01/2021

Legend

Change in Flood Level (m)

- < -0.5
- -0.5 - -0.3
- -0.3 - -0.1
- -0.1 - -0.01
- -0.01 - 0.01
- 0.01 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- > 0.5

Change in Flood Extent

- Was Wet Now Dry
- Was Dry Now Wet

0 10 20 40
Metres

JACOBS

Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

GDA 1994 MGA Zone 56

TITLE
Option 8B
Change in Flood Level
1% AEP Event

PROJECT
North Brother Local Catchments Flood Study

PROJECT #	MAP #
IA157500	FIGURE 7-16
DATE	
21/01/2021	

7.3.5 St Joseph's School, Laurieton

Flooding at the school results from natural flow paths being directed down to Ocean Drive to three culvert crossings. The culverts discharge on the low side of the road and along with road overflows, overland flooding passes through the school in three main flow paths, including one through the main cluster of school administration and classroom buildings. Council's stormwater drainage spatial layer does not show an existing underground trunk drainage conveying flows though the school grounds, although from review of aerial photography there appears to be drainage pits connected to a privately-owned system. Flows exceed 0.5m deep in the 1% AEP event with areas of very high (H5) flood hazard.

Peak overland flows in these flow paths are summarised in Table 7-6.

Table 7-6 Peak flood flows in overland flow paths at St Joseph's School

Location	Event AEP		
	0.2EY	5% AEP	1% AEP
Northern flow path (admin bldg.)	4	5.5	8
Middle flow path	5.5	6.5	8.5
Southern flow path	8.5	10	12.5
Total	17.5	22	29

Refer to Figure 7-17 for illustration of options.


HENRY KENDALL DR
INVESTIGATOR WAY
FLINDERS DR
BASS AVE
BAYSIDE CCT
OCEAN DR
Option 9B - New trunk drainage line 2x 3m x 1.2m box culvert including upgrade of Ocean Drive culverts. Alternative to Option 9A. Retain existing shallow overland flow path through school.
Provide inlet rock debris trap/basin.
Option 9A - Upgrade Ocean Drive culverts to 2 x 3m x 1.2m box culvert and widen existing open channel to 10m top width with 8m base width.
Provide inlet rock debris trap/basin.
Legend
Stormwater Pit/Node
Pipes and Culverts
Coastal Management SEPP 2018
Coastal Wetlands
Coastal Wetlands Proximity Area
1% AEP Peak Flood Depth (m)
0.05 - 0.1
0.1 - 0.2
0.2 - 0.5
0.5 - 1.0
1.0 - 2.0
> 2.0
0 25 50 100
Metres
JACOBS
Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.
GDA 1994 MGA Zone 56
TITLE
Options 9A and 9B
St Joseph's School, Laurieton
Assessed Options
PROJECT
North Brother Local Catchments Flood Study
PROJECT # IA157500
MAP # FIGURE 7-17
DATE 28/01/2021

7.3.5.1 Option 9A

Description of Option

Option 9A was assessed, involving widening and reconstruction of a landscaped open channel in the southern flow path. The southern flow path and road cross culvert is the main flow path and there is a formalised open channel provided for this flow path. The proposed channel would have an 8m base width (about 10m top width) and a depth of 1 – 1.5m. The existing channel has an approximately 6 – 8m top width with variable base width.

Box culverts were originally proposed for this site to fit under the existing channel, however, elevations are too low to fit such a culvert option while maintaining a surface flow path.

A rock debris trap/basin would need to be constructed at the Ocean Drive culvert inlet to reduce the inlet blockage risk.

Constraints assessment

There are a number of existing structures and features including buildings, footbridges, car parks and paths which would be potentially affected or considered in the design of Option 9A. The minimum clearance between buildings or other existing structures is about 19m.

The existing buildings are single storey and are likely to have shallow foundations. Additionally, one of the buildings is an existing old church building believed to be around 120 years old. The construction access & excavation zone for the proposed channel widening would need to extend approximately 3 – 5m from the edge of the channel to limit effect to the existing buildings.

Vibration due to construction activities can be a concern and a detailed structural inspection of the existing buildings should be conducted to assess if some areas of the existing buildings are more susceptible to such vibration. The final alignment of the proposed culvert can then be chosen to avoid these vibration sensitive zones.

The sediments adjacent to the school may be mildly contaminated. The soils in this location are likely to be high acid-sulphate. Trial pitting and geotechnical investigation and interpretation should be undertaken to confirm risks and mitigation measures.

There will be numerous building stormwater drains discharging into the existing open channels in the school grounds and these will need to be surveyed and coordinated with the design of the modified open channel.

The existing channel and its banks appear to be landscaped with well-established gardens, which are likely to be of high value to the school and adjacent church. The option needs to include landscaping to re-establish the gardens.

There are existing utilities along Ocean Drive (Optus, Telstra, NBN, power) which cross the existing culverts under the road. It is assumed that sufficient clearance from the utilities can be maintained if the upgraded culverts are installed at a similar elevation.

The channel through the mangrove/wetland areas would need to be widened downstream to Stingray Creek to accommodate increased flood flows and this would have localised impacts on sensitive habitats. Culvert and channel works would be within and in the vicinity of CM SEPP Coastal Wetlands and may require approval under Part 4 of the EP&A Act 1979 as designated development, subject to any provisions and exemptions to Council given that Council would be the proponent.

The school grounds have dense tree coverage which will inhibit construction access. Existing trees will need to be protected during the construction works. It is anticipated that that a REF will be required and would need a flora and fauna study.

Hydraulic performance

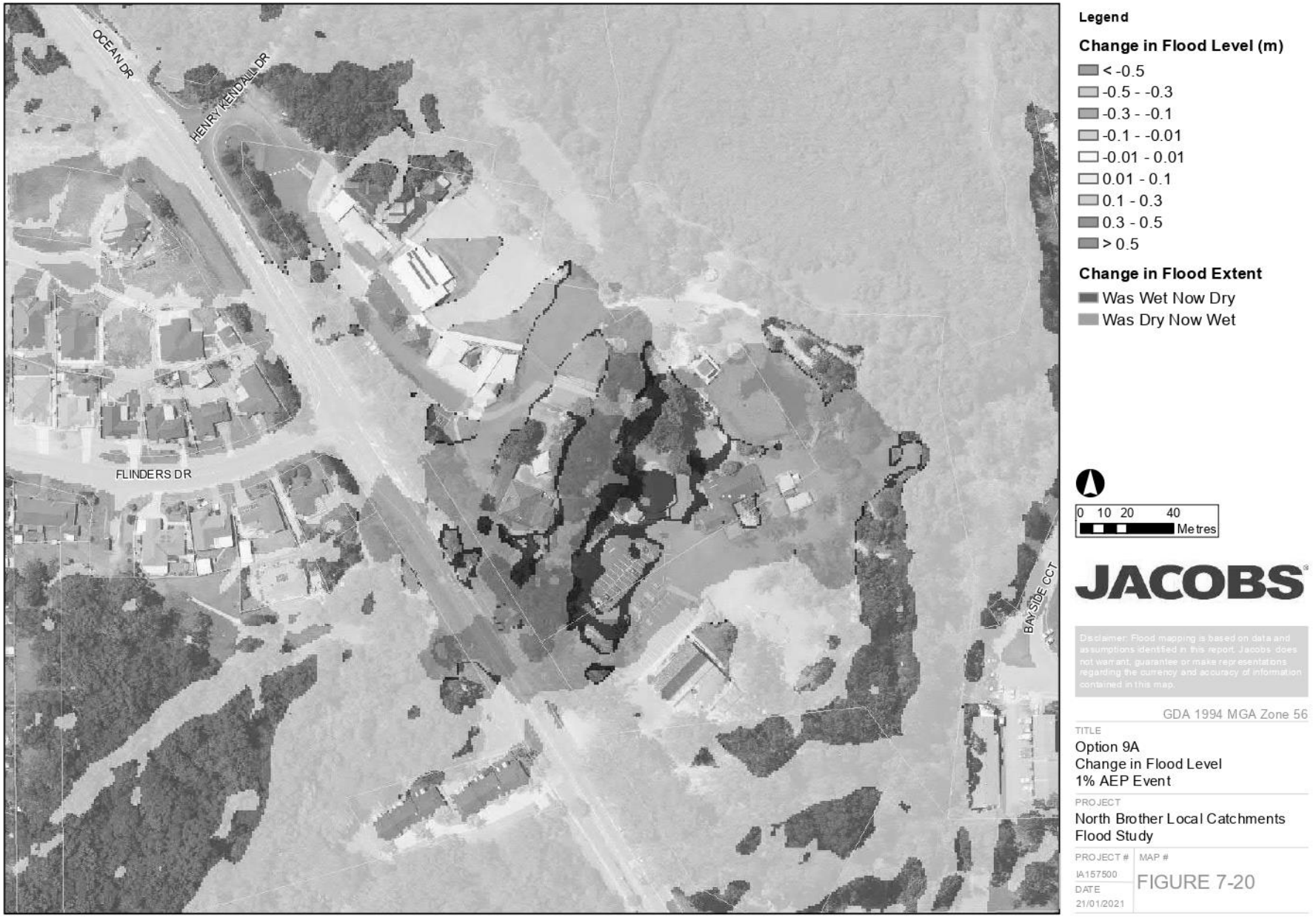
Flood impact maps, showing the change in flood levels, are presented on Figure 7-18 to Figure 7-20 for the 0.2EY, 5% and 1% AEP events, respectively. The hydraulic performance of Option 9A is summarised in Table 7-7.

Table 7-7 Hydraulic performance of Options 9A

Event AEP	Changes in flood conditions
0.2EY	• Maximum decreases of -0.4 to -0.5m in the channel (southern flow path) upstream and downstream of Ocean Drive culvert crossing, with reductions in flood extent • Decrease of -0.02 to -0.06m at and between school buildings, minimal reduction in flood extent • Some reduction in high-very high hazard extent in southern and middle flow paths including on walkways, minimal reduction in flood hazard around school office (only localised high hazard in existing case and mostly low hazard)
5% AEP	• Maximum decreases of -0.3 to -0.4m in the channel (southern flow path) upstream and downstream of Ocean Drive culvert crossing, with reductions in flood extent • Decrease of -0.02 to -0.08m at and between school buildings, minimal reduction in flood extent • Some reduction in high-very high hazard extent in southern and middle flow paths including on walkways, minimal reduction in flood hazard around school office (only localised high hazard in existing case and mostly low hazard)
1% AEP	• Maximum decreases of -0.3 to -0.4m in the channel (southern flow path) upstream and downstream of Ocean Drive culvert crossing, with reductions in flood extent • Decrease of -0.02 to -0.08m at and between school buildings, minimal reduction in flood extent • Some reduction in high-very high hazard extent in southern and middle flow paths including on walkways, minimal reduction in flood hazard around school office (only localised high hazard in existing case and mostly low hazard)
1% AEP plus climate change	Similar performance to 1% AEP event, in terms of reductions in flood levels in mitigated versus existing development case (with climate change). No reduction in performance due to sea level rise.


OCEAN DR
HENRY KENDALL DR
FLINDERS DR
BAYSIDE CCT
Legend
Change in Flood Level (m)
< -0.5
-0.5 - -0.3
-0.3 - -0.1
-0.1 - -0.01
-0.01 - 0.01
0.01 - 0.1
0.1 - 0.3
0.3 - 0.5
> 0.5
Change in Flood Extent
Was Wet Now Dry
Was Dry Now Wet
0 10 20 40
Metres
JACOBS
Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.
GDA 1994 MGA Zone 56
TITLE
Option 9A
Change in Flood Level
0.2EY Event
PROJECT
North Brother Local Catchments Flood Study
PROJECT #
IA157500
MAP #
FIGURE 7-18
DATE
21/01/2021


OCEAN DR
HENRY KENDALL DR
FLINDERS DR
BAYSIDE CCT
Legend
Change in Flood Level (m)
< -0.5
-0.5 - -0.3
-0.3 - -0.1
-0.1 - -0.01
-0.01 - 0.01
0.01 - 0.1
0.1 - 0.3
0.3 - 0.5
> 0.5
Change in Flood Extent
Was Wet Now Dry
Was Dry Now Wet
0 10 20 40
Metres
JACOBS
Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.
GDA 1994 MGA Zone 56
TITLE
Option 9A
Change in Flood Level
5% AEP Event
PROJECT
North Brother Local Catchments Flood Study
PROJECT #
IA157500
MAP #
FIGURE 7-19
DATE
12/02/2021


OCEAN DR
HENRY KENDALL DR
FLINDERS DR
BAYSIDE CCT
Legend
Change in Flood Level (m)
< -0.5
-0.5 - -0.3
-0.3 - -0.1
-0.1 - -0.01
-0.01 - 0.01
0.01 - 0.1
0.1 - 0.3
0.3 - 0.5
> 0.5
Change in Flood Extent
Was Wet Now Dry
Was Dry Now Wet
0 10 20 40
Metres
JACOBS
Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.
GDA 1994 MGA Zone 56
TITLE
Option 9A
Change in Flood Level
1% AEP Event
PROJECT
North Brother Local Catchments Flood Study
PROJECT #
IA157500
MAP #
FIGURE 7-20
DATE
21/01/2021

7.3.5.2 Option 9B

Description of Option

An alternative option to 9A is option 9B, consisting of installation of 2x 3m x 1.2m box culverts beneath the middle flow path. There is an existing shallow overland flow path through this alignment and it was assumed that this could be retained. The culverts would need to fit between existing school buildings. A rock debris trap/basin would need to be constructed at the Ocean Drive culvert inlet to reduce the inlet blockage risk.

Constraints assessment

The culverts would need to fit between two existing buildings and require reconstruction of a vehicle access driveway to one of the buildings. There is 16m clearance between the buildings. The existing buildings are single storey and are likely to have shallow foundations. The construction access and excavation zone for the proposed culverts would need to extend approximately 3 – 5m from the edge of the proposed culverts to limit effect to the existing buildings.

Vibration due to construction activities can be a concern and a detailed structural inspection of the existing buildings should be conducted to assess if some areas of the existing buildings are more susceptible to such vibration. The final alignment of the proposed culvert can then be chosen to avoid these vibration sensitive zones. Overall, the excavation for the proposed 1.2m deep box culverts can be located at least 5m from the existing structures which should, subject to investigations, not interfere with the existing building foundations.

The sediments adjacent to the school may be mildly contaminated. The soils in this location are likely to be high acid-sulphate. Trial pitting and geotechnical investigation and interpretation should be carried out by to confirm risks and mitigation measures.

There will be numerous building stormwater drains discharging into the existing open channels in the school grounds and these will need to be surveyed and coordinated with the design of the modified open channel.

There appears to be an existing pit and pipe drainage line beneath the middle flow path, which may need to be relocated for installation of the box culverts. This line should be maintained for local drainage.

There are existing utilities along Ocean Drive (Optus, Telstra, NBN, power) which cross the existing culverts under the road. It is assumed that sufficient clearance from the utilities can be maintained if the upgraded culverts are installed at a similar elevation.

The channel through the mangrove/wetland areas would need to be widened downstream to Stingray Creek to accommodate increased flood flows and this would have localised impacts on sensitive habitats. Culvert and channel works would be within and in the vicinity of CM SEPP Coastal Wetlands and may require approval under Part 4 of the EP&A Act 1979 as designated development, subject to any provisions and exemptions to Council given that Council would be the proponent.

Appropriate rock scour protection would be required at the culvert outlet.

Hydraulic performance

Flood impact maps, showing the change in flood levels, are presented on Figure 7-21 to Figure 7-23 for the 0.2EY, 5% and 1% AEP events, respectively. The hydraulic performance of Option 9B is summarised in Table 7-8.

Table 7-8 Hydraulic performance of Options 9B

Event AEP	Changes in flood conditions
0.2EY	• Maximum decreases of -0.2 to -0.3m in the middle flow path and adjacent buildings through the school, with substantial reductions in flood extent • Decrease of up -0.2m around school office and adjacent buildings, with substantial reduction in flood extents • Reductions in flood depths on Ocean Drive around Flinders Drive of up to -0.2m. reductions in flood levels/depths around Ocean Drive culvert crossing (middle flow path) of up to -0.3m with substantial reduction in flood extents • Reductions from high-very high hazard (up to H5) in the middle flow path in the existing case including on walkways, down to all low hazard (H1) in mitigation case • Reductions from localised high hazard (up to H4) around the school office in the existing case including on walkways, down to low hazard (H1, some localised H2) in mitigation case.
5% AEP	• Maximum decreases of -0.2 to -0.3m in the middle flow path and adjacent buildings through the school, with substantial reductions in flood extent • Decrease of up -0.2m around school office and adjacent buildings, with substantial reduction in flood extents • Reductions in flood depths of -0.1 to -0.2m. on Ocean Drive around Flinders Drive and reductions of up to -0.3m at culvert crossing • Reductions from high-very high hazard (up to H5) in the middle flow path in the existing case including on walkways, down to all low hazard (H1) in mitigation case • Reductions from localised high hazard (up to H4) around the school office in the existing case including on walkways, down to low hazard (H1, some localised H2) in mitigation case.
1% AEP	• Maximum decreases of -0.2 to -0.3m in the middle flow path and adjacent buildings through the school, with substantial reductions in flood extent • Decrease of up -0.2m around school office and adjacent buildings, with some reduction in flood extents • Reductions in flood depths on Ocean Drive around Flinders Drive of -0.1 to -0.2m. reductions in flood levels/depths around Ocean Drive culvert crossing (middle flow path) of up to -0.3m with substantial reduction in flood extents • Reductions from very high hazard (H5) in the middle flow path in the existing case including on walkways, down to mostly low hazard (H1-H2) in mitigation case • Reductions from high-very high hazard (H4-H5) around the school office in the existing case including on walkways, down to mostly low hazard (H1-H2, some localised H3-H4) in mitigation case.
1% AEP plus climate change	Similar performance to the 1% AEP event, in terms of reductions in flood levels in mitigated versus existing development case (with climate change). No reduction in performance due to sea level rise.


OCEAN DR
HENRY KENDALL DR
FLINDERS DR
BAYSIDE CCT
Legend
Change in Flood Level (m)
< -0.5
-0.5 - -0.3
-0.3 - -0.1
-0.1 - -0.01
-0.01 - 0.01
0.01 - 0.1
0.1 - 0.3
0.3 - 0.5
> 0.5
Change in Flood Extent
Was Wet Now Dry
Was Dry Now Wet
0 10 20 40
Metres
JACOBS
Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.
GDA 1994 MGA Zone 56
TITLE
Option 9B
Change in Flood Level
0.2EY Event
PROJECT
North Brother Local Catchments Flood Study
PROJECT #
IA157500
MAP #
FIGURE 7-21
DATE
21/01/2021

Legend

Change in Flood Level (m)

- < -0.5
- -0.5 - -0.3
- -0.3 - -0.1
- -0.1 - -0.01
- -0.01 - 0.01
- 0.01 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- > 0.5

Change in Flood Extent

- Was Wet Now Dry
- Was Dry Now Wet

0 10 20 40
Metres

JACOBS

Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

GDA 1994 MGA Zone 56

TITLE
Option 9B
Change in Flood Level
5% AEP Event

PROJECT
North Brother Local Catchments Flood Study

PROJECT # IA157500

MAP # FIGURE 7-22

DATE 21/01/2021


OCEAN DR
HENRY KENDALL DR
FLINDERS DR
BAYSIDE CCT
Legend
Change in Flood Level (m)
< -0.5
-0.5 - -0.3
-0.3 - -0.1
-0.1 - -0.01
-0.01 - 0.01
0.01 - 0.1
0.1 - 0.3
0.3 - 0.5
> 0.5
Change in Flood Extent
Was Wet Now Dry
Was Dry Now Wet
0 10 20 40
Metres
JACOBS
Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.
GDA 1994 MGA Zone 56
TITLE
Option 9B
Change in Flood Level
1% AEP Event
PROJECT
North Brother Local Catchments Flood Study
PROJECT #
IA157500
MAP #
FIGURE 7-23
DATE
21/01/2021

7.3.5.3 Consultation and selection of preferred option

St Joseph's School was consulted during the options assessment process, and advised that Option 9B was their preferred option in order to maintain the existing landscaped channel at Option 9A location. This, combined with the better hydraulic performance of Option 9B meant that it was selected for costing and multi-criteria assessment. Option 9A is not considered further in this study.

7.3.6 Property flood benefits and impacts from proposed options

An assessment of the benefits and impacts of the selected flood modification options tested was conducted, which included a count of individual properties where above-floor flooding was removed as a result of the option, and where new above-floor flooding was resultant from the options. Refer to Table 7-9 for the summarised results.

Table 7-9 Change in numbers of floor and property flooding from mitigation options

Description	Residential								Commercial/Non-residential							
	Floor flooding				Property flooding				Floor flooding				Property flooding			
	1%	2%	5%	20%	1%	2%	5%	20%	1%	2%	5%	20%	1%	2%	5%	20%
Option 4B	19	15	9	7	23	20	17	16	0	0	0	0	0	0	0	0
Option 6A	19	4	4	1	6	6	4	2	0	1	0	1	0	1	0	1
Option 6B-E	34	17	16	9	29	35	28	23	2	4	4	2	2	4	4	2
Option 9A	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Option 9B	0	0	0	0	0	0	0	0	2	3	3	2	2	3	3	2
Option 8B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

7.3.7 Other Options Considered

- A range of other potential mitigation options were identified for other flooding areas within the study area, but were ultimately excluded based on initial assessment of the nature of flooding issues, likely improvements to flooding from the options and consideration of key opportunities and constraints. Options selection was undertaken in consultation with the floodplain advisory sub-committee.
- Flood retarding basins (also called detention basins) are basin features which are usually formed by construction of an earth embankment or a retaining wall at the downstream end of the basin to store floodwaters, releasing them at a slower rate to reduce peak flows and hence flood levels and depths downstream of the basin. Flood depths in the basin area increase from the existing case as a result, hence detention basins are typically constructed in open space areas where an increase in flooding may be tolerable. Parks, reserves and sports fields which are located on drainage paths are often utilised as basin sites. There are no suitable sites identified in the study area. Additionally, development is generally situated away from main flow paths and watercourses on which detention basins may offer hydraulic benefits. The dispersed nature of predominantly overland flooding in the study area is not readily managed by detention basins.
- On-site stormwater detention (OSD) systems are generally installed on new development areas to offset the impacts of increased impervious areas on the property and resultant increased peak flows during storm events. Similar to detention basins, OSD systems temporarily store site runoff and release flows at a slower rate generally to maintain existing peak flow rates. They are typically not used to manage existing flooding issues and it is impractical to retrofit OSD systems on existing developments.
- Raising of Ocean Drive and other roads to improve flood access was not considered as a feasible option. Raising of the roads would typically result in flood impacts to upstream properties and would require a concurrent upgrade of cross drainage culverts. Given the numerous locations where Ocean Drive is flood-affected, the magnitude of flood flows and required size of upgraded culverts and space and property constraints downstream, this option was not considered further.
- Levees: Levee embankments are often placed around whole neighbourhoods or towns to protect them from more widespread riverine flooding. The terrain and nature of overland flooding in the North Brother study area is such that a levee structure would protect only a few dwellings, and would potentially redirect flow onto adjacent properties outside the levee resulting in flooding impacts. The issue of internal drainage inside the area protected by the levee would also need to be addressed. This option therefore was not considered further. A levee implemented for the purpose of protection from riverine flooding would not improve overland flooding, and could actually worsen overland flood conditions by reducing outflow from drainage low points.

7.4 Evaluation of Options

7.4.1 Cost-Benefit Analysis

Table 7-10 summarises the options assessment including likely constraints, hydraulic performance (changes to flooding conditions as estimated in the hydraulic model), savings in flood damages, cost of works and economic appraisal. The flood damages are presented in terms of the reduction in Net Present Value (NPV) of the damages from the base case to the mitigation case. The NPV was calculated by discounting the value of the AAD during each successive year after the present year for the design life of the proposed mitigation measures. A design life of 50 years and a discount rate of 7% are assumed. The flood damages calculations are based on OEH (2016b) guidelines.

The difference in the NPV of flood damages is the theoretical savings in flood damages which can be achieved by a particular mitigation option, over the design life of the option. Comparison of this saving in NPV to the cost of the mitigation option provides a basis for evaluating the economic feasibility of an option, whereby the reduction in NPV ("Benefit") are divided by the capital cost ("Cost"). A benefit-cost ratio greater than 1.0 would indicate that the capital cost of the works would be less than the savings in flood damages over the life of the works, and vice-versa for a ratio less than 1.0.

For the flood damage assessment, the PMF was assumed not be changed by the mitigation options given the magnitude of the flood event. The AAD is not sensitive to this assessment given the rarity of the PMF event. The flood damages also only consider overland flooding and do not account for damages due to peak mainstream flooding.

Costings for all options cover the basic design and construction costs and are based on preliminary services and utilities information (Dial Before You Dig) and do not include the cost for physically locating existing underground services and utilities.

7.4.2 Multi-Criteria Analysis

The options evaluation is based on a scoring system, with scores from -3 (strongly negative) to +3 (strongly positive) with 0 being a neutral score, for a range of aspects and issues relating to implementation of the mitigation options. The scoring system matrix is shown on Table 7-11.

A summary evaluation table of the mitigation options is presented in Table 7-12. Each option is given a relative rating for each criterion and is given a total score for further consideration by Council.

Table 7-10 Summary of assessed flood modification options performance

Option	Location	Description	Constraints and Impacts Plus other comments	Hydraulic Benefits (1% AEP event unless otherwise noted) *And Negative Impacts if Any*	Savings in Flood Damages (50 years life, 7% Discount Factor)	Cost of Works	Benefit Cost Ratio
4B	Koonwarra Street to Pelican Court, West Haven	• New additional trunk drainage line 2x 2.1m x 1.2m box culverts, intercepting flows at downstream end of channel on Captain Cook Bicentennial Drive villas, cross Ocean Drive and run under The Gateway. Inlet debris trap basin required. • Reprofile grassed verge of access road stub to increase surface outflow capacity from Pelican Court sag	• Existing underground utilities in Ocean Drive and The Gateway (Telstra, Optus, NBN, power, stormwater). • Substantial number of trees in western verge of The Gateway, require removal if running new trunk drainage in the verge. • Limited space to widen existing channel running through Captain Cook Bicentennial Drive villas and then turning at Ocean Drive. Presence of existing driveway crossing over channel into Ocean Drive property. • Existing power pole on Ocean Drive likely to require relocation • Minimal space for rock debris trap at new trunk drainage inlet structure. Requires more detailed site assessment for potential rock debris loads. • Works would be within/ in the vicinity of CM SEPP Coastal Wetlands and may require approval under Part 4 of the EP&A Act 1979 as designated development.	• Pelican Court – flood levels reduced by up to 0.5m in roadway and alleyway. Reductions on properties typically to -0.1m, up to -0.4m on 12 properties. • Ocean Drive property - flood levels reduced by -0.5m • Reduced flood hazard on Ocean Drive from up to H5 to H2. Note that road may be cut-off in other locations. • Reduced extent of H3-H5 hazard in Pelican Court. • 0.2EY event: Reduced flood hazard from H5 to H1-H2 in Pelican Court, some H3 in alleyway • Number of above-floor flooded properties reduced by 19 in the 1% AEP event. Option 4B reduces flood levels and hazard on Ocean Drive and Pelican Court including up to 20 dwellings.	$4,840,000	$2,787,000	1.74
6A	Tunis Street Overland Flow Path, Laurieton	Construct/raise berm between the natural flow path and the diversion channel above Blackbutt Crescent to reduce overflows into the diversion channel	• Works fully within national park area, likely requiring removal of a large number of trees for the proposed bund in addition to site access for construction plants. • The option will be constructed on a natural berm which appears to be formed from flood-flow deposits of rock rubble and other material. Geotechnical conditions may be challenging. • Periodic maintenance of the proposed bund would be required. An access road would need to be maintained. • Works would be within/ in the vicinity of CM SEPP Coastal Wetlands and may require approval under Part 4 of the EP&A Act 1979 as designated development.	• Reductions in flood levels of -0.05 to -0.2m on Gow Place properties and Laurieton retirement village villas, some localised areas greater than -0.02m. Reductions of -0.1m at Laurieton retirement village main facility. • Localised reductions of up to -0.4m on Peach Grove properties. One property experiences minor increases of less than +0.02m. • Minor reductions of up to -0.06m on residential and commercial properties on and to the east of Ocean Drive. • Number of above-floor flooded properties reduced by 19 (residential) in the 1% AEP event. • *Widespread increases of +0.03 to +0.07m on St Josephs School grounds. Given that this option results in worsening of flooding on an existing flood problem area, this option should be considered for exclusion.*	$2,265,000 net	$226,000	10.02

Option	Location	Description	Constraints and Impacts Plus other comments	Hydraulic Benefits (1% AEP event unless otherwise noted) *And Negative Impacts if Any*	Savings in Flood Damages (50 years life, 7% Discount Factor)	Cost of Works	Benefit Cost Ratio
6B+6C +6D+ 6E	Tunis Street Overland Flow Path, Laurieton	• Increase existing diversion channel capacity behind Blackbutt Crescent properties. Widen and remove/maintain vegetation • Construct new diversion channel behind Peach Grove properties north of Tunis Street • Install new 3 x 1.35m trunk drainage line from the easement down Tunis Street to discharge to the river (approximately 740m). Inlet debris trap basin required. • Upgrade and extend drainage in Gow Place to 1.05m dia pipe. Upgrade pit inlets. Install new 900mm pipe connection from the gully to the new trunk drainage line.	• Works would need to be undertaken in part in the national park. • Upgraded diversion channels are to be grassed and require maintenance to limit vegetation growth. • Close proximity to existing buildings likely to have shallow foundations. Wide construction footprint for trenching likely to take up most of road corridor. Appropriate traffic diversions would be required. • Vibration due to construction activities may be a concern. • Acid sulphate soils in this location. • Numerous existing underground utilities (Telstra, Optus, NBN, power, stormwater) under Tunis Street and adjoining streets. Approximately 10 crossings of the utilities are identified and would need to be protected. It is assumed that the existing utilities are at sufficiently shallow depth to enable the new trunk drainage to be laid beneath. • Design and construction will need to minimise traffic impacts including delivery truck access to Coles Supermarket loading dock. Costing is based on assumed trenched construction to reduce costs but there would be higher traffic disruptions. Pipe jacking of a section of the works could be considered to reduce traffic disruption, but construction costs are estimated to double. • A rock debris trap/basin would need to be constructed at the trunk drainage inlet to reduce the inlet blockage risk. • Works would be within/ in the vicinity of CM SEPP Coastal Wetlands and may require approval under Part 4 of the EP&A Act 1979 as designated development.	• Reductions in flood levels of up to -0.4m on Gow Place properties and Laurieton retirement village villas, including some reductions in flood extent. • Reductions in flood levels of up to -0.5m on Peach Grove and Blackbutt Crescent properties including reductions in flood extent. Some localised reductions of up to -0.7m. • Reductions of -0.1 to -0.2m on residential and commercial properties on and to the east of Ocean Drive. • Removal of areas of very high hazard (up to H5) in road and on properties between Blackbutt Crescent/Peach Grove and to the east of Kew Road/Bold Street. • Climate change scenario: the option generally has similar performance to 1% AEP, in terms of reductions in flood levels. Slight reduction in performance due to sea level rise in low elevation areas below 3m AHD, where the reductions fall from -0.07m in the current climate case to -0.01m in the climate change scenario. • Number of above-floor flooded properties reduced by 36 in the 1% AEP event (34 residential, 2 commercial).	$15,680,000	$12,043,000	1.30

Option	Location	Description	Constraints and Impacts Plus other comments	Hydraulic Benefits (1% AEP event unless otherwise noted) *And Negative Impacts if Any*	Savings in Flood Damages (50 years life, 7% Discount Factor, with 0.5m protection level)	Cost of Works	Benefit Cost Ratio
8B	Lake Street at Seymour Street, Laurieton	Install debris control structure at existing or proposed upgraded culvert inlet	• Works would be within/ in the vicinity of CM SEPP Coastal Wetlands and may require approval under Part 4 of the EP&A Act 1979 as designated development. • Inspection and maintenance after storm events required to increase reliability	• Reductions of -0.1m on private property dwelling and Laurieton United Services Club side entrance. • Reductions of up to -0.1m on Lake Street. • *Minor localised increases of less than 0.02m on some private properties due to reduced drainage capacity of local stormwater drainage branches.*	$8,000	$21,000	0.40
9B	St Joseph's School, Laurieton	Install 2x 3m x 1.2m box culvert in the middle flow path, including upgrade of Ocean Street culvert crossing. Inlet rock debris trap basin required	• Minimum clearance between buildings and other features is 16m • Existing buildings are single storey and are likely to have shallow foundations. One building believed to be around 120 years old. Vibration due to construction activities can be a concern and a detailed structural inspection of the existing buildings should be conducted to assess if some areas of the existing buildings are more susceptible to such vibration. The final alignment of the proposed culvert can then be chosen to avoid these vibration sensitive zones. • Sediments may be mildly contaminated and high acid-sulphate. • Existing drainage need to be surveyed and coordinated with the design of the modified open channel. Reconstruction of existing driveway required. • Existing utilities along Ocean Drive (Optus, Telstra, NBN, power). • Sensitive habitats downstream. Possible localised impacts from expanded channel draining to Stingray Creek. Works would be within/ in the vicinity of CM SEPP Coastal Wetlands and may require approval under Part 4 of the EP&A Act 1979 as designated development.	• Maximum decreases of -0.2 to -0.3m in the middle flow path and adjacent buildings through the school, with substantial reductions in flood extent • Decrease of up -0.2m around school office and adjacent buildings, with some reduction in flood extents • Reductions in flood depths on Ocean Drive around Flinders Drive of -0.1 to -0.2m. Reductions in flood levels/depths around Ocean Drive culvert crossing (middle flow path) of up to -0.3m with substantial reduction in flood extents • Reductions from H5 hazard in the middle flow path in the existing case including on walkways, down to mostly H1-H2 • Reductions from H4-H5 hazard around the school office in the existing case including on walkways, down to mostly H1-H2 hazard, some localised H3-H4 in mitigation case. Reductions from H4 down to H1-H2 in up to 5% AEP event.	$500,000	$2,471,000	0.18

Table 7-11 Options scoring system matrix

Aspect	Score						
	-3	-2	-1	0	1	2	3
	Negative			Neutral	Positive		
Impact on Flood Behaviour	> 100mm increase	50 – 100mm increase	< 50mm increase	Neutral, or benefits countered by negative impacts	< 50mm decrease	50 – 100mm decrease	> 100mm decrease
Number of Properties Benefited	>5 properties negatively impacted	2-5 properties negatively impacted	< 2 properties negatively impacted	Neutral, or benefits countered by negative impacts	< 2 properties benefitted	2-5 benefitted	>5 properties benefitted
Technical Feasibility	Significant issues (unproven, high risk)	Some issues (complex, some difficulty)	Minor issues	Neutral	Moderately straightforward	Straightforward	No issues (proven, well established, no risk)
Economic Merit (benefit/cost ratio)	Very low (0-0.4)	Low (0.4-0.6)	Slightly low (0.6-0.8)	Neutral (0.8-1.2)	Slightly high (1.2-1.5)	High (1.5-2)	Very high (>2)
Financial Feasibility (funding, Government assistance & grants)	Very unlikely to receive funding	-	Unlikely to receive funding	Neutral	Likely to receive funding	-	Very likely to receive funding
Environmental and Ecological Benefits	Significant disbenefits	Some disbenefits	Minor disbenefits	Neutral	Minor benefits	Some benefits	Significant benefits
Impact on Risk to Life	Significant increase in risk to life	Some increase in risk to life	Minor increase in risk to life	Neutral	Minor decrease in risk to life	Some decrease in risk to life	Significant decrease in risk to life
Impacts on SES	Significant disbenefit to SES	-	Some disbenefit to SES	Neutral	Some benefit to SES	-	Significant benefit to SES
Long-term Performance (design life & climate change)	Very low	-	Low	Neutral	High	-	Very high
Legislative & Permissibility Requirements (including political & administrative	Significant issues affecting implementation	-	Some issues affecting implementation	Minor issues affecting implementation	Negligible issues affecting implementation	-	No issues affecting implementation
Social Impact / Community Acceptance	Large majority against	Most against	Some against	Neutral	Some for	Most for	Large majority for

Table 7-12 Evaluation of Options

Option	Impact on Flood Behaviour	Number of Properties Benefited	Technical Feasibility	Economic Merit (benefit/cost ratio)	Financial Feasibility (cost, funding, Government assistance & grants)	Environmental and Ecological Benefits	Impact on Risk to Life	Impacts on SES	Long-term Performance (design life & climate change)	Legislative & Permissibility Requirements (including political & administrative)	Social Impact / Community Acceptance	Total score	Rank
4B	3	3	-1	2	1	0	2	1	3	0	2	16	**2**
6A	1 net	3	1	3	0	-2	1	1	-1	-3	-1	3	**5**
6B – 6E	3	3	-2	1	-2	0	3	3	1	-1	2	11	**3**
8B	2	0	3	-2	2	0	1	0	3	0	0	9	**4**
9B	3	2	-1	-3	1	0	3	3	3	3	3	17	**1**

7.4.3 Conclusions on Options Evaluation

Five flood modification options were assessed based on hydraulic performance, ability to reduce flood risk to life, economic merit (benefit-cost ratio (BCR)) and overall financial feasibility, in addition to other criteria. While each option may have low scoring in some aspects such as economic merit or financial feasibility, their evaluation score is elevated by high performance in other aspects. Conversely, options may be scored down due to significant constraints which may make their implementation unjustified. Discussion on each of the options in order of ranking is provided below.

1) Option 9B: Although ranking very low on economic merit due to low reduction in flood damages to St Josephs School buildings relative to implementation cost, the scoring for this option is significantly increased by high reductions in flood levels and flood hazard, and the resultant reduced risk to safety of a vulnerable cohort of the population (i.e. primary school children) and increased benefits to emergency management. High score for perceived community support due to improved flooding conditions at a primary school. Although there are expected to be minor technical challenges in construction, the cost of implementation is perceived to be moderately achievable. A **High** priority for implementation is recommended.

2) Option 4B: Generally good scores across all evaluation criteria, including for reductions in flooding, flood hazard flood damages, high economic merit, reduced risk to life due to reduced hazard, and moderately high community support, based on relatively high number of properties benefitting in this known flood problem area. Although there are expected to be minor technical challenges in construction, the cost of implementation is perceived to be moderately achievable. A **High** priority for implementation is recommended.

3) Option 6B-6E: High scoring for high improvements to flooding, very high numbers of properties benefitting (up to 34 residential buildings with floor flooding removed, refer Table 7-9), positive economic merit and benefits to risk to life and SES/emergency management. Moderately low score for technical challenges due to significant length of trunk drainage to be constructed through Laurieton CBD, resultant high cost of implementation and potential challenges obtaining full funding. Moderately high score for community support – although high numbers of residential and commercial properties are benefitted, some objection could be encountered due to the disruptions to certain businesses and to road users during construction. Below neutral score for legislative issues, as environmental approvals and Review of Environmental Factors may be required. Based on these factors, a **Medium** priority for implementation is recommended, which would include a more detailed feasibility study.

4) Option 8B: Moderately high score for reduction in flood levels, however, these are mainly restricted to the Lake Street crossing, with no properties significantly benefitting. Low economic benefit score due to low reduction in flood damages, but moderately positive scores for low cost, ease of implementation and reduced risk of culvert blockage resulting in reduced flows over the road and reduced risk to traffic. Based on these factors, a **Medium** priority for implementation is recommended.

5) Option 6A: Although this option provides high flood benefits to a large number of properties and high economic merit, it worsens flooding in a known problem area at St Josephs School. Further, significant works are required within Dooragan National Park including clearing of large area of vegetation for construction of a flow diversion berm and maintenance access road. Ongoing inspection and maintenance to the berm is expected to ensure structural stability following storm events. Approvals from NPWS and other agencies may be challenging to obtain and there may be community objection to vegetation impacts. Based on these factors, a low score is obtained and **this option is not recommended for further consideration.**

These options are included in the Draft Floodplain Risk Management Plan as appropriate. It is recommended that Council and the committee consider and provide agreement on the scoring of options prior to finalisation of the Draft Floodplain Risk Management Plan.

8. Non-Structural Measures

8.1 Property Modification Measures

8.1.1 Voluntary Purchase of High Hazard Properties

Voluntary purchase (VP) of high flood hazard properties may be considered in order to eliminate the potentially high risk of loss of life and damage to property from these areas by physically removing the dwellings at risk to hazardous flood conditions.

OEH (now DPIE) has prepared Guidelines for Voluntary Purchase Schemes (OEH, 2013b). This describes the eligibility criteria for NSW Government funding for VP schemes, which include:

- no other feasible flood risk management options are available to address the risk to life at the property;
- residential properties and not commercial and industrial properties;
- buildings were approved and constructed prior to 1986;
- properties are located either 1) within high hazard areas where there is a significant risk to life for occupants and those who may have to evacuate or rescue them, 2) within a floodway where the removal of the house may be part of a floodway clearance program aimed to reduce the significant impacts caused by the existing development on flood behaviour elsewhere in the floodplain, or 3) within the footprint of a proposed flood mitigation measure or where a flood mitigation measure may result in a significant increase in flood risk to a house that cannot be protected.

In total, there are 19 residential properties affected by very high hazard flooding, considered as being H5 rating or higher (refer Section 5.1.3 for description of flood hazard rating), in the 1% AEP event which may be eligible for voluntary purchase. This excludes any villas, units or strata buildings. There are limits to the funding available for a voluntary purchase program and additional eligibility criteria may apply. Feasibility of a voluntary purchase program may be limited by the relatively high property prices in the study area. Note that the flood risk at about five of the 19 properties could be reduced if the proposed flood modification works are implemented.

Two high flood hazard properties have been nominated for voluntary purchase in order to form a floodway to relieve flooding in Koonwarra Street and Pelican Court, however, consultation with the residents indicated that they did not wish to participate in the voluntary purchase program.

Although the high costs of property acquisition and potentially low community interest may be impediments to a voluntary house purchase scheme, it needs to be considered as a measure to address the existing flood risk posed to the 19 existing residential properties which are subject to very high hazard flooding.

Recommendation

Council should consider a feasibility study to better assess the community appetite (particularly residents of the affected properties), opportunities and constraints for potential implementation of a voluntary purchase scheme.

8.1.2 Voluntary House Raising

Voluntary house raising (VHR) has long been a traditional response to flooding in New South Wales, as demonstrated by the number of raised houses in frequently flooded urban areas such as Lismore and Fairfield (Floodplain Development Manual, 2005). There are advantages associated with house raising which are noted as follows (Frost and Rice, 2003).

- A reduction of flood damages due to personal items being stored above the nominated flood level
- A reduction in danger to personal safety and a reduction in the cost of potentially needing to evacuate residents
- Potentially cost-effective alternative to voluntary purchase, with positive social outcomes (i.e. home owners who have strong sentimental value on their properties can remain in the same location).

Some of the disadvantages include:

- Residents' concern over security and privacy due to an open, exposed ground floor
- Accessibility issues for the elderly or people with a disability
- Following raising, residents may develop a false sense of security from impacts. This can result in a belief that they will not be impacted by flooding or reluctance to evacuate when required.
- Over time and when flooding has not occurred, residents may be inclined to utilise the ground floor and converting it to a habitable area.

OEH (now DPIE) has prepared *Guidelines for Voluntary House Raising Schemes* (OEH, 2013a). This describes the eligibility criteria for NSW Government funding of VHR schemes including:

- not located in floodways;
- limited to areas of low flood hazard;
- the suitability of individual houses for raising;
- residential properties and not commercial and industrial properties;
- buildings were approved and constructed prior to 1986;
- properties cannot be benefiting substantially from other floodplain mitigation measures;
- VHR should generally return a positive net benefit in damage reduction relative to its cost (benefit–cost ratio greater than 1).

Inclusion of a property in a voluntary house raising scheme places no obligation on the owner to sell the property or on the council or NSW Government to fund the purchase of the property. Owner participation in the scheme is voluntary and there are limitations on the availability of funding.

Whilst house raising can be considered for a range of building types, it is easiest and cheapest for timber-framed houses clad with non-masonry materials. A large proportion of houses in the study area which area flood-affected are of single or double brick construction which are considered costly and impractical for raising.

Due to the factors outline above, house raising is not considered feasible as a mitigation measure for dwellings within the study area.

8.1.3 Planning and development controls

8.1.3.1 General

Land use planning and development controls are an essential element in managing flood risk and the most effective way of ensuring future flood risk is managed appropriately. Planning controls including flood planning levels, flood related development control plans and restrictions on permissible types of development in different parts of the floodplain are recommended to ensure that development in the study area occurs in an appropriate manner in relation to flooding.

8.1.3.2 Amendments to LEP

The *Port Macquarie Hastings Local Environmental Plan 2011* (LEP 2011) provides land use controls for the LGA and has been developed to be consistent with the FDM. Part 7.3 of the LEP 2011 contains clauses on flood planning. The LEP includes mapping of known flood liable lands, where there are flood studies completed for those areas. It currently does not include the overland flood areas of the North Brother local catchments.

While the LEP does require consideration of the compatibility of development to the "flood hazard of the land", it only makes reference to the flood liable lands and flood planning area. It does not make reference to the actual flood hazard rating, that being governed by flood depth, velocity and/or velocity-depth product, or to the hydraulic category of the floodplain (floodway, flood storage etc.).

Recommendation

The following updates to LEP 2011 and the Section 10.7 certificates are recommended:

- Amendment of LEP 2011 to include the North Brother local catchments flood mapping on the LEP Flood Planning Map. The current flood prone land mapping and flood planning area mapping does not include this study area.
- The Section 10.7 certificates are recommended to provide flood information for properties such as flood levels and flood planning levels across the lot, in addition to the flood hazard and hydraulic categories present on each lot.

8.1.3.3 Amendments to Flood Policy and new Overland Flood Policy

As discussed in Section 3.3.4, Council's Flood Policy (2015) includes development controls which are mainly geared towards mainstream flooding. There are a number of controls which are not applicable or are not compatible with overland flooding. Amendment to the Flood Policy was not considered practical to incorporate conditions for overland flooding as it would affect the readability of the document. Hence, it is recommended that Council prepare a new Overland Flood Policy to define appropriate flood planning and development controls for areas identified as being affected by overland flooding, allowing more flexibility for Council to prescribe the appropriate flood planning controls. This arrangement is not dissimilar to the provision of separate Development Control Plans (DCPs) for different locations to administer varied development controls which are appropriate for that location.

The Overland Flood Policy would be largely based on the Flood Policy, with incompatible development controls omitted, such as those related to reliable site access for new residential developments and minimum areas above the FPL2 for property adjustments. The Overland Flood Policy would apply to areas where an overland flow study has been adopted (e.g. North Brother study area) and other areas as deemed appropriate by Council. Reference to the mapped areas of Overland Floodway, Overland Flood Storage and Overland Flood Fringe and the overland flood planning level areas (FPL1 – FPL4) should be made as appropriate. These areas have been mapped as a part of the study.

The Overland Flood Policy should make reference to the (mainstream) Flood Policy, as the development conditions based on mainstream flooding may take precedence over the overland flood development conditions for areas where the mainstream flooding is dominant. Similarly, the Flood Policy should be updated to reference the Overland Flood Policy and for users to check whether the Overland Flood Policy applies to their property.

In regard to overland floodway areas, as these may be relatively localised on a property, provision in the Overland Flood Policy may be appropriate allowing development on the existing floodway area so long as a property flood study is undertaken to demonstrate that the floodway can be safely relocated/redirected without adverse impact to adjacent properties and that the proposed development can be adequately designed for the hydraulic conditions.

Proposed amendments to the Flood Policy and inclusions in the Overland Flood Policy are outlined below.

Comments and Recommendations

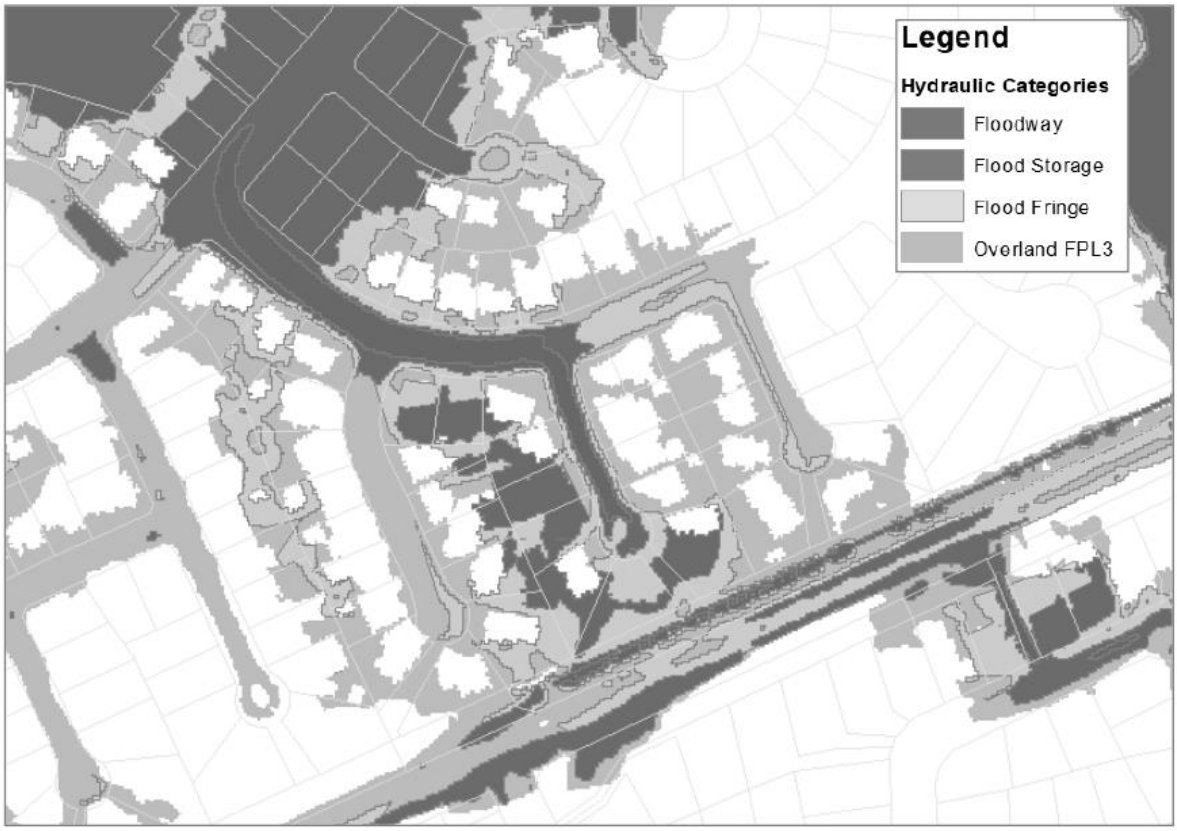
- A new Overland Flood Policy is recommended to be developed to provide greater flexibility for Council to administer development controls which are better tailored for areas affected by overland flooding only. The Overland Flood Policy would apply to areas where an overland flood study has been adopted, and any other areas deemed applicable by Council. The flood mapping prepared in this North Brother Local Catchments Flood Study should be referenced by the Overland Flood Policy as appropriate.
- The Flood Policy should be updated to reference the Overland Flood Policy.
- Both flood policies should state that both the mainstream and overland flooding conditions need to be considered for development and re-development of properties.

- Consider allowing relocation of overland floodway as part of a development application, with the requirement that a property flood study is prepared that demonstrates that relocation can be done in a safe and adequate manner.
- Design flood events are referred to in the Flood Policy in terms of Average Recurrence Interval (ARI) which is not in line with current floodplain management best practice of referring to events by Annual Exceedance Probability (AEP). Update to the Flood Policy should include reference to AEP terminology and/or definitions on conversion in its glossary (i.e. 5% AEP = 20 year ARI, and 1% AEP = 100 year ARI).
- Consider incorporation of the ARR 2019 flood hazard categorisation system into the Flood Policy to reflect the current best practice in defining flood hazard conditions.
- "High flood hazard" could be considered as H3 or higher hazard (ARR 2019 hazard categories). The lower threshold for H3 hazard is similar or slightly lower than the high and transitional hazard categories in the *Floodplain Development Manual* method.

8.1.3.4 Application of Hydraulic Categories and Flood Planning Levels

The current Flood Policy requires the consideration of the overland hydraulic category mapping and the overland flood planning level mapping in determining flood development controls for proposed developments. However, some potential incompatibilities are observed. Based on the procedures in the Flood Policy, areas out to the extent of the flood fringe (up to the climate change 1% AEP extent, with filtering) would have development controls such as minimum floor levels. For residential developments, this would be set by FPL3 (climate change 1% AEP flood level plus 0.5m freeboard). However, review of the mapping indicates that the FPL3 extent is generally larger in extent than the flood fringe, due to the 0.5m freeboard. Based on the Flood Policy procedure, proposed residential development outside the flood fringe would not need to adhere to FPL3, which therefore causes a discontinuity on required floor levels for proposed buildings on either side of the FPL3 extent line. Refer to Figure 8-1, which illustrates an example area where the FPL3 extent is markedly larger than the flood fringe extent.

Figure 8-1 Example of potential inconsistency of overland hydraulic category and overland flood planning level mapping



Potential options for consideration by Council, for the development of the Overland Flood Policy and application of development controls:

1. Keep the overland hydraulic category mapping and the overland flood planning level mapping as is, and permit the discontinuity in minimum floor levels at the flood fringe extent line.
2. Discard the hydraulic category mapping system for overland flooding, but retain the overland floodway area mapping. Given the nature of overland flooding, the overland flood storage areas are relatively shallow in depth in any case, and development of those areas (for example, by floodplain filling) are unlikely to affect floodplain storage for overland flooding in most cases. Retain the overland flood planning level mapping system (FPL1 – FPL4) and use the overland floodway mapping to define potentially unsuitable locations for development.
3. Extend the overland flood fringe area out to the FPL3 extent to capture areas where the FPL3 would apply in the initial assessment of proposed overland floodplain development.

Consultation with Council indicated that option 2 was the preferred option for administering planning controls in the proposed Overland Flood Policy. For most types of development, including residential development but excluding critical and sensitive properties, overland flood planning controls would apply to areas within the Overland FPL3 extent. There would be restrictions on development in floodway areas, similar with the mainstream Flood Policy, which would apply to 273 lot parcels where there are floodway areas on the lot. Note that these include national park, open space and other public spaces, which have not been filtered from the lot count.

Recommendation

It is recommended that Council use the combination of the overland FPL1 – FPL4 mapping with the overland floodway mapping in administering planning controls in the Overland Flood Policy.

8.1.3.5 Rezoning

Rezoning could be considered where there is an incompatibility of the flood hazard or hydraulic category on the property compared to the type of land use. Section 5.4 identifies sensitive properties and critical facilities which are affected by high hazard flooding and floodway (as well as flood storage and flood fringe) areas. Unlike mainstream flooding, the high hazard and floodway areas are generally localised in the 1% AEP event. Rezoning of entire properties, especially larger premises occupied by schools, nursing homes etc. to preclude those land uses is likely to result in the suitable parts of the properties being underutilised.

Properties with larger areas of high hazard up to H5/H6 in PMF include:

- St Joseph's School
- Laurieton Retirement Village
- Stockland Camden View Retirement Village.

Rezoning of these properties in response to flood hazard in the PMF event could be considered, although many of these sensitive properties are large facilities and there is an absence of large vacant lots to which these facilities could be relocated, and relocation would be an expensive and complex exercise. Other measures and development controls may be appropriate to manage redevelopment of these properties. Therefore, rezoning of the identified affected sensitive properties and critical facilities is generally not recommended, based on the overland flood conditions presented in this study. Rezoning in response to mainstream flood conditions has not been assessed.

8.1.4 Council Redevelopment

This measure is an alternative to voluntary purchase (refer Section 8.1.1) whereby Council would still purchase high-impacted flooded properties on a voluntary basis but instead of rezoning the land, the property is redeveloped with new dwellings designed to withstand the high hazard flooding conditions on the property and resist flood damages. The intention is for the redeveloped property to be resold with a break-even financial outcome, which offsets the high property purchase costs which tend to make voluntary purchase unfeasible.

However, initial assessment identifies a number of issues with this approach:

- It would be in conflict with Council's Flood Policy in addition to other planning policies which preclude (re)development in floodway and high flood hazard areas.
- This approach may need to be fully funded by Council.
- Specialised building design and engineering would be required to withstand high to extreme hazard flood forces (H5 and H6 hazard rating) in the 1% AEP event and rarer, which adds to the cost of this option.
- This approach would not reduce the risk of flooding on the population in the PMF.
- There is a high upfront cost to be borne by Council for each redevelopment.
- There may also be probity issues in the case of Council acquiring the property, redeveloping and reselling the property.
- The generally older characteristics of the local population may mean that there is a reduced capacity for the residents of properties to move elsewhere. There may be reluctance to sell-off the properties in this regard. Conversely, however, there may be increased uptake in this option for residents who are frequently affected by flooding.

Recommendation

A feasibility study by Council is recommended to determine if these issues related to Council redevelopment can be addressed to make this a viable approach. Development controls such as floor levels above the PMF for flood refuge would need to be assessed for suitability in a town planning context.

8.1.5 Flood Proofing and Flood Compatible Design of Individual Buildings

Flood compatible design refers to the design and construction of buildings with appropriate water-resistant materials such that flood damage to the building itself (structural damage) and possibly its contents, is minimised should the building be inundated. *Reducing Vulnerability of Buildings to Flood Damage* (Hawkesbury-Nepean Floodplain Management Steering Committee, 2007) provides a comprehensive discussion of the various options for building design to minimise the impact of flooding. These include structural and architectural design and building materials, in addition to design considerations such as setting of electrical equipment above flood levels to reduce risk of their damage.

Flood compatible and flood proofing design measures are prescribed for different types of development in Council's Flood Policy (2015), including the minimum elevations in the development which the flood compatible materials must reach in all parts of proposed buildings. These conditions should be included in the proposed new Overland Flood Policy.

Promotion of types of flood proofing measures should also be undertaken as a part of flood awareness and readiness improvement programs (refer Section 8.2.3).

Flood proofing of residential properties can also refer to implementing external measures such as walls or landscaping to redirect flows away from and around vulnerable parts of the house, such as doorways and other entry points. It is generally a measure that can be pursued by individual property owners in low hazard areas to prevent above floor inundation but may result in diversion of flows to neighbouring properties and resultant impacts. A flood impact assessment may be required by Council as per the Flood Policy to ensure adverse flood impacts to adjacent properties are prevented.

Recommendation

- Council to include requirements for flood compatible building materials and design in the Overland Flood Policy.
- Promotion of flood proofing measures should also be included in flood education and awareness programs.

8.2 Response Modification Measures

8.2.1 Flood Warning Systems

The study area includes local catchments and overland flow paths where flash flooding may occur. Flash flood catchments are those defined as catchments in which less than six hours may elapse between heavy rainfall and flooding. Flash flooding usually results from relatively short intense bursts of rainfall, commonly from thunderstorms. This is problematic in urban areas where drainage systems may not cope. Flash floods tend to be quite local and it is difficult to provide effective warning because of their rapid onset. The reasons for this have been identified for flash flood catchments as follows (McKay, 2004, 2008):

- Flash floods are less predictable than larger scale flooding. Rainfall over small catchments is usually not well predicted by numerical weather prediction models
- For flash floods, there is insufficient time to develop reliable flood warnings and for effective the dissemination and response to the flood warnings. More rapid user response is required, which necessitates specialised communication systems and a high level of public flood awareness

- A reliance on rainfall triggers increases the frequency of false alarms
- The use of water level triggers does not allow sufficient time for response.

It is not possible for BOM to issue specific predictions for flash flood catchments based on their regional rainfall gauging network. More importance is placed on the role of the SES and other agencies to interpret the regional warnings which are provided by BOM to warn the community of the potential road closures and damage as a result of predicted storms and flash floods.

Flash flood warning systems have been proposed for some catchments, such as the Avalon overland flood areas on the Northern Beaches of Sydney. However, the time to peak for critical storm events in the Avalon area is about 1 hour from the start of the storm, and about 30 minutes after peak rainfall rates in the design storm event (MHL, 2016), which offers a short warning time. The critical duration in that area for the 1% AEP event is the 2 hour event.

In contrast, although some of the lower areas in North Brother study area have a critical storm duration of up to 2 hours, the critical duration for most of the study area is generally the 30 minute duration event. Time to peak in many flow paths, especially on known problem areas further up the mountain, is in the range of 15 minutes. Due to the steepness of the local catchments the overland flooding is expected to peak almost instantaneously (5 to 10 minutes) in response to high intensity rainfall. Therefore, there would be minimal to no warning provided for many locations in the study area. Potential delays in analysis of rainfall data and subsequent dissemination of warnings via phone or text systems would further erode the warning time.

Given the issues and challenges discussed above, the development of a flash flood warning system for the study area is not recommended. Greater emphasis should be placed on the importance of flood education and awareness in the community. Local residents have a role in being able to understand how the issued weather warnings and actual occurrences of intense rainfall during a storm may translate to flooding impacts to their properties, and in addition, be aware of ways to prepare their properties to reduce flood damages and risk to life.

8.2.2 Flood Depth Signage on Roads

A number of road crossings are affected by significant flooding. Flood depth signage is recommended for key locations primarily to warn drivers of the flood hazard during a flood event and reduce occurrences of people driving into floodwaters. Flood depth signage may also act as a passive reminder to residents of the potential for flooding in their neighbourhood streets. Nominated locations are where H3 or higher flood hazard occurs in the 1% AEP event, including:

- Ocean Drive 70m east of Sirius Drive
- Ocean Drive 380m east of Fairwinds Avenue
- Ocean Drive 30m east of The Gateway
- Bold Street sag between Laurie Street and Mill Street
- Bold Street sag between Mill Street and Hanley Street.

While there are other roads affected by high hazard flooding conditions, Ocean Drive and Bold Street are higher-trafficked roads and crossed by major flow paths with a higher risk of vehicles being washed off the road.

Recommendation

It is recommended that flood depth signage be installed at key road crossings as a warning of the flood hazard during a flood event and reduce occurrences of people driving into floodwaters, in addition as a passive reminder of flooding risk.

8.2.3 Flood Education, Awareness and Readiness

Flood education and awareness should be promoted throughout the study area. Measures may include information brochures in English and multi-lingual including promotion of NSW SES FloodSafe brochures and website (http://www.floodsafe.com.au/). Additionally, Council or SES may run educational workshops or distribute information sheets to help people plan and prepare for a flood.

Section 10.7 certificates issued by Council could be used to inform property owners about flood risk to their properties, where there are flood studies completed within Port Macquarie Hastings LGA.

Additionally, Council's floodplain management web page and social media could be further developed to enhance the messaging on flood risk and flood preparation, particularly in relation to overland flooding. This may include flood mapping on an interactive mapping portal on the website itself rather than links to the flood study reports and mapping, where it can be difficult for community members to navigate through often lengthy technical reports. Information on, or links to external websites (SES, floodsafe, etc), should be included for advice for residents on how to prepare for flooding.

During flood events, Council should consider listing roads which are closed to flooding (and roads recently opened as the flooding recedes) on their website and social media. This will encourage road users to find alternative routes and reduce the number of drivers encountering flooded roads and potentially driving into floodwaters. Due to the short duration of flash flooding, this measure would not be suitable most affected roads in the study area. Some roads with trapped drainage points such as Sirius Drive and Pelican Court where ponded floodwater takes longer to drain out could be considered for this measure.

A flood education and awareness program should be developed by Council which outlines and schedules various flood education methods to be implemented (e.g. brochures, news articles highlighting previous flooding, SES events, Council web pages etc.). The program should be reviewed after each significant flood event to assess the effectiveness of the program, reinvigorate flood awareness in the community and plan the roll-out of new flood information as it becomes available.

As a part of an overall flood education and awareness program for the study area, Council should consult with operators of sensitive properties and facilities to provide information on the flood risk on the property and promote the development of a flood management plan for the properties (refer to Section 8.2.5 for further details).

Recommendation

It is recommended that Council develops a flood education program to promote flood awareness and readiness in the community. Measures may include:

- Promotion of FloodSafe brochures to help residents understand the flood risk and prepare their property and personal plans for a flooding event.
- Flood depth signage on key roads affected by flooding.
- List of road closures and roads recently opened on website/social media page during flood events
- Section 10.7 certificates to inform property owners about flood risk to their properties
- Provide flood mapping on an interactive mapping portal on Council's website for easier viewing
- Promotion and support for SES information events
- Enhanced messaging on flood risk and flood preparedness on Council's floodplain management webpage particularly for overland flooding.
- Consult with operators of sensitive properties affected by high flood hazard to provide information on the flood risk and promote the development of a flood management plan for the properties.

The program should be reviewed after each significant flood event.

8.2.4 Improved flood evacuation response and procedures

Flood evacuation is under the control of the NSW SES and the NSW SES needs to update the current evacuation planning based on information presented in this report, including flood depth and hazard mapping.

Recommendation

It is recommended that the NSW SES updates the current emergency planning, such as development of a Local Flood Plan or update of the EMPLAN, based on information presented in this study.

8.2.5 Development of Flood Management Plans

A flood management plan is a document which outlines and discusses the measures to help manage the flood risk on a particular property, and its occupants and visitors to the site. The purposes of the plan are:

- To address existing, future and continuing flood risks on the site;
- To promote a satisfactory awareness of expected flood behaviour and risk;
- To identify measures to become flood prepared, and
- To recommend a course of action during and after flood events.

Flood management plans can be likened to a fire evacuation plan or a bushfire emergency plan and should be tailored specifically for a particular property. It outlines procedures for prior, during and after a flood event and the roles and responsibilities, generally of facility staff, in enacting the flood management plan. It may also describe evacuation routes and refuge places.

Several facilities are affected by very high to extreme (H5, up to H6) flood hazard in the PMF. Development of a flood management plan for the facilities should be considered to manage the flood risk to occupants. Council should consult with the facility operators subject to high flood hazard as a part of an overall flood education and awareness program for the study area and promote the development of a flood management plan for the properties.

The plans would address the flood risk on the existing sites and provide procedures on monitoring of weather and resulting flooding conditions, and evacuation of occupants to flood-safe spaces on the property, such as second floor of existing buildings if adequate. Assessment of the suitability of the buildings as flood refuges should be undertaken by SES.

Recommendation

Council should consult with high flood risk facilities and occupants of dwellings subject to high flood hazard regarding management of flood risk on the site. Development of a flood management plan for the site should be considered by the facility operators with the assistance of Council/NSW SES.

9. Draft Floodplain Risk Management Plan

9.1 Purpose of the Plan

The Draft Floodplain Risk Management Plan provides input into the strategic and statutory planning roles of Councils. It provides a steering document to enable Council to effectively manage flood liable land moving forward. It also suggests an implementation plan based on priorities of floodplain risk management measures and availability of funding.

The Draft Plan, consisting of proposed floodplain risk management measures, are provided in Table 9-1 and were developed from the recommendations made in the Draft Floodplain Risk Management Study documented in the preceding sections of this report. consultation with the community, Council and the FRMC on the recommendations and the preliminary proposed measures was undertaken. The Draft Floodplain Risk Management Plan remains as “Draft” status until such time that it is adopted by Council.

9.2 Funding and Implementation

9.2.1 Estimated Costs

The proposed works-based measures included in the Draft Plan are based on surface works and hence the cost for implementing the Draft Plan is expected to be relatively low. Costs were estimated for non-works based measures. The costs of planning, policy, administrative and organisational non-works measures are largely unknown to the consultant. The timing of the proposed works will be dependent on Council’s overall budgetary commitments and the availability of funding from external sources. The Plan can be progressively implemented with an anticipated timeframe of 3-5 years for high priority options and 5-10 years for medium priority options.

9.2.2 Alternative Funding sources

There are a number of funding bodies, which Council could consider applying to for supplementary funds. The Department of Planning, Industry and Environment (DPIE) offers support to local Councils through Floodplain Management Grants. Assistance under this Program is usually $2 from government for every $1 from Council.

The Natural Disaster Resilience Program (NDRP) is a joint Commonwealth and State government program funded through the National Partnership Agreement on Natural Disaster Resilience. It provides funding through the Floodplain Grant Scheme (FRMGS) to address flood activities allocated through the existing Floodplain Management Program managed by DPIE (described above).

The Community Resilience Innovation Program (CRIP) is another program funded through the NDRP and supports a broad range of community-led projects designed to increase all-hazard disaster preparedness and build community capacity and resilience. Flood education and awareness programs may be eligible. Applications for funding from State or Commonwealth programs are highly competitive and the limited funds are allocated on an annual basis. Options put forward for funding assistance must be well supported and justified through demonstrated strong cost/benefit ratio and inclusion of positive environmental and social outcomes.

In addition to State and Federal Government, Council could approach other organisations (for example Transport for NSW, NSW SES) or private owners (such as property developers, where appropriate) to assist with funding of measures.

9.3 On-going Review of Plan

This Draft Floodplain Risk Management Plan should be regarded as a robust document, which requires review and amendments to be made over time. At a minimum, it is recommended that the Plan be reviewed every 10 years. In addition to scheduled reviews, the Plan should be reviewed following flood events, any change in State or Local Government legislation or alterations to funding availability. Implementation of the Plan should be monitored by the FRMC. The local community should continue to be informed of progress through Newsletters available via the Council website or displayed at Council Offices.

Table 9-1 Draft Floodplain Risk Management Plan

ID	Measures considered	Responsibility	Initial Cost	Ongoing Cost	Features of the Measure	Recommended Priority Rankings
FM1	**Option 9B** St Joseph's School, Laurieton	Council. Possible co-funding contribution from School	$2,781,000	Council maintenance costs	• Install 2x 3m x 1.2m box culvert in the middle flow path through the School, including upgrade of Ocean Street culvert crossing. Inlet rock debris trap basin required	**High**
FM2	**Option 4B** Koonwarra Street to Pelican Court, West Haven	Council	$2,787,000	Council maintenance costs	• New additional trunk drainage line 2x 2.1m x 1.2m box culverts, intercepting flows at downstream end of channel on Captain Cook Bicentennial Drive villas, cross Ocean Drive and run under The Gateway. Inlet debris trap basin required. • Reprofile grassed verge of access road stub to increase surface outflow capacity from Pelican Court sag	**High**
FM3	**Option 6B – 6E** Tunis Street Overland Flow Path, Laurieton	Council	$12,043,000	Council maintenance costs	• Increase existing diversion channel capacity behind Blackbutt Crescent properties. Widen and remove/maintain vegetation • Construct new diversion channel behind Peach Grove properties north of Tunis Street • Install new 3 x 1.35m trunk drainage line from the easement down Tunis Street to discharge to the river (approximately 740m). Inlet debris trap basin required. • Upgrade and extend drainage in Gow Place to 1.05m dia pipe. Upgrade pit inlets. Install new 900mm pipe connection from the gully to the new trunk drainage line. • Feasibility study is recommended to investigate constructability, constraints and opportunities in greater detail.	**Medium**

ID	Measures considered	Responsibility	Initial Cost	Ongoing Cost	Features of the Measure	Recommended Priority Rankings
FM4	**Option 8B** Lake Street at Seymour Street, Laurieton	Council	$21,000	Council maintenance costs	• Install debris control structure at existing or proposed upgraded culvert inlet	**Medium**
PM1	LEP amendments	Council	Staff costs	N/A	• Amendment of LEP 2011 to include the North Brother local catchments flood mapping on the LEP Flood Planning Map. The current flood prone land mapping and flood planning area mapping does not include this study area. • Further review and refinement of the Overland Flood Planning Mapping may be undertaken by Council prior to adoption and implementation. • The Section 10.7 certificates are recommended to provide flood information for properties such as flood levels and flood planning levels across the lot, in addition to the flood hazard and hydraulic categories present on each lot.	**High**
PM2	Flood Policy Amendments and new Overland Flood Policy	Council	Staff costs	N/A	• A new Overland Flood Policy is recommended to be developed to provide greater flexibility for Council to administer development controls which are better tailored for areas affected by overland flooding only. The Overland Flood Policy would apply to areas where an overland flood study has been adopted, and any other areas deemed applicable by Council. The flood mapping prepared in this North Brother Local Catchments Flood Study including Overland Hydraulic Categories mapping and FPL1 – FPL4 mapping, including should be referenced by the Overland Flood Policy as appropriate.	**High**

ID	Measures considered	Responsibility	Initial Cost	Ongoing Cost	Features of the Measure	Recommended Priority Rankings
					• The Flood Policy should be updated to reference the Overland Flood Policy. • Both flood policies should state that both the mainstream and overland flooding conditions need to be considered for development and re-development of properties. • Design flood events are referred to in the Flood Policy in terms of Average Recurrence Interval (ARI) which is not in line with current floodplain management best practice of referring to events by Annual Exceedance Probability (AEP). Update to the Flood Policy should include reference to AEP terminology and/or definitions on conversion in its glossary (i.e. 5% AEP = 20 year ARI, and 1% AEP = 100 year ARI). • Consider incorporation of the ARR 2019 flood hazard categorisation system into the Flood Policy to reflect the current best practice in defining flood hazard conditions. • "High flood hazard" could be considered as H3 or higher hazard (ARR 2019 hazard categories). The lower threshold for H3 hazard is similar or slightly lower than the high and transitional hazard categories in the Floodplain Development Manual method.	

ID	Measures considered	Responsibility	Initial Cost	Ongoing Cost	Features of the Measure	Recommended Priority Rankings
PM3	Scoping study on a voluntary house purchase/ voluntary redevelopment scheme for very high flood hazard properties	Council	Staff costs	$0K	• Further investigation on feasibility of a voluntary purchase / voluntary redevelopment scheme for very high flood hazard (H5 rating and higher) properties. The scoping study should investigate community interest (affected residents), opportunities and constraints (funding, technical, administrative etc) • Council to investigate and develop resolution of the identified policy and probity issues related to a voluntary redevelopment scheme. • Voluntary redevelopment scheme is to recommend engineering and economic assessments be undertaken for flood-durable development designs to determine feasibility. • Include development controls such as provision of floor levels above PMF level and flood-free emergency access for such developments. • Being a voluntary scheme, current residents may not be in favour of participating.	**Low**
RM1	Develop flood management plan for selected sensitive properties	Council (advocacy only), property operator (funding and implementation), SES (advice)	Cost to be borne by property operator	N/A	• Council should consider consultation with operators of sensitive properties (schools, pre-schools and retirement villages) affected by high hazard flooding regarding management of flood risk on the site. Development of a flood management plan for the sites should be considered. • The plans should contain procedures for monitoring weather and warnings and evacuation of occupants to flood-safe spaces within the property if possible. • Emergency and evacuation procedures shall include a flood risk management procedure.	**High**

ID	Measures considered	Responsibility	Initial Cost	Ongoing Cost	Features of the Measure	Recommended Priority Rankings
RM2	Update of Local Flood Plan	SES	Staff costs	N/A	• It is recommended that Port Macquarie Hastings EMPLAN be updated based on the findings of this study, including intelligence on flood behaviour, impacted and sensitive properties, affected roads etc.	**High**
RM3	Development of flood education and awareness program	Council, SES	$20K	Staff costs	It is recommended that Council develops a flood education program to promote flood awareness and readiness in the community. Measures may include: • Promotion of FloodSafe brochures to help residents understand the flood risk and prepare their property and personal plans for a flooding event. • Promotion of flood proofing measures should also be included in flood education and awareness programs • Section 10.7 certificates to inform property owners about flood risk to their properties • Provide flood mapping on an interactive mapping portal on Council's website for easier viewing • Promotion and support for SES information events • Enhanced messaging on flood risk on Council's floodplain management webpage. The program should be reviewed on a regular (e.g. 5 yearly) basis or after each major flood event.	**Medium**

ID	Measures considered	Responsibility	Initial Cost	Ongoing Cost	Features of the Measure	Recommended Priority Rankings
RM4	Road flood depth signage	Council	$5K per location, five locations	$0K	Install new flood depth signage at selected locations: • Ocean Drive 70m east of Sirius Drive • Ocean Drive 380m east of Fairwinds Avenue • Ocean Drive 30m east of The Gateway • Bold Street sag between Laurie Street and Mill Street • Bold Street sag between Mill Street and Hanley Street.	**High**

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11. Glossary

Annual Exceedance Probability (AEP)

The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. In this study AEP has been used consistently to define the probability of occurrence of flooding. It is to be noted that design rainfalls used in the estimation of design floods up to and including 100 year ARI (ie. 1% AEP) events was derived from 1987 Australian Rainfall and Runoff. The following relationships between AEP and ARI applies to this study (AR&R, 2019).

Frequency Descriptor	EY	AEP (%)	AEP (1 in x)	ARI
Very frequent	**12**			
	6	99.75	1.002	0.17
	4	98.17	1.02	0.25
	3	95.02	1.05	0.33
	2	86.47	1.16	0.50
Frequent	**1**	**63.2**	1.58	1.00
	0.69	**50.00**	2	1.44
	0.5	39.35	2.54	2.00
	0.22	**20.00**	5	4.48
	0.2	18.13	5.52	5.00
Infrequent	0.11	**10.00**	10.00	9.49
	0.05	**5.00**	20	20.0
	0.02	**2.00**	50	50.0
	0.01	**1.00**	**100**	100
Rare	0.005	0.50	**200**	200
	0.002	0.20	**500**	500
	0.001	0.10	**1000**	1000
Extremely Rare	0.0005	0.05	**2000**	2000
	0.0002	0.02	5000	5000
			↓	
Extreme			PMP	

Australian Height Datum (AHD)

A common national surface level datum approximately corresponding to mean sea level.

Average Annual Damage (AAD)

Depending on its size (or severity), each flood will cause a different amount of flood damage to a flood prone area. AAD is the average damage per year that would

	occur in a nominated development situation from flooding over a very long period of time.
Average Recurrence Interval (ARI)	The long-term average number of years between the occurrences of a flood as big as or larger than the selected event. For example, floods with a discharge as great as or greater than the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.
Catchment	The land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.
DRAINS	DRAINS is a computer program which is used to simulate local catchment rainfall-runoff and stormwater system hydraulics and is widely used across Australia.
Development	Is defined in Part 4 of the EP&A Act In fill development: refers to the development of vacant blocks of land that are generally surrounded by developed properties and is permissible under the current zoning of the land. Conditions such as minimum floor levels may be imposed on infill development. New development: refers to development of a completely different nature to that associated with the former land use. Eg. The urban subdivision of an area previously used for rural purposes. New developments involve re-zoning and typically require major extensions of exiting urban services, such as roads, water supply, sewerage and electric power. Redevelopment: refers to rebuilding in an area. Eg. As urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large scale. Redevelopment generally does not require either re-zoning or major extensions to urban services.
Effective Warning Time	The time available after receiving advise of an impending flood and before the floodwaters prevent appropriate flood response actions being undertaken. The effective warning time is typically used to move farm equipment, move stock, raise furniture, evacuate people and transport their possessions.
Exceedances per Year (EY)	The number of times an event is likely to occur or be exceeded within any given year.
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.
Flood fringe areas	The remaining area of flood prone land after floodway and flood storage areas have been defined.

Flood liable land	Is synonymous with flood prone land (i.e.) land susceptibility to flooding by the PMF event. Note that the term flooding liable land covers the whole floodplain, not just that part below the FPL (see flood planning area)
Floodplain	Area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is flood prone land.
Floodplain risk management options	The measures that might be feasible for the management of particular area of the floodplain. Preparation of a floodplain risk management plan requires a detailed evaluation of floodplain risk management options.
Floodplain risk management plan	A management plan developed in accordance with the principles and guidelines in this manual. Usually include both written and diagrammatic information describing how particular areas of flood prone land are to be used and managed to achieve defines objectives.
Flood plan (local)	A sub-plan of a disaster plan that deals specifically with flooding. They can exist at state, division and local levels. Local flood plans are prepared under the leadership of the SES.
Flood planning levels (FPLs)	Are the combination of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans. FPLs supersede the "designated flood" or the “flood standard” used in earlier studies.
Flood proofing	A combination of measures incorporated in the design, construction and alteration of individual buildings and structures subject to flooding, to reduce or eliminate flood damages.
Flood readiness	Readiness is an ability to react within the effective warning time.
Flood risk	Potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk in this manual is divided into 3 types, existing, future and continuing risks. They are described below. Existing flood risk: the risk a community is exposed to as a result of its location on the floodplain. Future flood risk: the risk a community may be exposed to as a result of new development on the floodplain. Continuing flood risk: the risk a community is exposed to after floodplain risk management measures have been implemented. For a town protected by levees, the continuing flood risk is the consequences of the levees being overtopped. For an area without any floodplain risk management measures, the continuing flood risk is simply the existence of its flood exposure.
Flood storage areas	Those parts of the floodplain that are important for the temporary storage of floodwaters during passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the

	severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas
Floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels.
Freeboard	Provides reasonable certainty that the risk exposure selected in deciding on a particular flood chosen as the basis for the FPL is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. Freeboard is included in the flood planning level.
Hazard	A source of potential harm or situation with a potential to cause loss. In relation to this manual the hazard is flooding which has the potential to cause damage to the community.
Local overland flooding	Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.
m AHD	Metres Australian Height Datum (AHD)
m/s	Metres per second. Unit used to describe the velocity of floodwaters.
m^3/s	Cubic metres per second or "cumecs". A unit of measurement of creek or river flows or discharges. It is the rate of flow of water measured in terms of volume per unit time.
Mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.
Modification measures	Measures that modify either the flood, the property or the response to flooding.
Overland flow path	The path that floodwaters can follow as they are conveyed towards the main flow channel or if they leave the confines of the main flow channel. Overland flow paths can occur through private property or along roads.
Probable Maximum Flood (PMF)	The largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation couplet with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain.
Probable Maximum Precipitation (PMP)	The PMP is the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends (World Meteorological Organisation, 1986). It is the primary input to PMF estimation.
Risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of the manual it is the likelihood of

	consequences arising from the interaction of floods, communities and the environment.
Runoff	The amount of rainfall which ends up as a streamflow, also known as rainfall excess.
Stage	Equivalent to water level (both measured with reference to a specified datum)
TUFLOW	TUFLOW is a computer program which is used to simulate free-surface flow for flood and tidal wave propagation. It provides coupled 1D and 2D hydraulic solutions using a powerful and robust computation. The engine has seamless interfacing with GIS and is widely used across Australia.

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Appendix A. Community Consultation

PORT MACQUARIE-HASTINGS COUNCIL

Community Bulletin No. 1 - October 2017

JACOBS

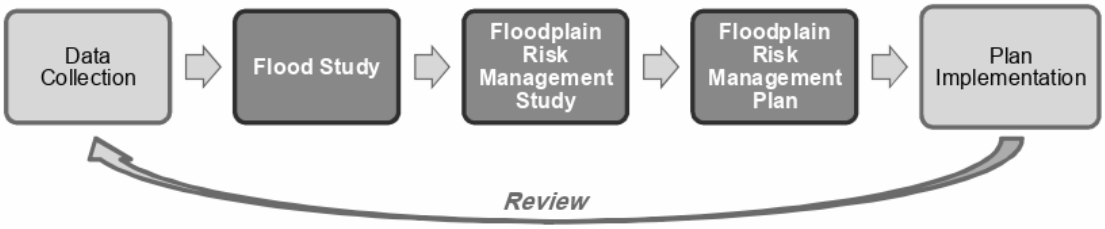
North Brother Local Catchments Flood Study

Port Macquarie Hastings Council is currently conducting the North Brother Local Catchments Flood Study. This Community Bulletin is the first in a series of Bulletins aimed at informing residents of the status of the project and how they can be involved in the process. Council has engaged consultants, Jacobs Group Australia, to undertake the Study.

The focus of the study is to understand the behaviour of local catchment flash flooding from North Brother Mountain and the flood risk that it poses to the community. This will assist Council to develop measures to manage the impact of flooding and guide strategic planning for future development of the area. It includes areas of the villages of Laurieton, West Haven, Lakewood, Kew and Deauville.

An integral part of the study process is community consultation and involvement. This element of the process aims to inform the community of the study and invite residents to provide information on their views and experiences with flooding in the area. The management of flood prone land is primarily the responsibility of Councils and follows a number of stages as shown below. The project is currently in the Flood Study stage, and will later move to the Floodplain Risk Management Study and Floodplain Risk Management Plan stages as the project progresses.

The Stages of Floodplain Risk Management



Objectives of the Study

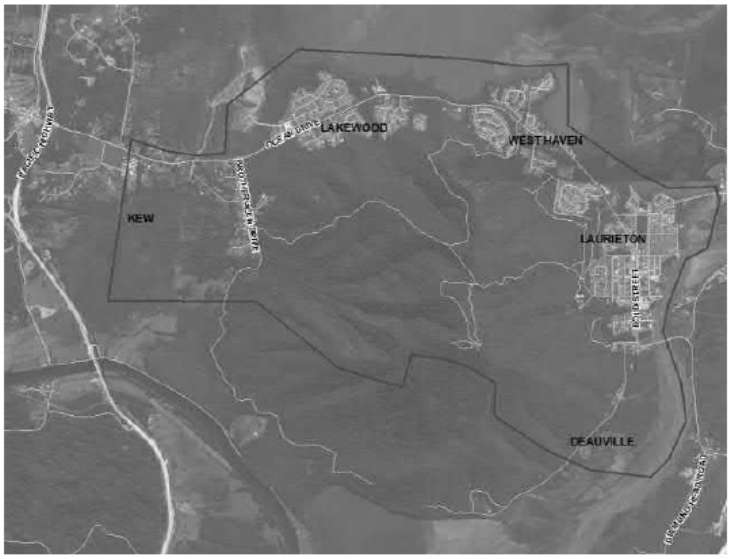
The objectives of the study are to:

1. Define the overland and flash flooding behaviour in the study area. Computer flood modelling will be undertaken to do this during the current flood study stage.
2. Identify and evaluate possible flood mitigation and management measures to reduce the flood risk. These may be structural and planning measures or "response" measures.
3. Develop a staged plan for implementing these measures.

Community Survey

We are seeking feedback from the community on previous flooding events in the area and views on possible management measures via the attached survey. The results of the survey will help inform a flood study for the area, which will be placed on public exhibition in early 2018, and a subsequent floodplain risk management study. The information that you provide will improve the flood model being developed.

Study Area



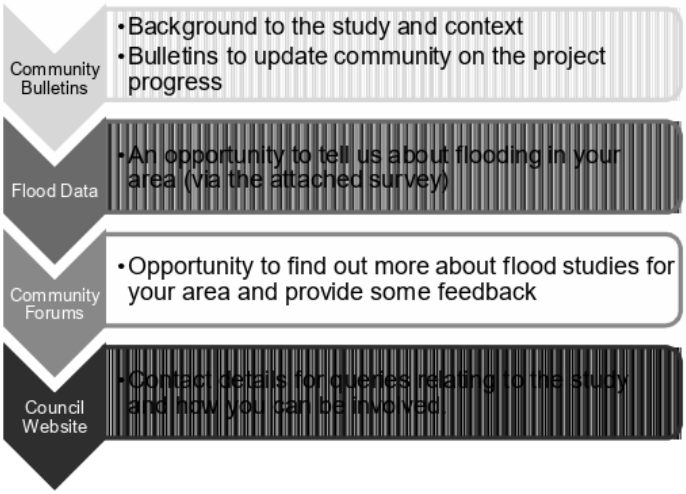
The Flood Problem

The study area typically experiences short duration flooding, which occurs when intense rainfall exceeds the capacity of the stormwater network or creek channel. In urbanised areas, this flooding has the potential to cause major damage to property and risk to life. Notable local flash flooding in the study area recently occurred in:

- April 2008
- June 2011
- March 2013
- January 2016.

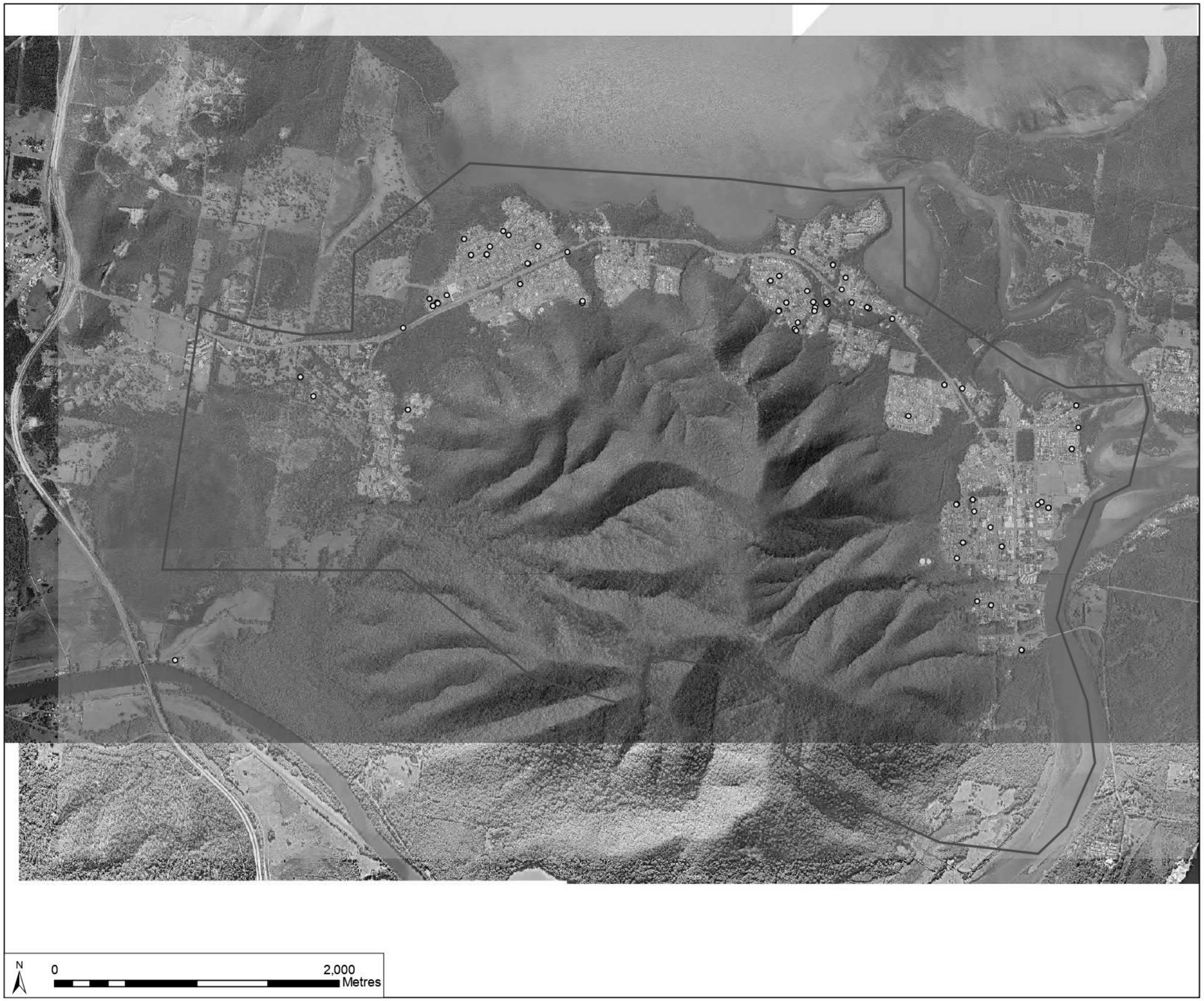
How can you get involved?

Engagement of the community in the floodplain risk management process is very important to Council. We will be providing a number of opportunities for the community to have input during the course of this study.



Some of the most important information for the study is collected from residents and local business operators. We would be very interested to receive records of flooding in your area including photographs, observations of flood depths or some comments on your experience. You can help us with this information by completing the questionnaire for your area and returning the completed community survey by 31 October 2017. The questionnaires can be found in Council's web site www.haveyoursay.pmhc.nsw.gov.au/ Port Macquarie Hastings Council appreciates your cooperation and will keep you informed with ongoing community bulletins.

For more information contact Port Macquarie Hastings Council on (02) 6581 8111 or visit **haveyoursay.pmhc.nsw.gov.au**



GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	Calibration and Verification Points
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	FIGURE C-1
DATE 25/06/2018	

Summary of key survey questions and responses

* Note, not all responses have been included in this summary. Responses mentioning specific locations and addresses have been omitted for privacy reasons.

Do you live in the study area?

Response	Count	% of responses
No	15	5%
Yes	276	95%

Do you own or rent in the study area?

Response	Count	% of responses
Own and occupy	280	98%
Rent	6	2%

Do you own or manage a business in the study area?

Response	Count	% of responses
No	264	94%
Yes	17	6%

What kind of business?

Response	Count
Home based	6
Shop/ commercial premises	6
Industrial	1
Other	3

Are you aware of flooding in the Study Area?

Response	Count	% of responses
Aware	136	48%
Some knowledge	77	27%
Not aware	71	25%

When have you experienced significant flooding in the area?

Response	Count	% of responses
Not affected	142	51%
Property Flooded	43	15%
Minor Disruption (roads flooded by driveable)	69	25%
House or business flooded	17	6%
Access cut off	9	3%

What damage resulted from this flood in your residence?

Response	Y - no rating	Minor	Moderate	Major	None or Not Aware
Damage to garden, lawns or backyard	32	28	6	3	39
Damage to external house walls	4	1	3	1	46
Damage to internal parts of house (floor, doors, walls etc)	8	6	1	4	46
Damage to possessions (fridge, television etc)	0	0	0	5	7
Damage to car				1	49
Damage to garage	11	10	3	0	46
Other	"Minor road damage" "Back sunroom was flooded" "Had to put a drain under the garden bed to the stormwater drain" "Dirt washed into pool"				
What was the cost of repairs, if any?	Covered by insurance: 4 Up to $1000: 7 $1000 - $5000: 6 $5000 - $10000: 2 $10000 - $20000: 3 >$20000: 2 ($50K and $70K)				

What damage resulted from this flood in your business?

Response	Y - no rating	Minor	Moderate	Major	None or Not Aware
Damage to surroundings	3	6	1	0	24
Damage to Building	3	2	0	0	25
Damage to Stock	2	1	1	0	24
Other	1	-	-	-	25

Please rank the following development types according to what you consider should be assigned greatest priority in protecting from flooding (1 = greatest priority to 7 = least priority). Please identify specific items if necessary.

	Count							% of Responses						
Rating	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Commercial	12	1	71	62	8	3	138	4%	0%	24%	21%	3%	1%	47%
Heritage items	13	1	12	24	43	76	28	7%	1%	6%	12%	22%	39%	14%
Residential	98	22	71	30	11	2	0	42%	9%	30%	13%	5%	1%	0%
Community Facilities	22	13	48	62	48	26	2	10%	6%	22%	28%	22%	12%	1%
Critical utilities	59	94	40	19	8	3	0	26%	42%	18%	9%	4%	1%	0%
Emergency Facilities	110	62	24	15	8	3	2	49%	28%	11%	7%	4%	1%	1%
Recreation areas and facilities	5	2	4	5	12	46	138	2%	1%	2%	2%	6%	22%	65%

Please rank the following by placing numbers from 1 to 6 (1 = greatest priority to 6 = least priority)

	Count						% of Responses					
Rating	1	2	3	4	5	6	1	2	3	4	5	6
A) Protecting residents/business from flooding	135	30	21	19	27	12	55%	12%	9%	8%	11%	5%
B) Protecting land of residents/businesses from flooding	24	60	24	31	33	63	10%	26%	10%	13%	14%	27%
C) Maintaining an emergency flood free access	55	43	73	32	29	7	23%	18%	31%	13%	12%	3%
D) Providing flood signage for public safety	16	28	26	34	43	88	7%	12%	11%	14%	18%	37%
E) Support from SES	27	44	48	63	36	16	12%	19%	21%	27%	15%	7%
F) Providing flood warning	59	28	29	46	42	31	25%	12%	12%	20%	18%	13%

Are you aware of any works that have been carried out near you that you believe have negatively impacted on the flood behaviour at your property? (Tick all boxes that apply)

Response	Count	% of responses
A) Not aware of any measures	215	70%
B) Building or renovation activities	14	5%
C) Fencing	5	2%
D) Creek works	14	5%
E) Upgraded roads, culverts	20	6%
F) Overland flow obstructions	22	7%
G) Other (please specify)	18	6%

Comment responses

Aged Council drain does not comply with current standards & industry specification. see Council minutes 20th March, 2013.
Uphill development
Y- New bridge- sections impact on flow on Laurieton side.
Y- Rear boundary neighbour has shadehouse against back fence. This has resulted in the way the water flows, it does not follow the land contour, it hits the shadehouse and all water from surrounding properties come onto our property.
Y- We have a creek at the back of us which needs to be fixed every year this needs to be done last time they did it they enclosed the poor birds that live in the walls of the creek. We don't have enough drainage in the street of Honeysuckle.
Footpath has been raised in front of our house for the sake of the units built next door, the footpath has been partly done but still not finished and we are still getting water. Also our neighbours right through their ground floor Council was going to extend the footpath and raise the level up to the same as the units.
Y - stormwater getting into sewage pipes and overflowing sewerage problem is very bad in our Lakewood area.
Y - Laurieton reservoirs/stormwater drain - see atachments
Y - nature strip falling toward smy house and not away to the main road
erosion out front increasing in stormwater water drainage re rain driveway access affected from north brother runoff and subdivision runoff
Y - new developments have increased storm water runoff with NO increase in storm pipes lower in the system
Y - land use planning
Silting of Camden Haven River heads/bar
Stormwater drainage on eastern side of Quarry Way inadequate
Easement drains under property now out of alignment
Refer to my letter, apply better cleaning of drainage under Kew Road to allow flow to the lake
Road drainage and easements directed onto our property.

Are you aware of any works that have been carried out near you that you believe have improved the flood behaviour at your property? (Tick all boxes that apply)

Response	Count	% of responses
A) Not aware of any measures	205	68%
B) Building or renovation activities	8	3%
C) Fencing	3	1%
D) Creek works	19	6%
E) Upgraded roads, culverts	39	13%
F) Overland flow obstructions	12	4%
G) Other (please specify)	15	5%

Comment responses

Council has made efforts to improve situation but so with no success.
New stormwater drain.
The creek to creek walkway has improved our access out of town
None, no work done
Water diversion swale on crown land
Y - concrete drain installed behind our property (but it is inadequate to cope with volumes of water in heavy rain)
Y - culverts in reserve, no footpath provided for elderly
Council drainage is the only time I have concern for flooding
Y - reservoirs/stormwater drain. Lack of maintenance has caused serious concerns of flooding
River walls to improve depth of river bar
Y - foot paths
Y - nearby creek cleared of plant debris and plastic bottles etc.
Cleaning of existing storm drains
Very little of any

Which of the following measures do you think Council should consider for reducing the floodrisk at your property? (1 = greatest priority to 7 = least priority).

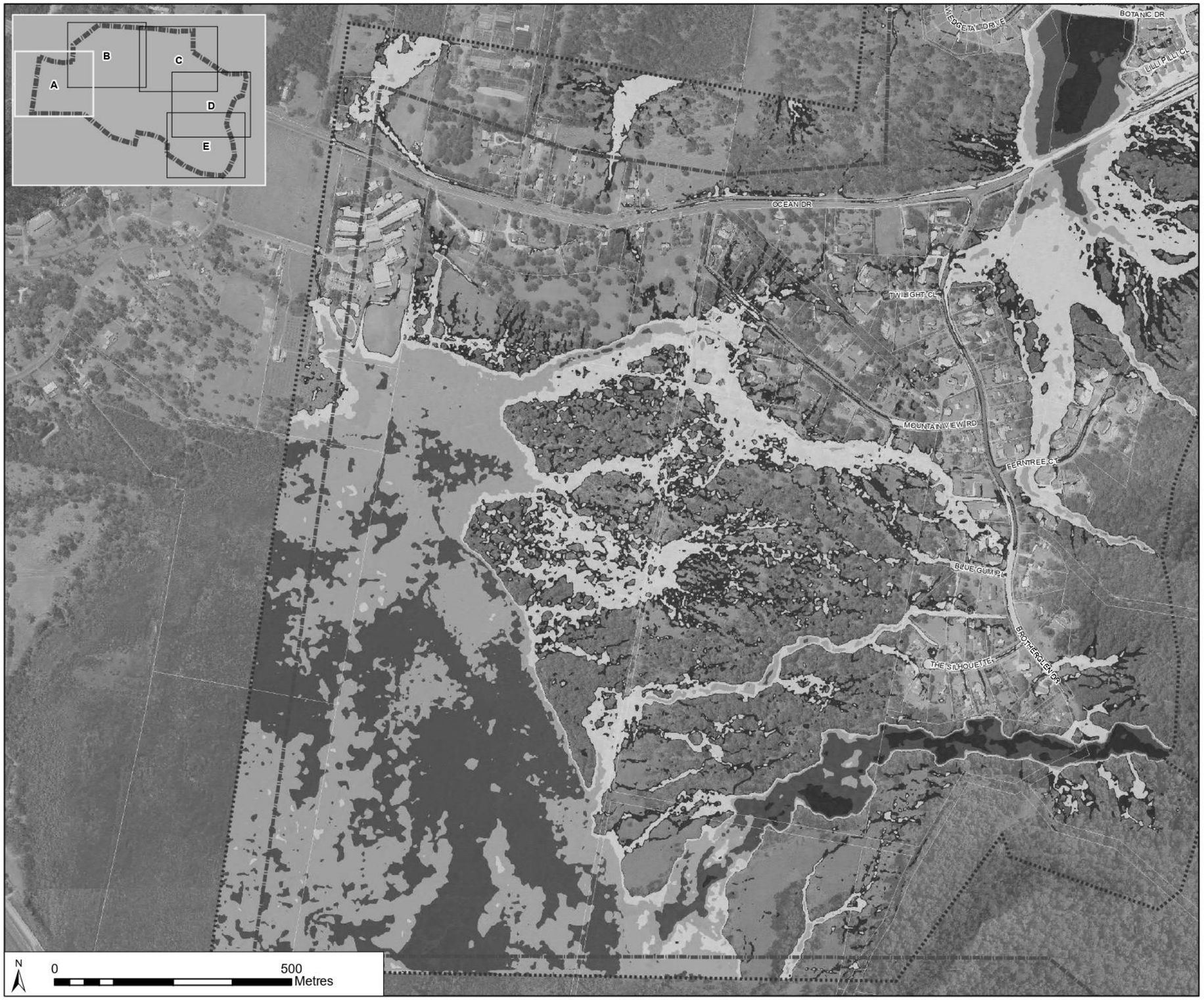
	Count					% of Responses				
Rating	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
A) Zoning, building & development controls, including fencing	38	46	51	23	3	24%	29%	32%	14%	2%
B) Upgrading stormwater drainage	167	33	10	0	0	80%	16%	5%	0%	0%
C) Upgrading roads	29	66	53	22	3	17%	38%	31%	13%	2%
D) Public awareness & education	13	18	36	85	7	8%	11%	23%	53%	4%
E) Other (please specify)	0	0	0	4	39	0%	0%	0%	9%	91%

Comment responses

Publish max flood line not just the 100 year flood line on maps on NSW Planning Portal.
How about a levee if there is a perceived problem
Walkway to main road for elderly who can't drive and rely on walking and mobility scooter to town along the lake and public access to main road.
MAINTAIN DRAINS, EASEMENT
Planting trees on the streetside providing more parklands.
KEEP STORM DRAINS CLEAR BY REGULAR INSPECTIONS & CLEARING IF NECESSARY
Fixing the creek so the water will flow out to the lake
Keep culverts clear of vegetation and rubbish on southern side of Ocean Drive opposite the Gateway Road
Installing kerb and gutter to our street.
Clean out drains and creeks
New kerb and gutter on low side of roads.
Trees in drain behind xx, xx and xx Koonwarra Street at bend of drain blocks up. I have to keep cleaning it out, Council won't.

Putting kerb and guttering from Ocean Drive into Lake Street and Castle Street. Houses have bene built about 60 years but no kerb and gutter. Would be good to have to get rid of the water instead of having stagnant water and lots of mosquitoes
Carry out drainage maintenance work as per letter dated 13/6/13 - see attached
Actually putting in place stormwater drainage
Cleaning gutters and weed growth at joints and any other blockages on a regular basis
The open drain on Lord Street Laurieton, between Laurie Street and Seymour Street should be replaced with pipes.
Dredging the river beds
Better drainage of water coming off the mountain. Something to slow the flow.
Lift/build up the verge outside my house to the equivalent height to recent building adjacent to my property
Inappropriate building on wetlands or flood prone areas
I don't believe my property is under threat of flooding
Not a risk

Appendix B. Flood Mapping



Legend

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area
- Limit of Mapping

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and LakesSystem Flood Study (2013) for riverine flooding mapping.

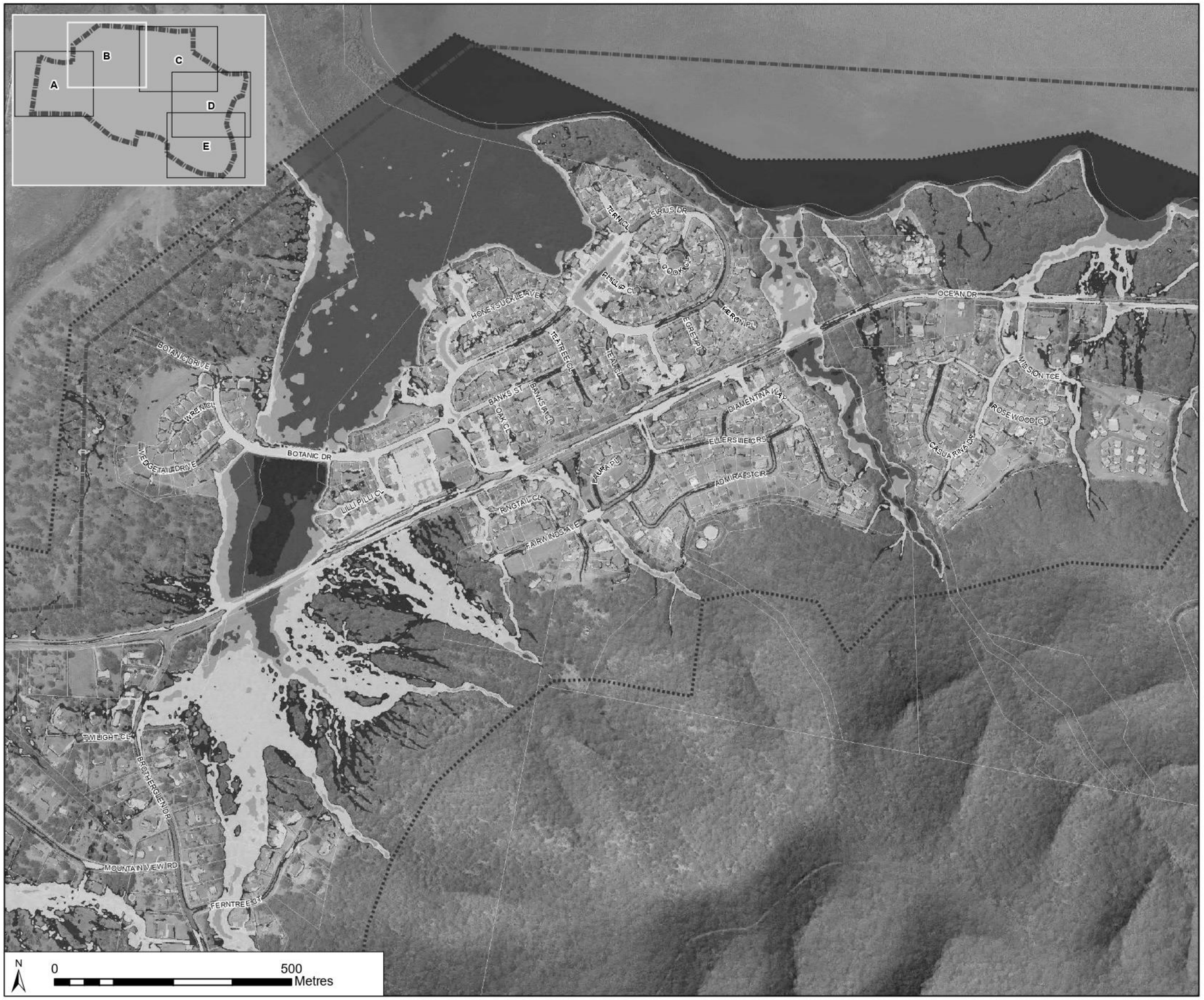
GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	1% AEP Design Flood Peak Flood Depths
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP B-1(A)
DATE 3/03/2020	



Legend

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area
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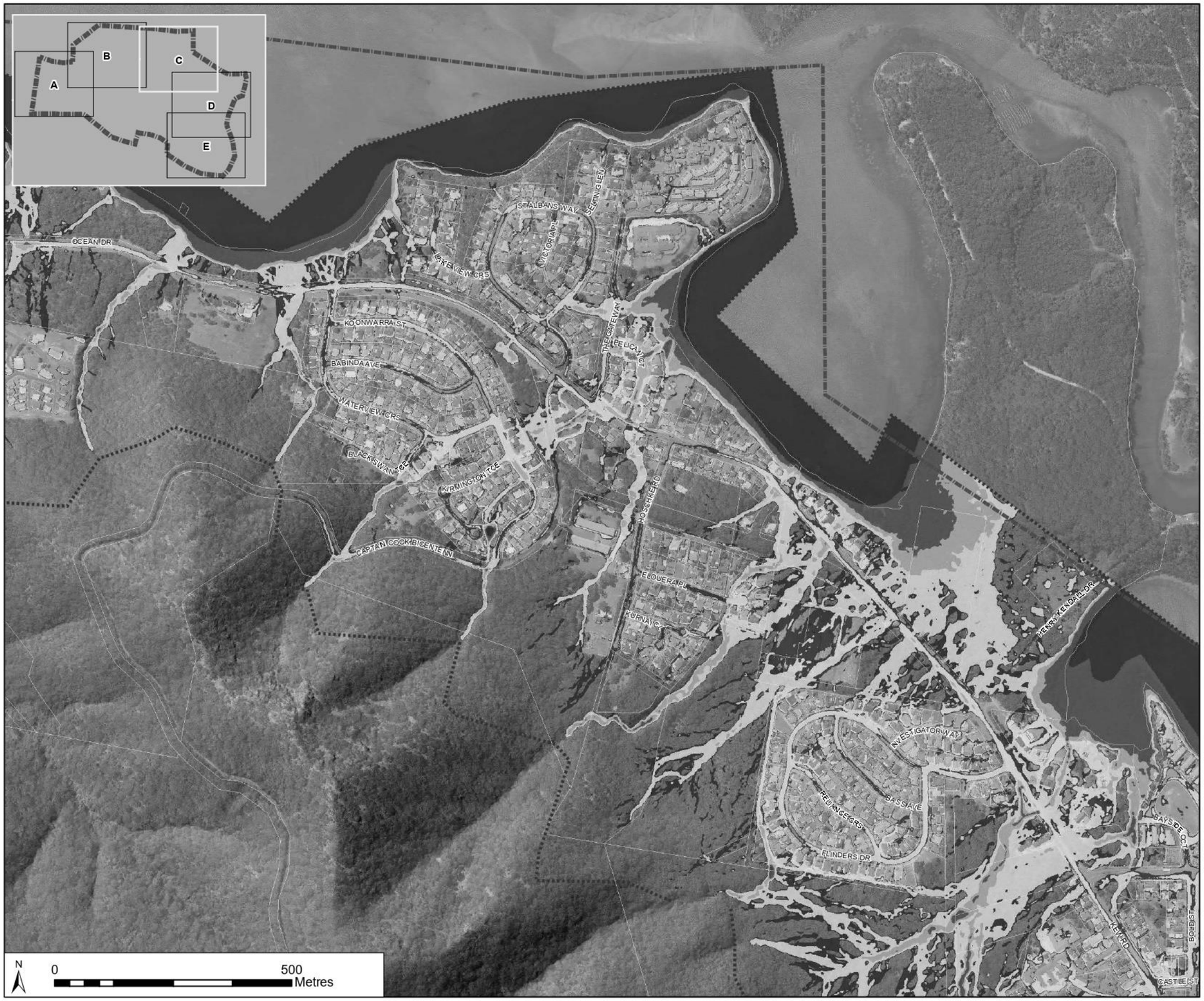
JACOBS

TITLE	1% AEP Design Flood Peak Flood Depths
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP B-1(B)
DATE 3/03/2020	



Legend

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area
- Limit of Mapping

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GDA 1994 MGA Zone 56
Scale: A3

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JACOBS

TITLE	1% AEP Design Flood Peak Flood Depths
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP B-1(C)
DATE 3/03/2020	

Legend

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area
- Limit of Mapping

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and LakesSystem Flood Study (2013) for riverine flooding mapping.

GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

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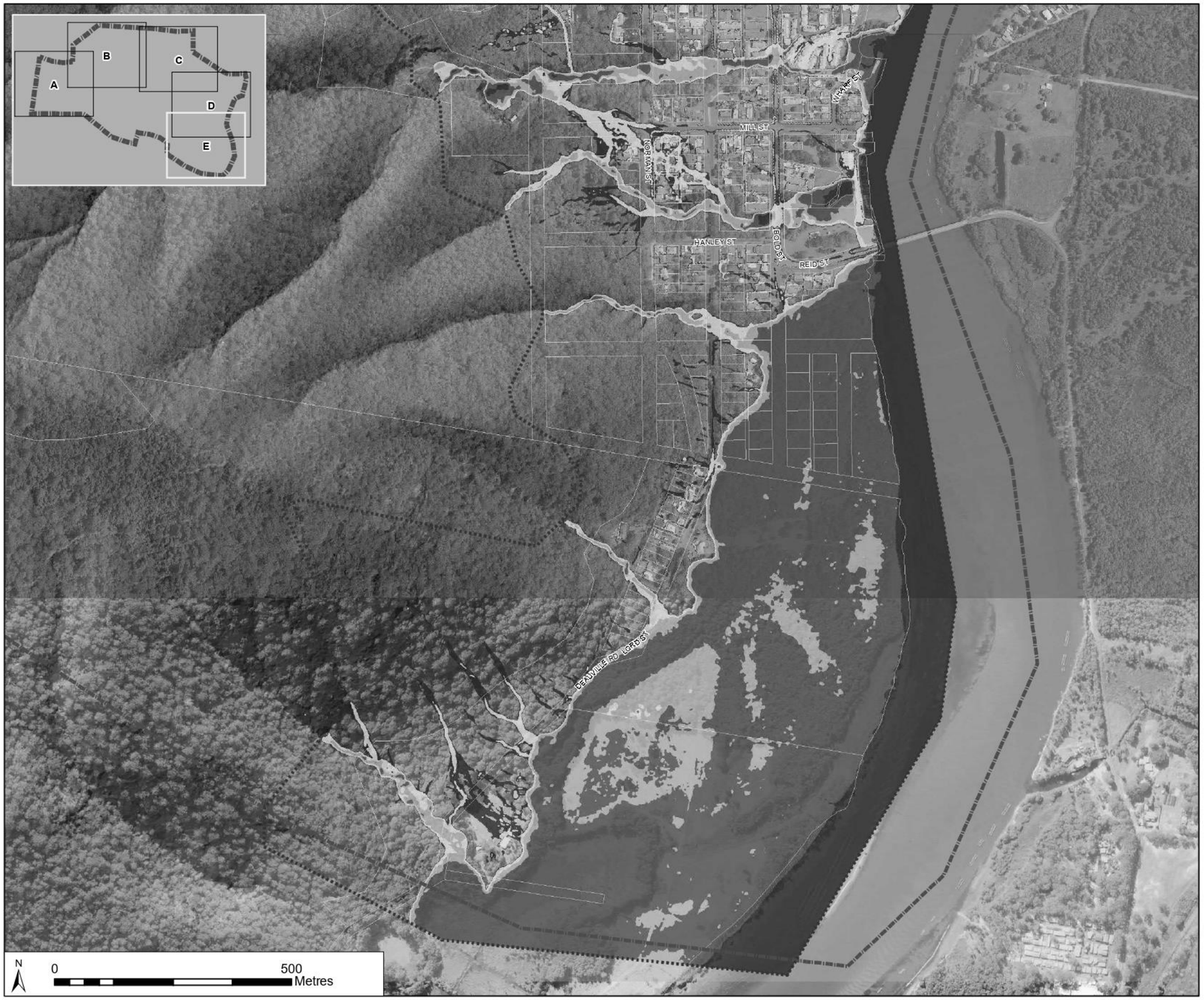
JACOBS

TITLE	1% AEP Design Flood Peak Flood Depths
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP B-1(D)
DATE 3/03/2020	



Legend

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area
- Limit of Mapping

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GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

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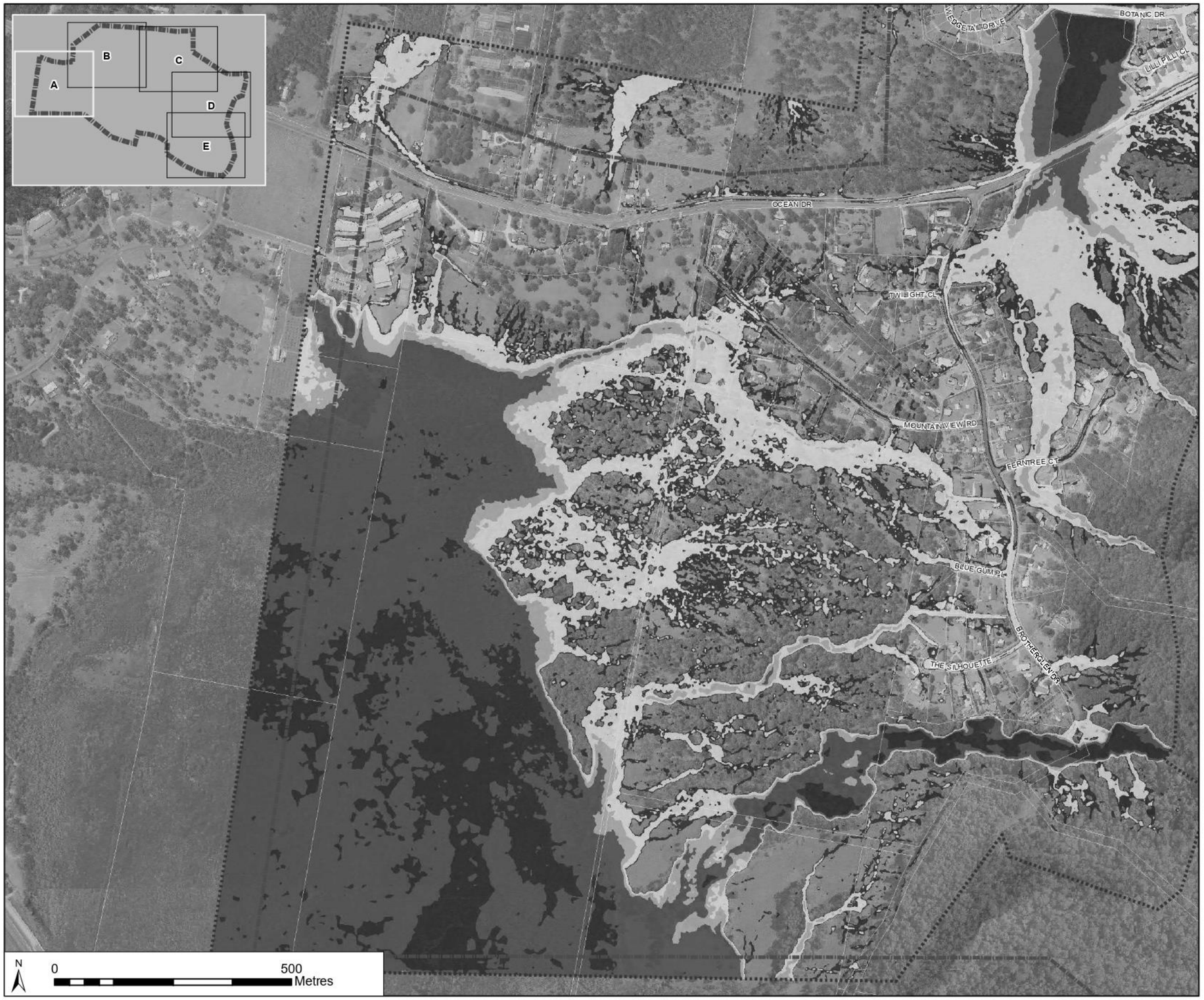
JACOBS

TITLE	1% AEP Design Flood Peak Flood Depths
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP B-1(E)
DATE 3/03/2020	



Legend

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area
- Limit of Mapping

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GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

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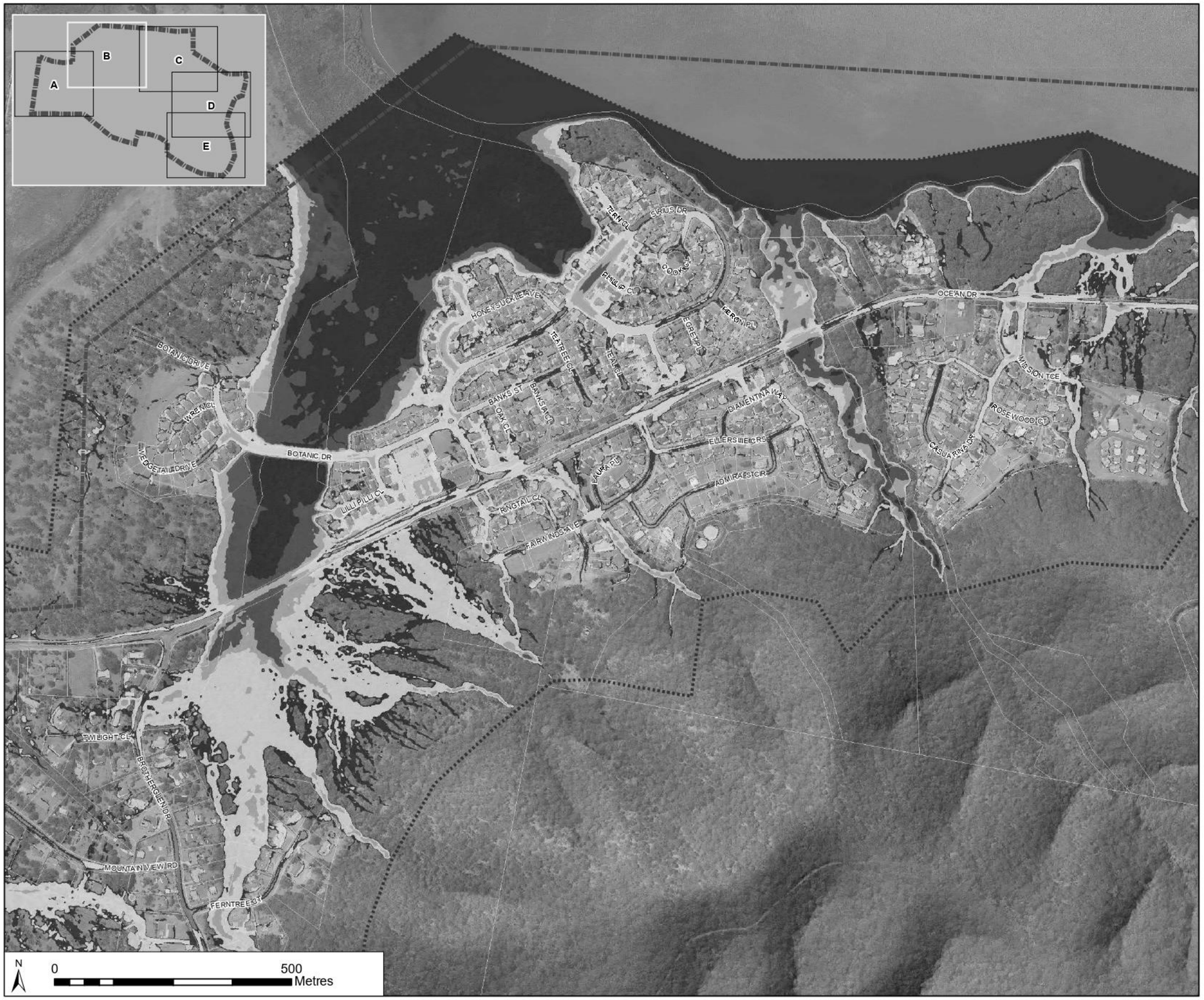
JACOBS

TITLE	1% AEP Design Flood Climate Change Scenario Peak Flood Depths
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP B-2(A)
DATE 3/03/2020	



Legend

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area
- Limit of Mapping

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GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

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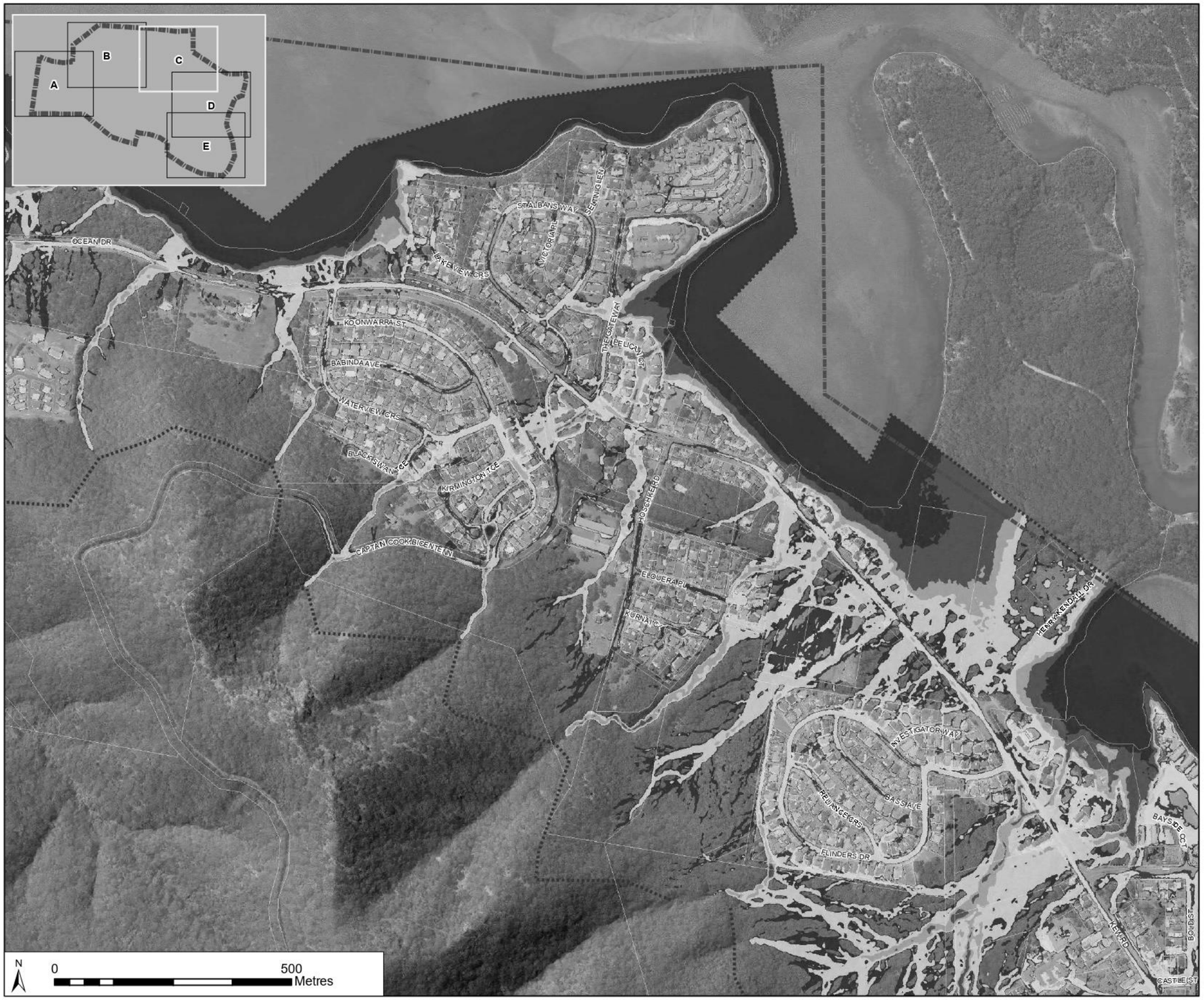
JACOBS

TITLE	1% AEP Design Flood Climate Change Scenario Peak Flood Depths
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP B-2(B)
DATE 3/03/2020	



Legend

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area
- Limit of Mapping

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GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

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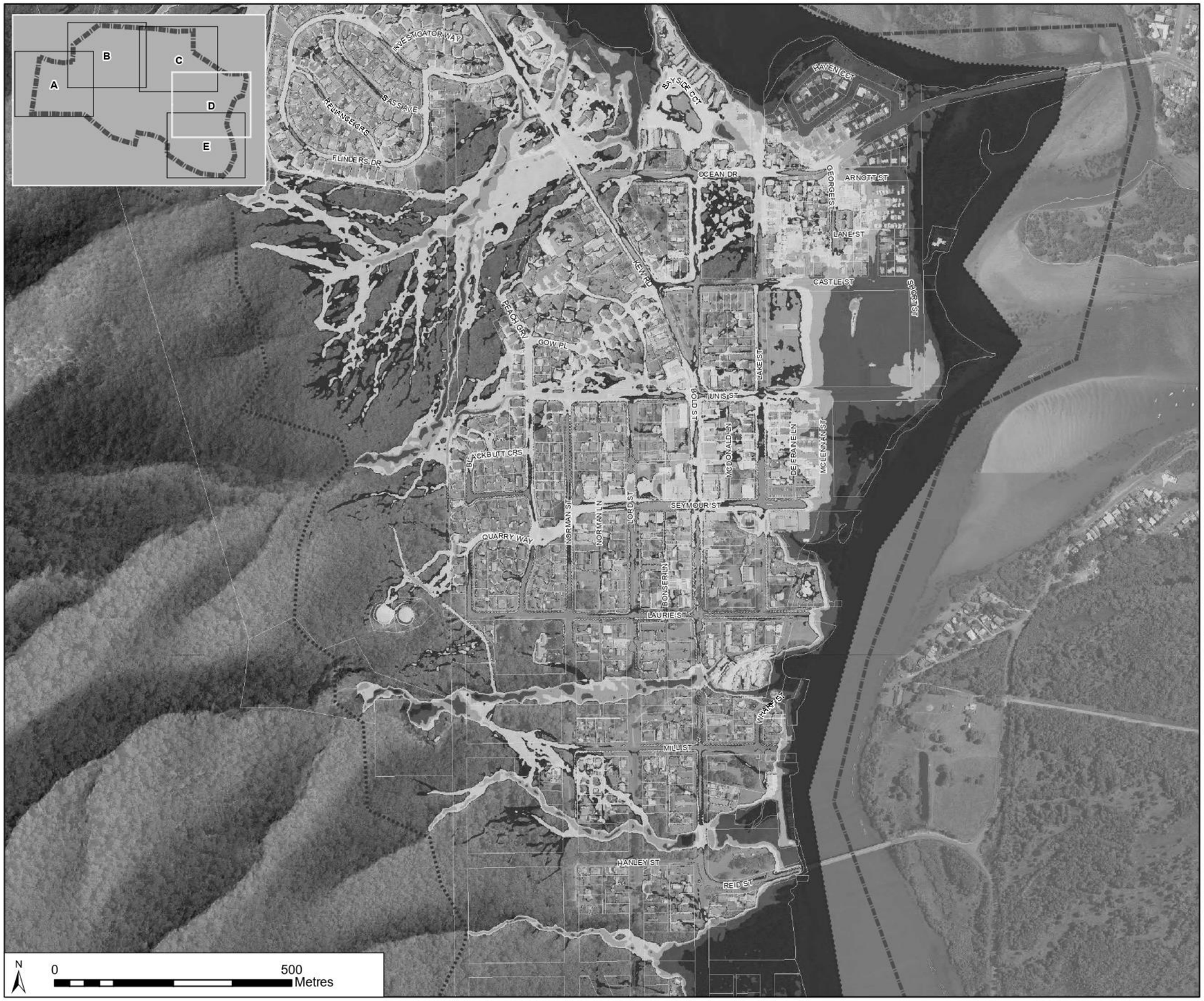
JACOBS

TITLE	1% AEP Design Flood Climate Change Scenario Peak Flood Depths
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP B-2(C)
DATE 3/03/2020	



Legend

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area
- Limit of Mapping

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and LakesSystem Flood Study (2013) for riverine flooding mapping.

GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

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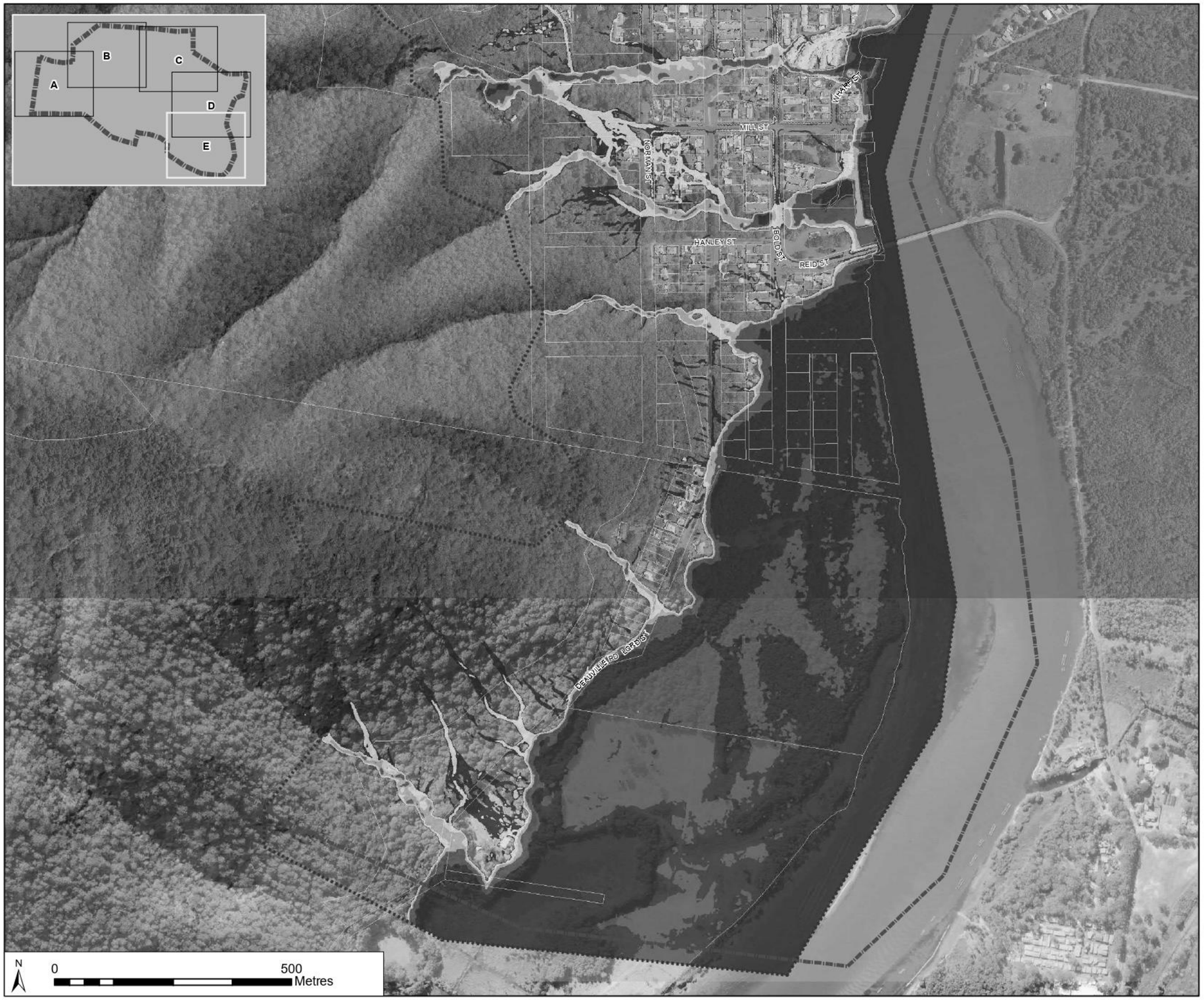
JACOBS

TITLE	1% AEP Design Flood Climate Change Scenario Peak Flood Depths
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP B-2(D)
DATE 3/03/2020	



Legend

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area
- Limit of Mapping

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GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

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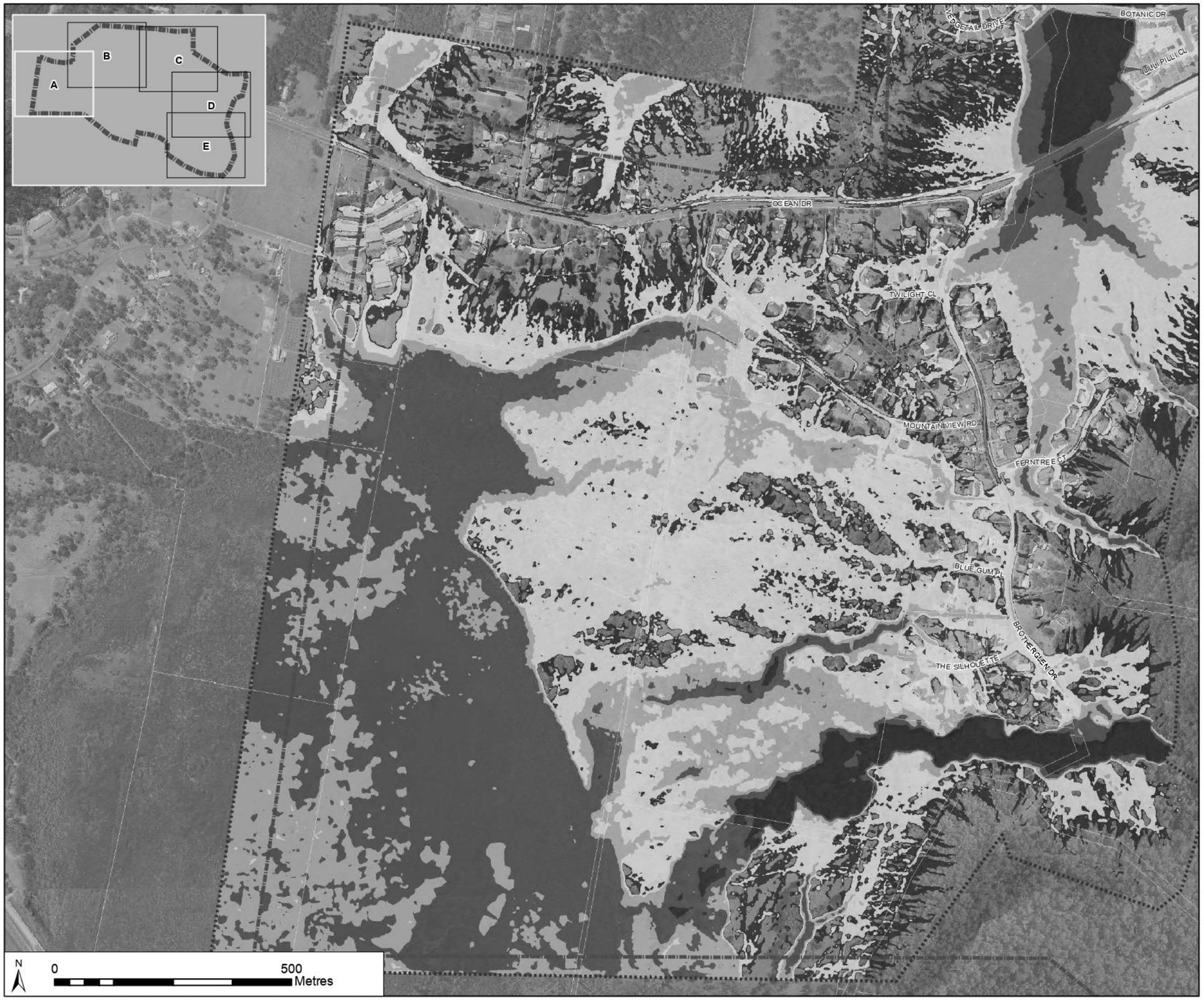
JACOBS

TITLE	1% AEP Design Flood Climate Change Scenario Peak Flood Depths
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP B-2(E)
DATE 3/03/2020	



Legend

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area
- Limit of Mapping

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and Lakes System Flood Study (2013) for riverine flooding mapping.

GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

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JACOBS

TITLE	Probable Maximum Flood Peak Flood Depths
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP B-3(A)
DATE 28/11/2018	

Legend

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area
- Limit of Mapping

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and Lakes System Flood Study (2013) for riverine flooding mapping.

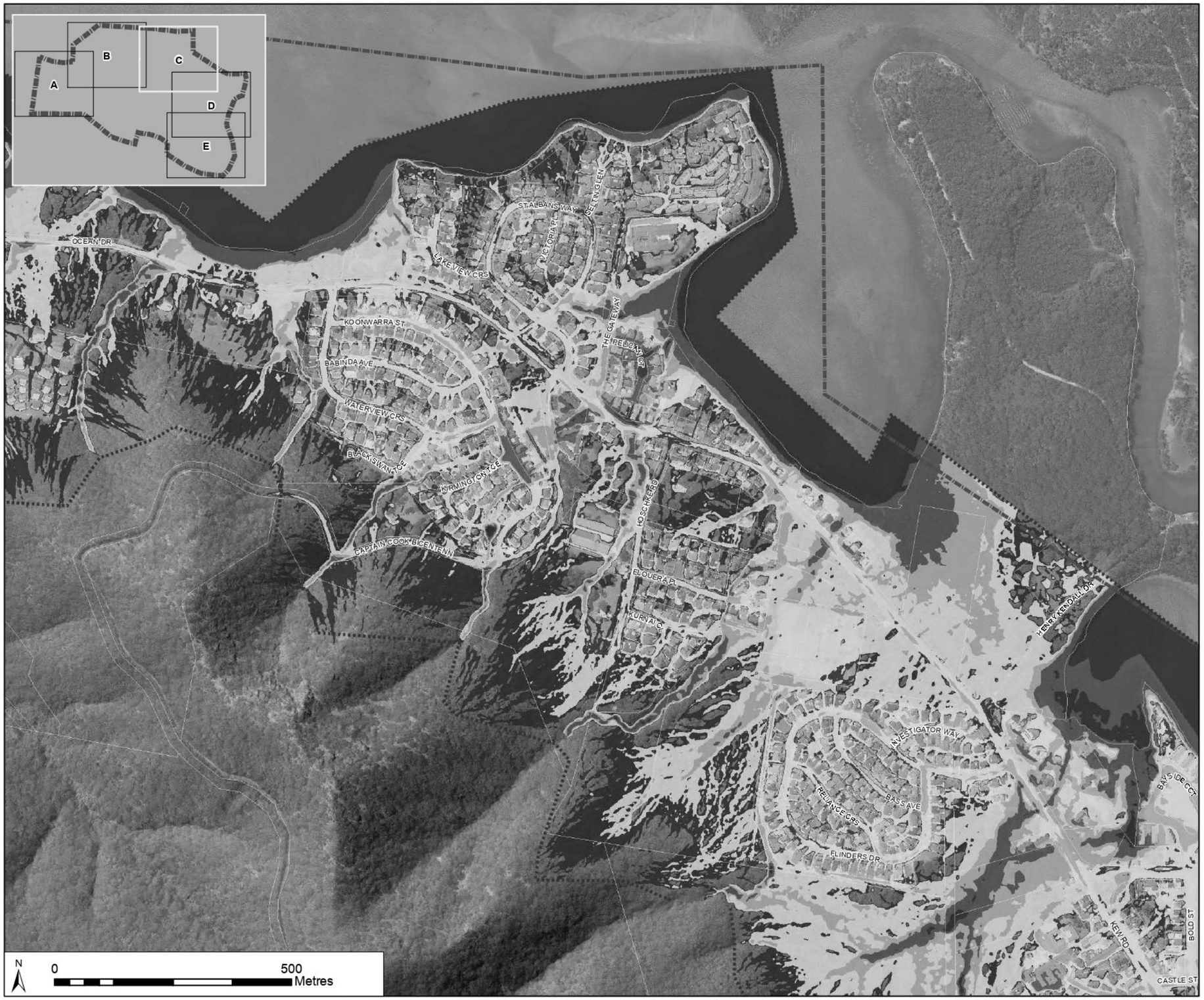
GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	Probable Maximum Flood Peak Flood Depths
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP B-3(B)
DATE 28/11/2018	



Legend

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area
- Limit of Mapping

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and Lakes System Flood Study (2013) for riverine flooding mapping.

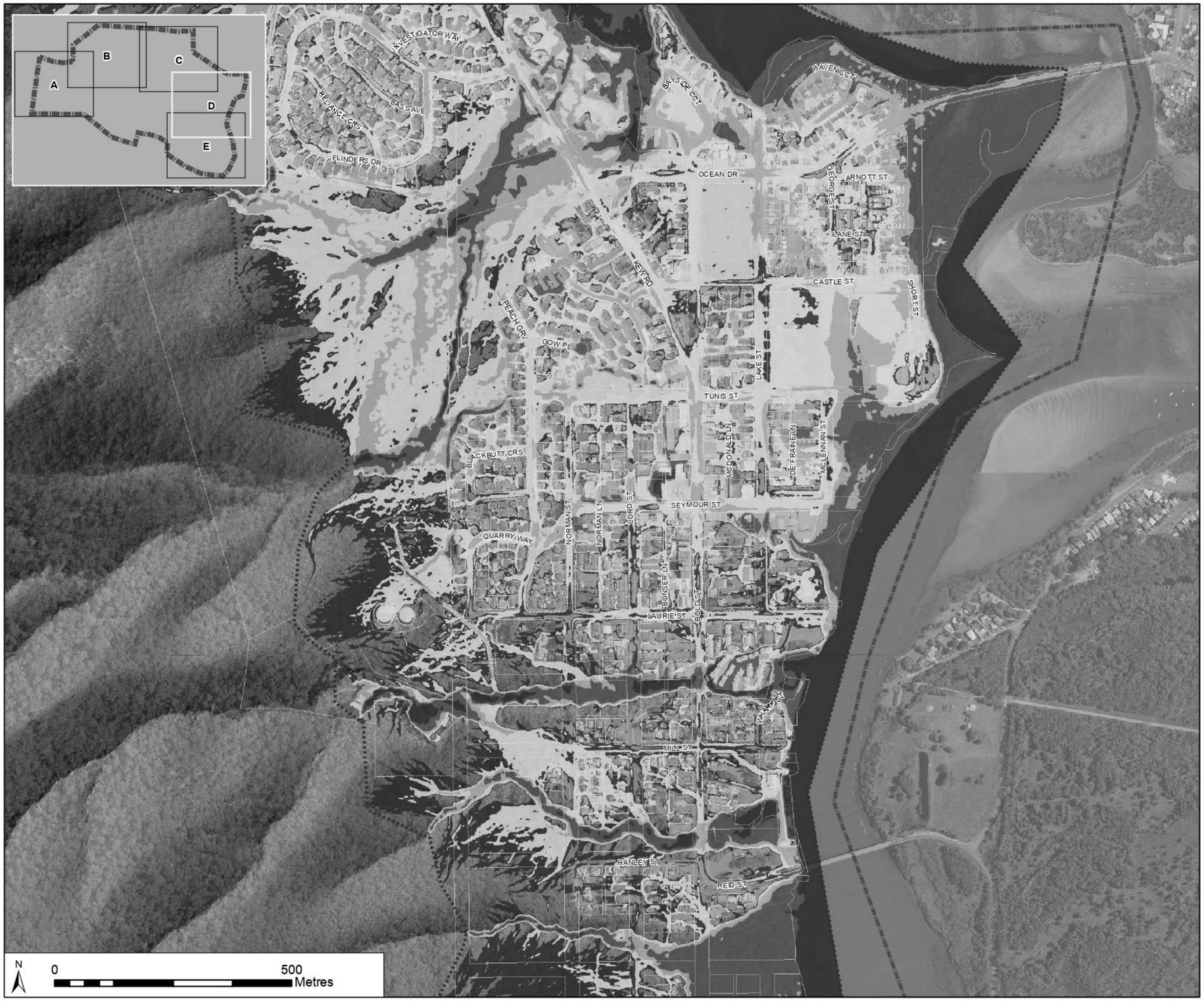
GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	Probable Maximum Flood Peak Flood Depths
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP B-3(C)
DATE 28/11/2018	



Legend

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area
- Limit of Mapping

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and Lakes System Flood Study (2013) for riverine flooding mapping.

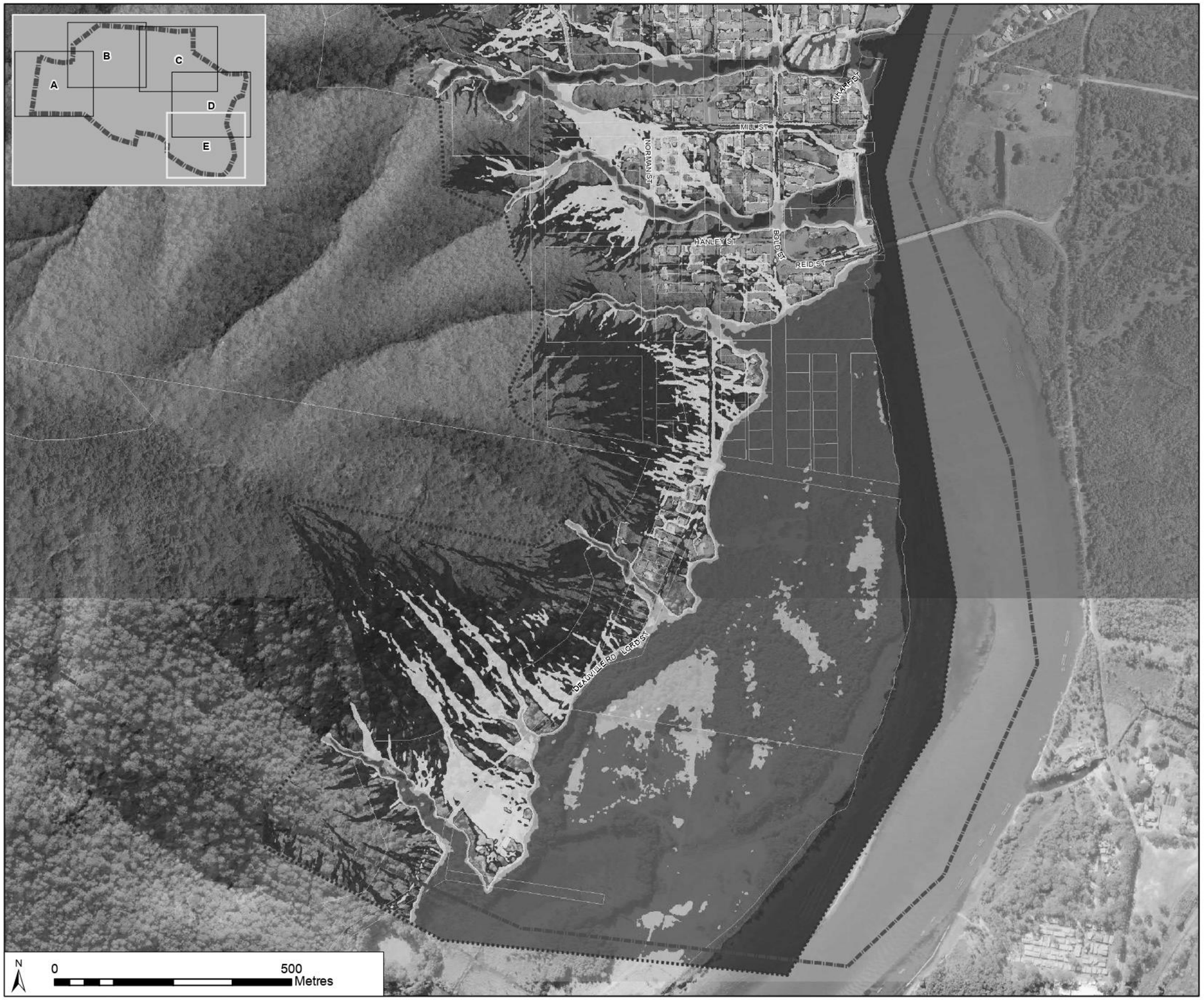
GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	Probable Maximum Flood Peak Flood Depths
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP B-3(D)
DATE 28/11/2018	



Legend

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area
- Limit of Mapping

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and Lakes System Flood Study (2013) for riverine flooding mapping.

GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	Probable Maximum Flood Peak Flood Depths
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP B-3(E)
DATE 28/11/2018	

Appendix C. Flood Planning Mapping

Legend

Flood Hazard Category

- H1 - Generally safe for vehicles, people and buildings.
- H2 - Unsafe for small vehicles.
- H3 - Unsafe for all vehicles, children and the elderly.
- H4 - Unsafe for all people and all vehicles.
- H5 - Unsafe for all people and all vehicles. Buildings require special engineering design and construction.
- H6 - Unsafe for Vehicles and people. All building types considered vulnerable to failure.
- Study Area
- Limit of Mapping

NOTES:
1. The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and Lakes System Flood Study (2013) for riverine flooding mapping.
2. The climate change scenario comprises a 10% increase in the 1% AEP rainfall and a 0.9m sea level rise.

GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	1% AEP Design Flood Climate Change Scenario Flood Hazard Categories
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP C-1(A)
DATE 27/01/2021	

Legend

Flood Hazard Category

- H1 - Generally safe for vehicles, people and buildings.
- H2 - Unsafe for small vehicles.
- H3 - Unsafe for all vehicles, children and the elderly.
- H4 - Unsafe for all people and all vehicles.
- H5 - Unsafe for all people and all vehicles. Buildings require special engineering design and construction.
- H6 - Unsafe for Vehicles and people. All building types considered vulnerable to failure.
- Study Area
- Limit of Mapping

NOTES:
1. The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and Lakes System Flood Study (2013) for riverine flooding mapping.
2. The climate change scenario comprises a 10% increase in the 1% AEP rainfall and a 0.9m sea level rise.

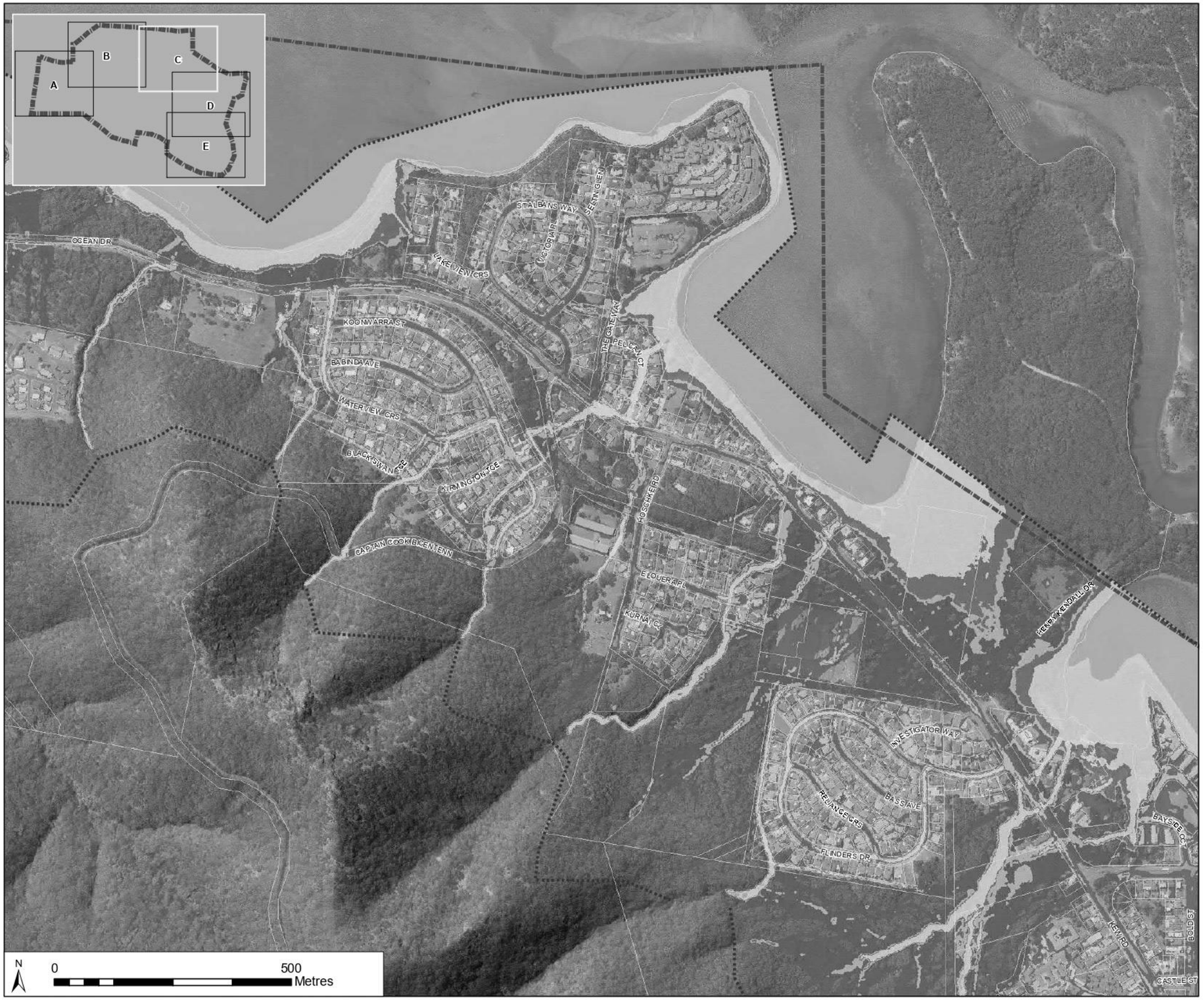
GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS®

TITLE	1% AEP Design Flood Climate Change Scenario Flood Hazard Categories
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP C-1(B)
DATE 27/01/2021	



Legend

Flood Hazard Category

- H1 - Generally safe for vehicles, people and buildings.
- H2 - Unsafe for small vehicles.
- H3 - Unsafe for all vehicles, children and the elderly.
- H4 - Unsafe for all people and all vehicles.
- H5 - Unsafe for all people and all vehicles. Buildings require special engineering design and construction.
- H6 - Unsafe for Vehicles and people. All building types considered vulnerable to failure.
- Study Area
- Limit of Mapping

NOTES:
1. The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and Lakes System Flood Study (2013) for riverine flooding mapping.
2. The climate change scenario comprises a 10% increase in the 1% AEP rainfall and a 0.9m sea level rise.

GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	1% AEP Design Flood Climate Change Scenario Flood Hazard Categories
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP C-1(C)
DATE 27/01/2021	

Legend

Flood Hazard Category

- H1 - Generally safe for vehicles, people and buildings.
- H2 - Unsafe for small vehicles.
- H3 - Unsafe for all vehicles, children and the elderly.
- H4 - Unsafe for all people and all vehicles.
- H5 - Unsafe for all people and all vehicles. Buildings require special engineering design and construction.
- H6 - Unsafe for Vehicles and people. All building types considered vulnerable to failure.
- Study Area
- Limit of Mapping

NOTES:
1. The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and Lakes System Flood Study (2013) for riverine flooding mapping.
2. The climate change scenario comprises a 10% increase in the 1% AEP rainfall and a 0.9m sea level rise.

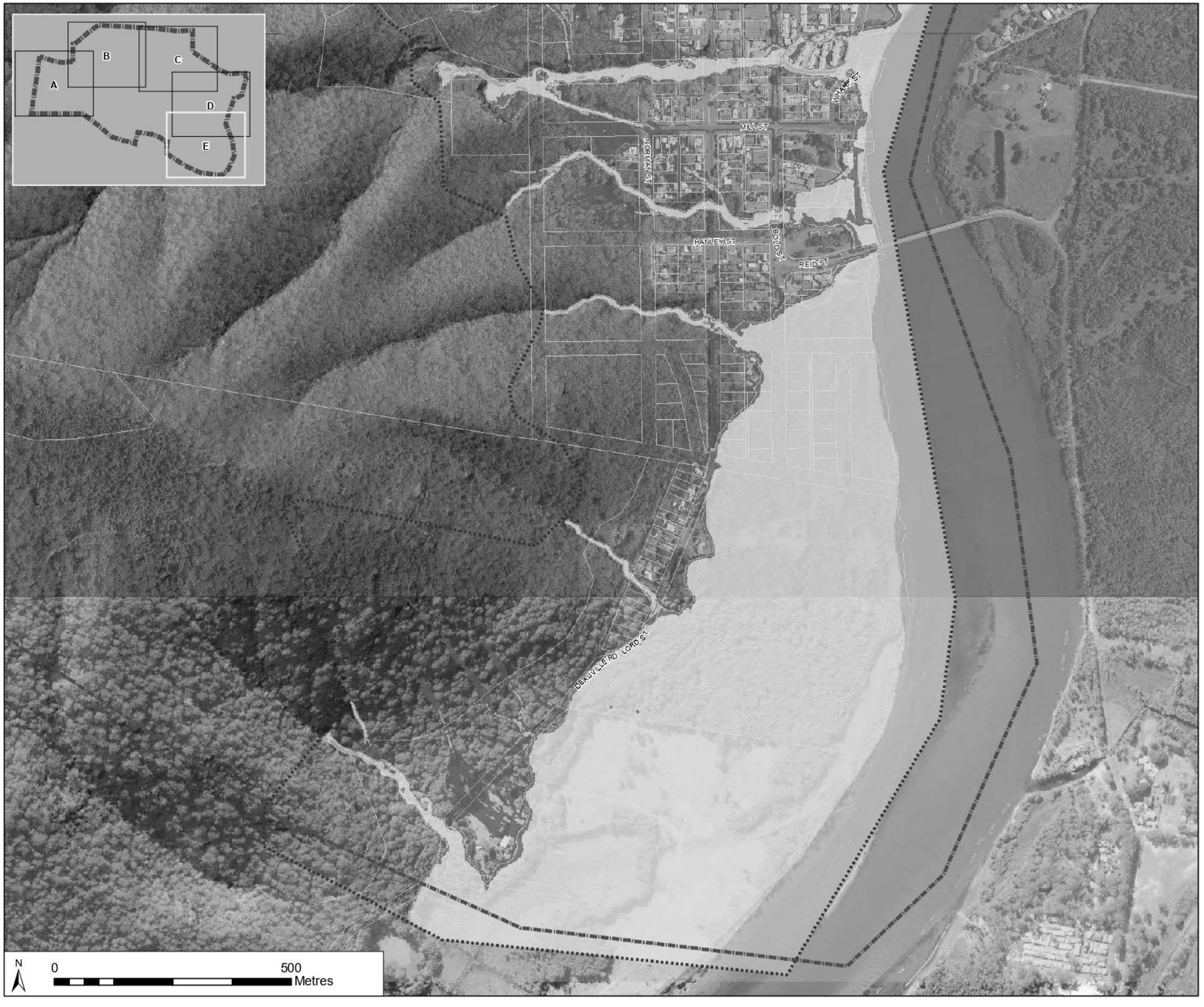
GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	1% AEP Design Flood Climate Change Scenario Flood Hazard Categories
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP C-1(D)
DATE 27/01/2021	



Legend

Flood Hazard Category

- H1 - Generally safe for vehicles, people and buildings.
- H2 - Unsafe for small vehicles.
- H3 - Unsafe for all vehicles, children and the elderly.
- H4 - Unsafe for all people and all vehicles.
- H5 - Unsafe for all people and all vehicles. Buildings require special engineering design and construction.
- H6 - Unsafe for Vehicles and people. All building types considered vulnerable to failure.
- Study Area
- Limit of Mapping

NOTES:
1. The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and Lakes System Flood Study (2013) for riverine flooding mapping.
2. The climate change scenario comprises a 10% increase in the 1% AEP rainfall and a 0.9m sea level rise.

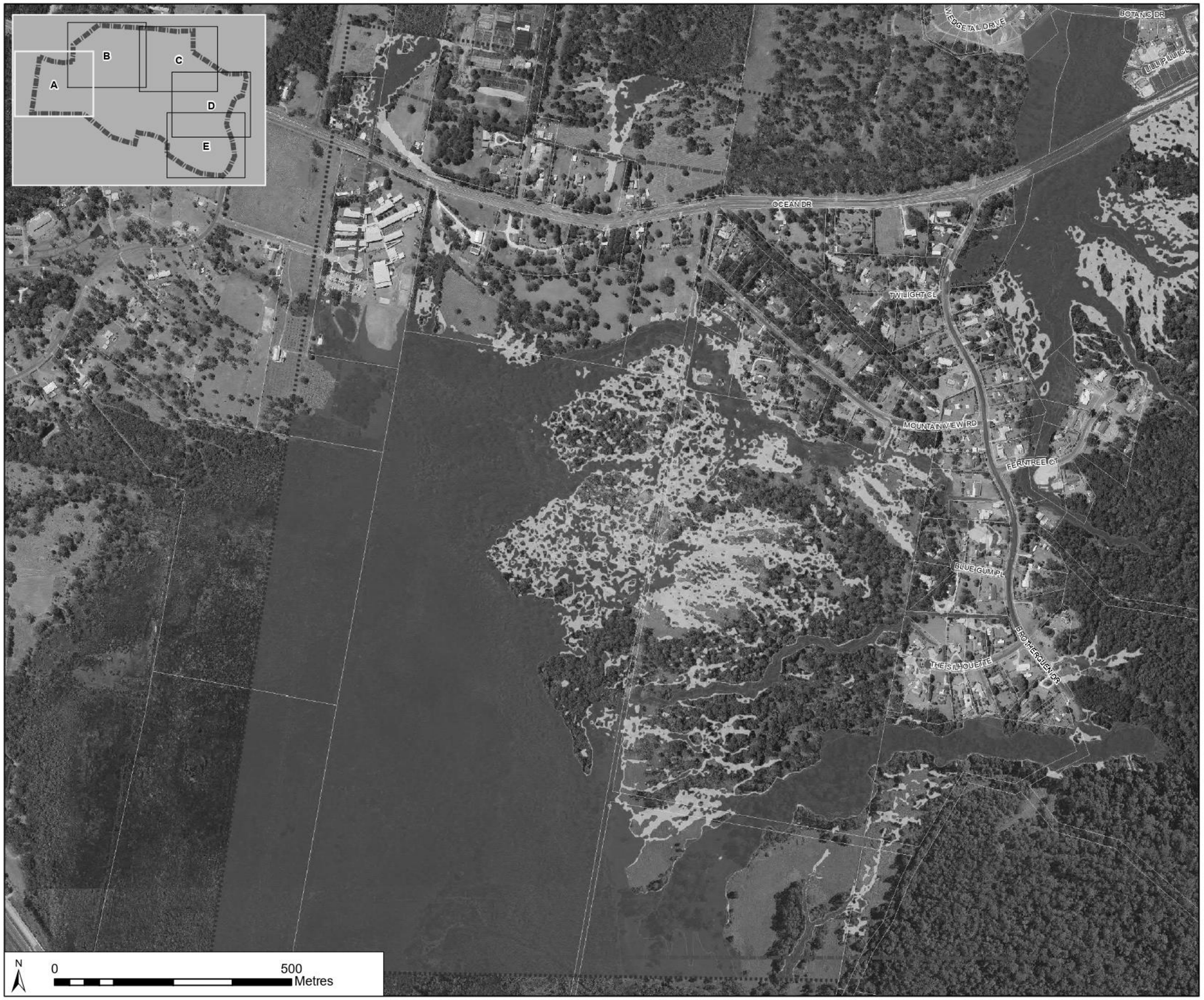
GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS®

TITLE	1% AEP Design Flood Climate Change Scenario Flood Hazard Categories
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500 DATE 27/01/2021	MAP C-1(E)



Legend

Hydraulic Categories

- Floodway
- Flood Storage
- Flood Fringe
- Watercourse
- Limit of Mapping
- Study Area

NOTES:
1. The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and Lakes System Flood Study (2013) for riverine flooding mapping.
2. The climate change scenario comprises a 10% increase in the 1% AEP rainfall and a 0.9m sea level rise.

GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS®

TITLE	1% AEP Design Flood Climate Change Scenario Hydraulic Categories
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP C-2(A)
DATE 28/01/2021	

Legend

Hydraulic Categories

- Floodway
- Flood Storage
- Flood Fringe
- Watercourse
- Limit of Mapping
- Study Area

NOTES:
1. The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and Lakes System Flood Study (2013) for riverine flooding mapping.
2. The climate change scenario comprises a 10% increase in the 1% AEP rainfall and a 0.9m sea level rise.

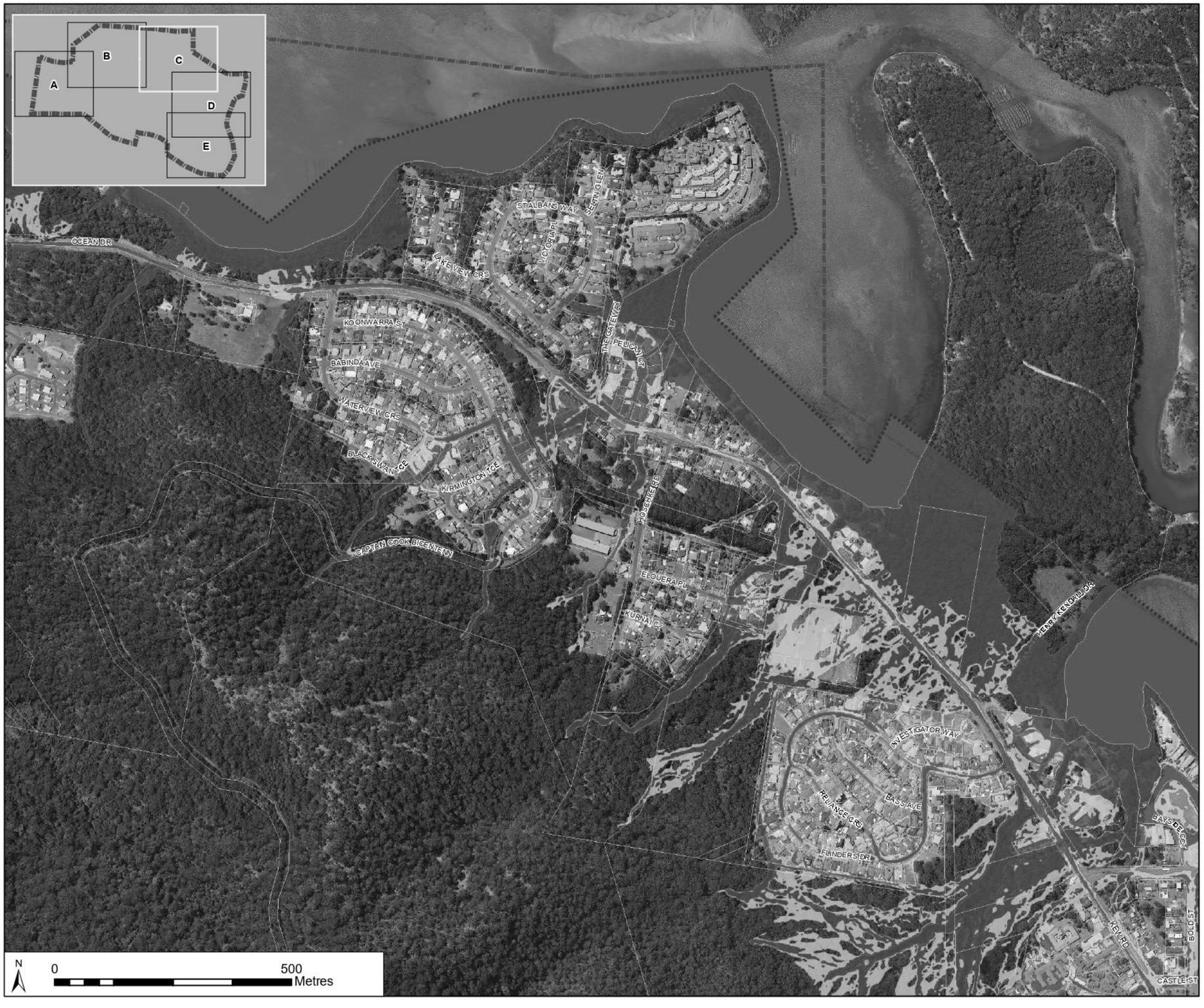
GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	1% AEP Design Flood Climate Change Scenario Hydraulic Categories
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP C-2(B)
DATE 28/01/2021	



Legend

Hydraulic Categories

- Floodway
- Flood Storage
- Flood Fringe
- Watercourse
- Limit of Mapping
- Study Area

NOTES:
1. The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and Lakes System Flood Study (2013) for riverine flooding mapping.
2. The climate change scenario comprises a 10% increase in the 1% AEP rainfall and a 0.9m sea level rise.

GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	1% AEP Design Flood Climate Change Scenario Hydraulic Categories
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP C-2(C)
DATE 28/01/2021	

Legend

Hydraulic Categories

- Floodway
- Flood Storage
- Flood Fringe
- Watercourse
- Limit of Mapping
- Study Area

NOTES:
1. The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and Lakes System Flood Study (2013) for riverine flooding mapping.
2. The climate change scenario comprises a 10% increase in the 1% AEP rainfall and a 0.9m sea level rise.

GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	1% AEP Design Flood Climate Change Scenario Hydraulic Categories
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP C-2(D)
DATE 28/01/2021	

Legend

Hydraulic Categories

- Floodway
- Flood Storage
- Flood Fringe
- Watercourse
- Limit of Mapping
- Study Area

NOTES:
1. The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and Lakes System Flood Study (2013) for riverine flooding mapping.
2. The climate change scenario comprises a 10% increase in the 1% AEP rainfall and a 0.9m sea level rise.

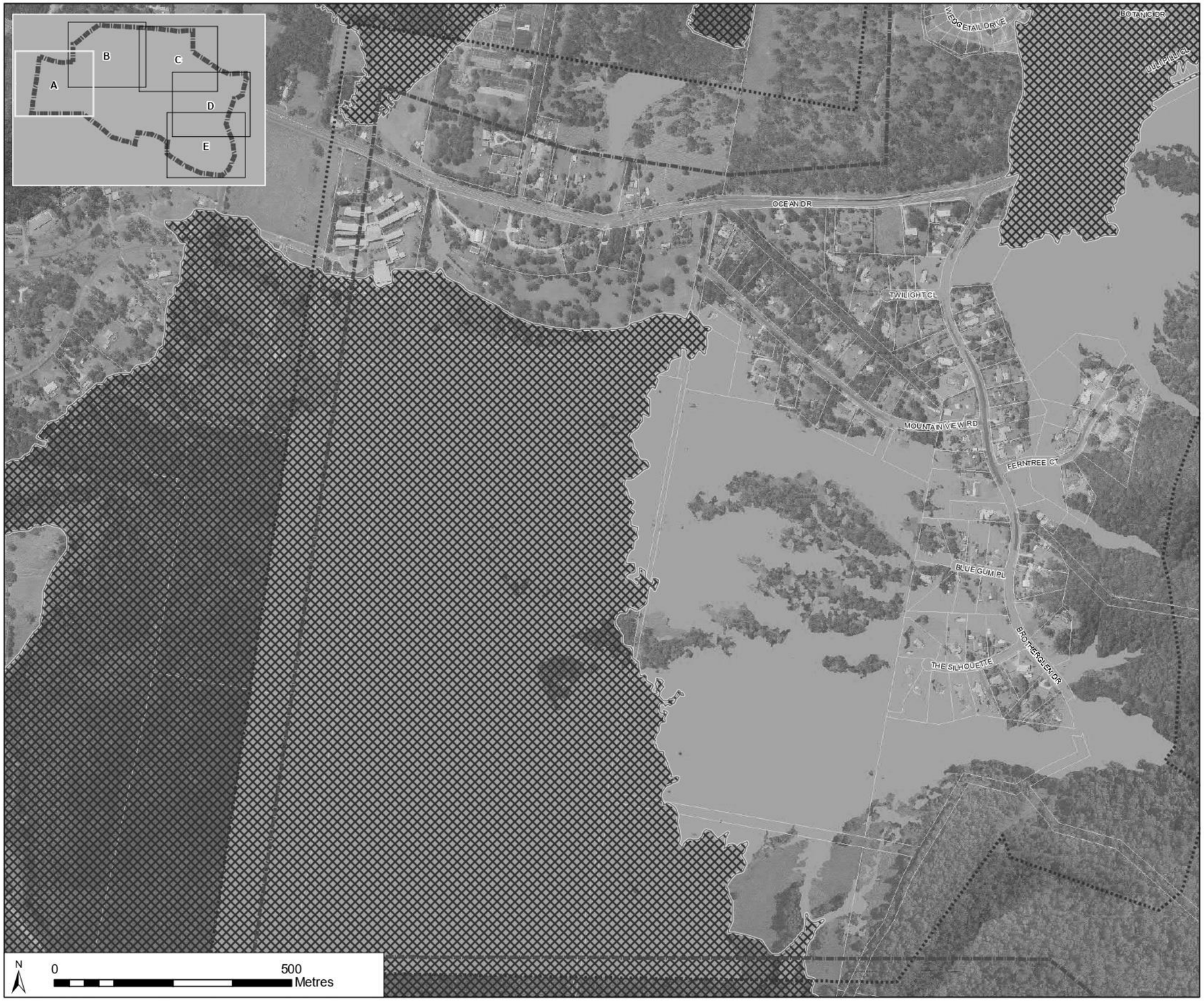
GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	1% AEP Design Flood Climate Change Scenario Hydraulic Categories
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP C-2(E)
DATE 28/01/2021	



Legend

- Overland FPL3 Extent
- Mainstream Flood Planning Area. Development controls in Flood Policy 2015 may apply.
- Study Area
- Limit of Mapping

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and Lakes System Flood Study (2013) for riverine flooding mapping.

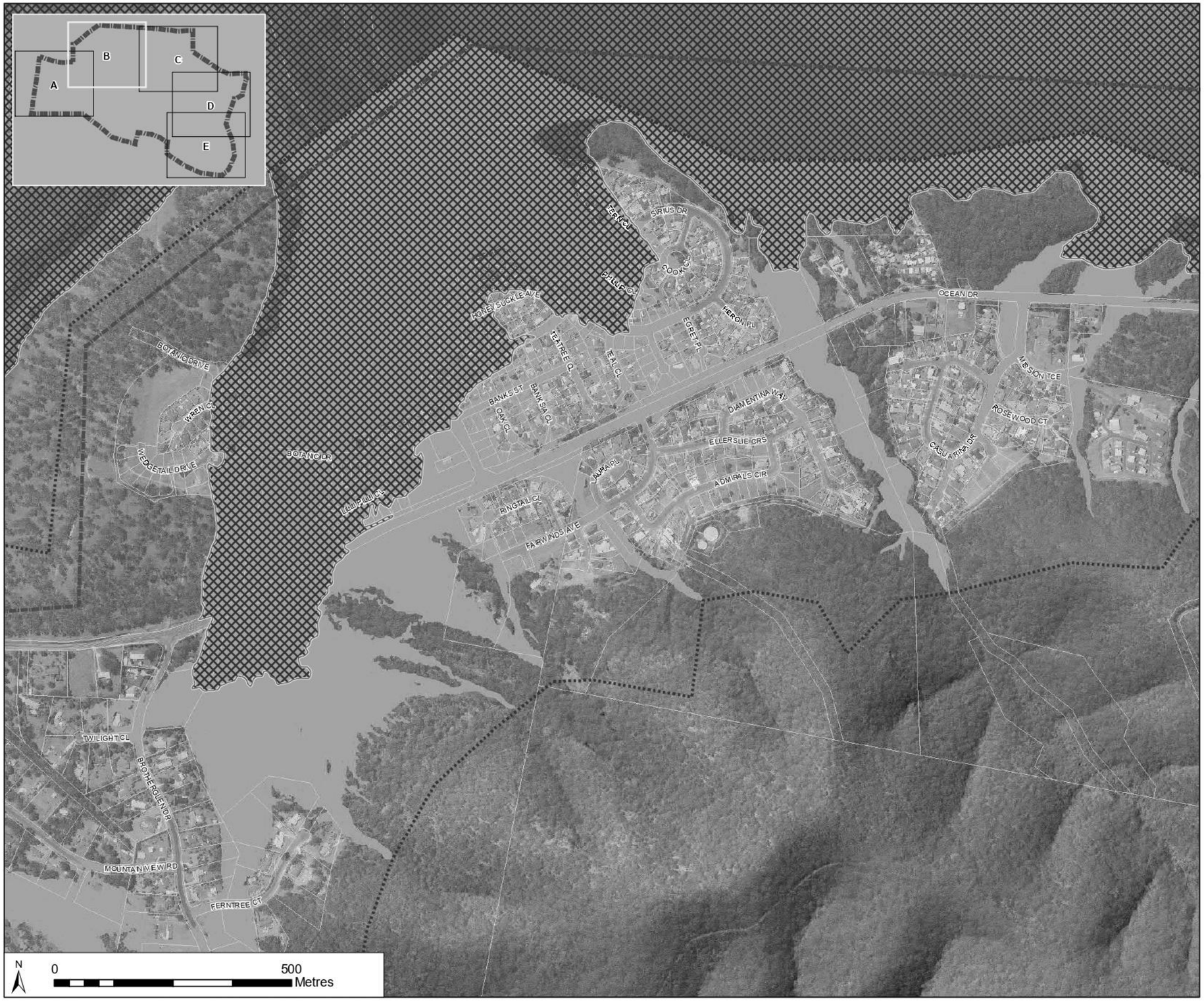
GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	Provisional Overland Flood Planning Level Extent
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP C-3(A)
DATE 9/02/2021	



Legend

- Overland FPL3 Extent
- Mainstream Flood Planning Area. Development controls in Flood Policy 2015 may apply.
- Study Area
- Limit of Mapping

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and Lakes System Flood Study (2013) for riverine flooding mapping.

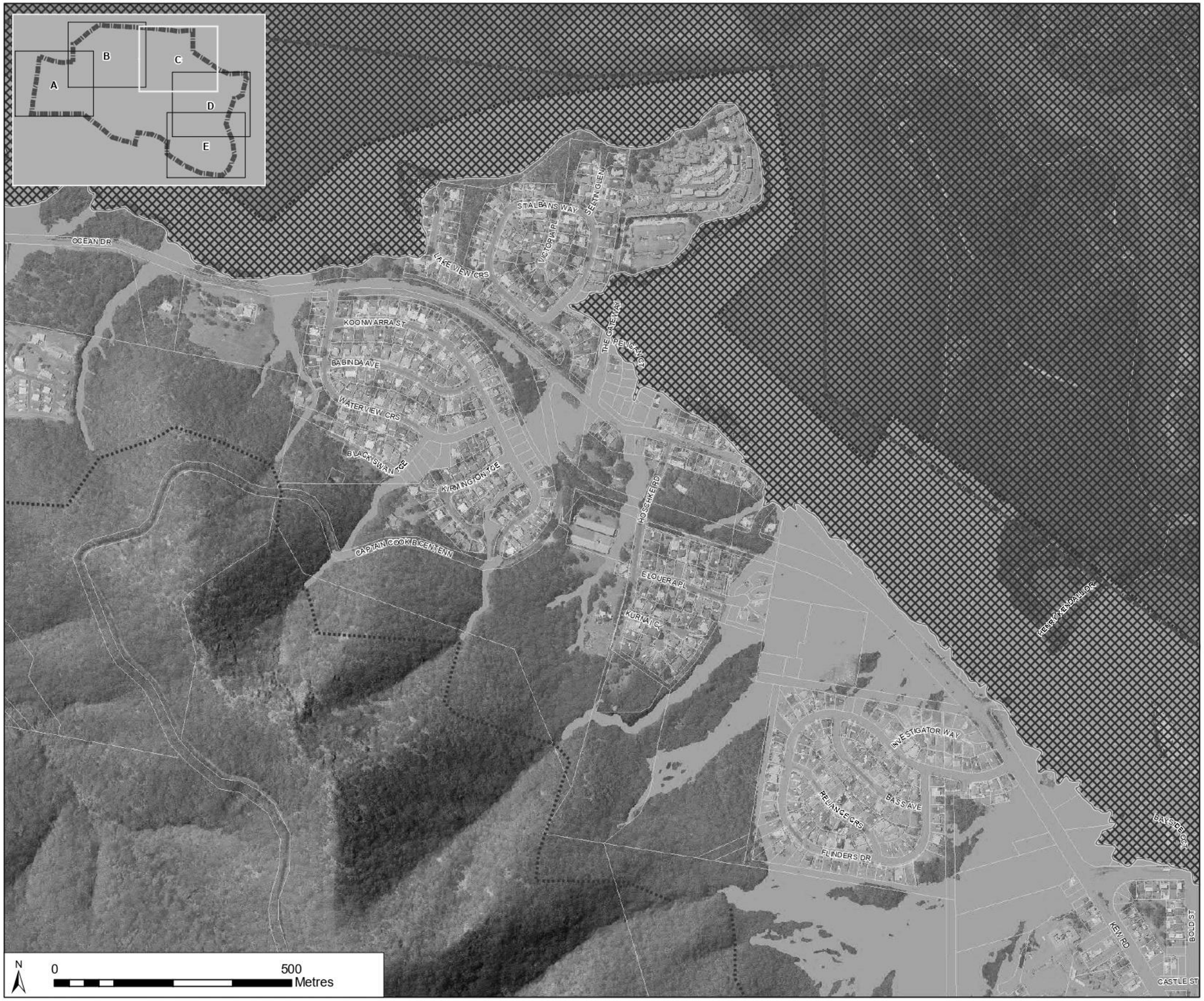
GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	Provisional Overland Flood Planning Level Extent
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP C-3(B)
DATE 9/02/2021	



Legend

- Overland FPL3 Extent
- Mainstream Flood Planning Area. Development controls in Flood Policy 2015 may apply.
- Study Area
- Limit of Mapping

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and Lakes System Flood Study (2013) for riverine flooding mapping.

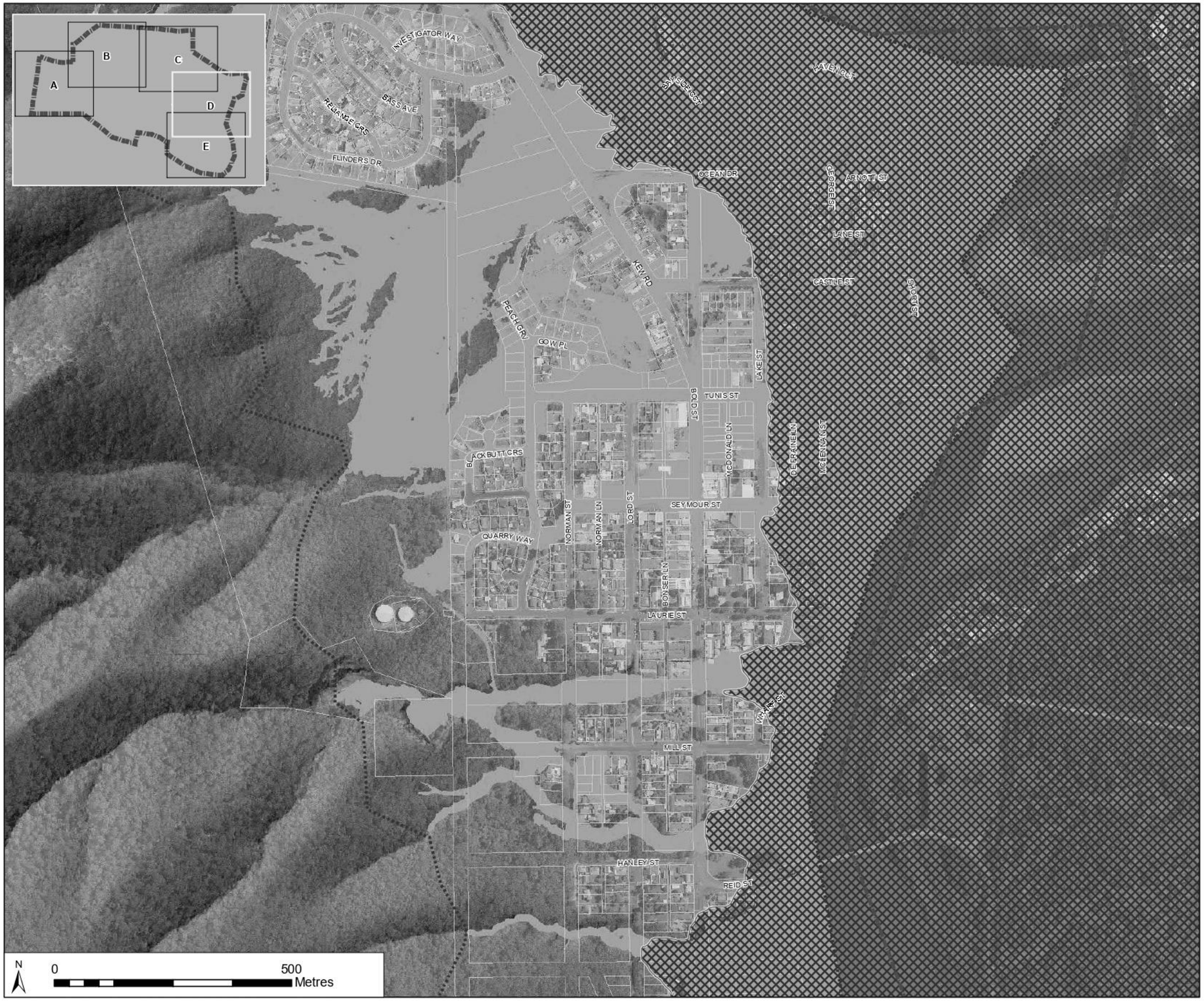
GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	Provisional Overland Flood Planning Level Extent
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP C-3(C)
DATE 9/02/2021	



Legend

- Overland FPL3 Extent
- Mainstream Flood Planning Area. Development controls in Flood Policy 2015 may apply.
- Study Area
- Limit of Mapping

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and Lakes System Flood Study (2013) for riverine flooding mapping.

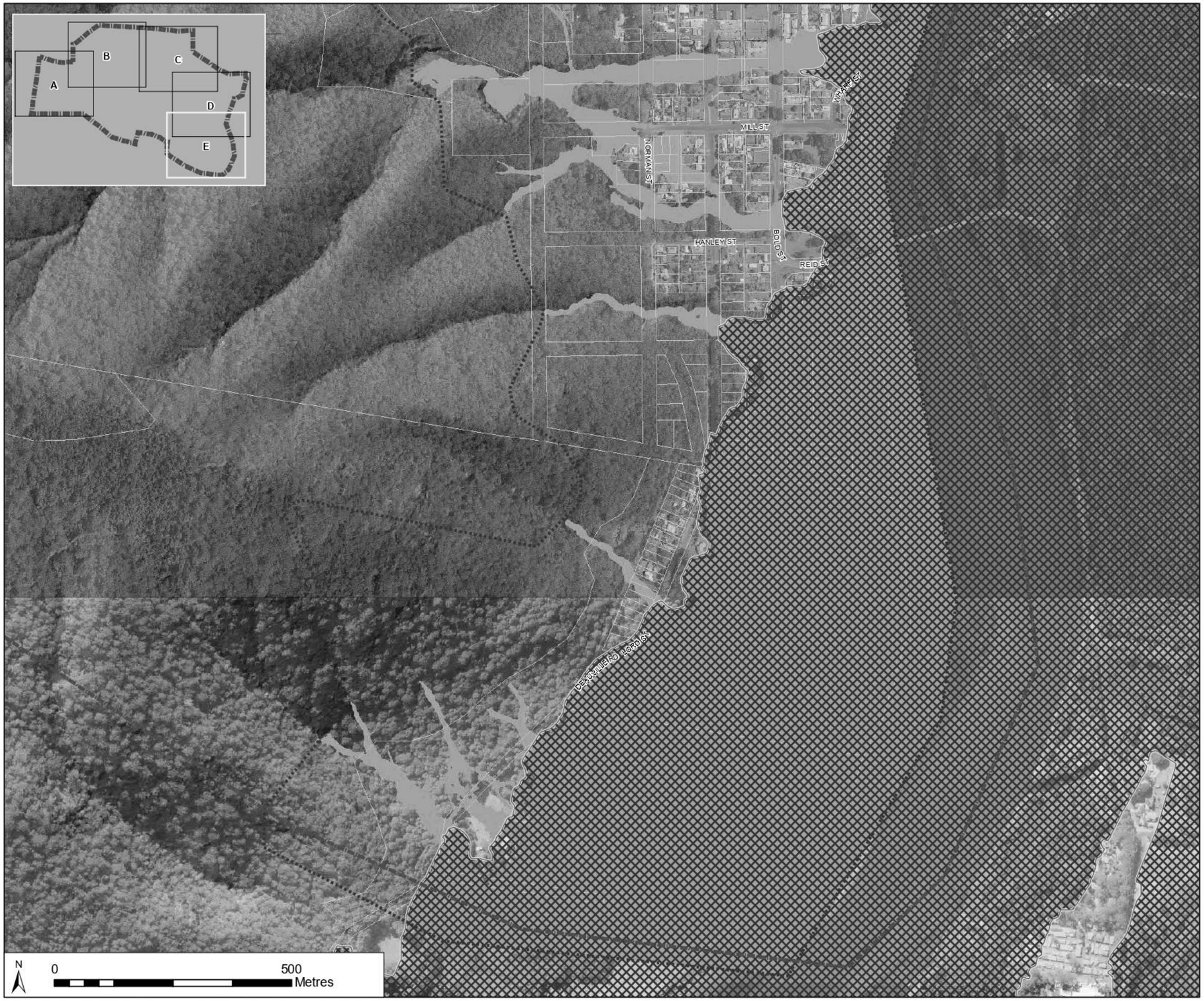
GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	Provisional Overland Flood Planning Level Extent
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP C-3(D)
DATE 9/02/2021	



Legend

- Overland FPL3 Extent
- Mainstream Flood Planning Area. Development controls in Flood Policy 2015 may apply.
- Study Area
- Limit of Mapping

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and Lakes System Flood Study (2013) for riverine flooding mapping.

GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	Provisional Overland Flood Planning Level Extent
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP C-3(E)
DATE 9/02/2021	

Appendix D. Flood Modification Options Cost Summaries

Table D-1: Summary of the implementation cost of Option 4B

Item	Total
Site Preparation	
-Demolish existing road, trees cut, clearing vegetation, and disposal; spread and level soil within 10km	$36,000
-Excavation in clay in trench (250m long and 1.5m deep) for new culverts and new flowpath at Pelican Court and cartage within 10km and side protection	$116,000
-Dispose of demolished mixed materials	$58,000
-Turf, laid, rolled and watered for two weeks	$4,000
-Safety fencing	$5,000
Stormwater Drainage	
-Installation of 2x 2.1m x 1.2m concrete precast culverts	$1,063,000
-Construction of headwall- foundation	$6,000
-Construction of headwall- 200mm wingwall	$9,000
-Rock protection and debris control screen	$20,000
-Nominal allowance for culvert inlet rock debris trap	$200,000
Service Relocation/Protection	
-Relocation of power pole with meter box	$15,000
-Allowance for relocation/protection for existing utilities - (electricity, optus, sewer pipes, etc)	$10,000
Road Construction	
-Road re-construction	$19,000
Sub Total	$1,561,000
Other	
Allowance for works on private property	$0
Traffic and pedestrian management (28days)	$66,000
Cost of consultancy (feasibility studies, REF, design, structural investigations, etc)	$300,000
Contingency (30%)	$469,000
Contractor's Prelims and Indirect Costs (25%)	$391,000
Grand Total	$2,787,000

Table D-2: Summary of the implementation cost of Option 6A

Item	Total
Site Preparation	
-Clearing vegetation, and disposal	$1,000
-Cut down 65nos. tree and cart away	$11,000
-Safety fencing	$1,000
Construction of low height levee	
-Construction of 160m long 1m high bund	$66,000
-Sediment control and planting	$34,000
Sub Total	$113,000
Other	
Cost of consultancy (feasibility studies, REF, design,etc)	$50,000
Contingency (30%)	$34,000
Contractor's Prelims and Indirect Costs (25%)	$29,000
Grand Total	$226,000

Table D-3: Summary of the implementation cost of Option 6B-6E

Item	Total
Site Preparation	
-Demolish existing road, trees cut, clearing vegetation, and disposal; spread and level soil within 10km	$548,000
-Excavation in clay in trench (750m long and 3m deep) for new culverts and cartage within 10km and side protection	$657,000
-Excavation in clay for new channel (230m and 1m deep)	$148,000
-Dispose of demolished mixed materials	$2,016,000
-Turf, laid, rolled and watered for two weeks	$4,000
-Safety fencing	$10,000
Stormwater Drainage	
-Installation of 3-1350mm, 1-900 and 1- 1050mm concrete precast culverts	$3,482,000
-Construction of headwall- foundation	$16,000
-Construction of headwall- 200mm wingwall	$18,000
-Rock protection and debris control screen	$20,000
-Nominal allowance for culvert inlet rock debris trap	$200,000
Channel works	
Geotextile lining of upgraded channel	$10,000
Riprap lining of upgraded channel	$15,000
Service Relocation/Protection	
-Allowance for relocation/protection for existing utilities - (electricity, optus, sewer pipes, etc)	$130,000
Road Construction	
-Road re-construction	$259,000
Sub Total	$7,533,000
Other	
Allowance for works on private property	$0
Traffic and pedestrian management (28days)	$66,000
Cost of consultancy (feasibility studies, REF, design, structural investigations, etc)	$300,000
Contingency (30%)	$2,260,000
Contractor's Prelims and Indirect Costs (25%)	$1,884,000
Grand Total	$12,043,000

Table D-4: Summary of the implementation cost of Option 8B

Item	Total
Site Preparation	
-Clearing vegetation, and disposal	$2,000
Debris Control Installation	
Debris control screen	$10,000
Sub Total	$12,000
Other	
Cost of consultancy (feasibility studies, design)	$2,000
Contingency (30%)	$4,000
Contractor's Prelims and Indirect Costs (25%)	$3,000
Grand Total	$21,000

Table D-5: Summary of the implementation cost of Option 9B

Item	Total
Site Preparation	
-Demolish existing road and driveway, trees cut, clearing vegetation, and disposal; spread and level soil within 10km	$42,000
-Excavation in clay in trench (150m long and 1.5m deep) for new culverts and cartage within 10km and side protection	$130,000
-Dispose of demolished mixed materials	$45,000
-Turf, laid, rolled and watered for two weeks	$10,000
-Safety fencing	$2,000
Stormwater Drainage	
-Installation of 2x -3000mmX1200mm concrete precast box culverts	$1,173,000
-Construction of headwall- foundation	$6,000
-Construction of headwall- 200mm wingwall	$9,000
-Rock protection and debris control screen	$10,000
-Nominal allowance for culvert inlet rock debris trap	$200,000
Construction of Driveway	
-Reinstate 2 driveways	$9,000
Service Relocation/Protection	
-Allowance for relocation/protection for existing utilities - (optus, sewer pipes, etc)	$10,000
Road Construction	
-Road re-construction	$8,000
Sub Total	$1,654,000
Other	
Allowance for works on private property	$0
Traffic and pedestrian management (7days)	$16,000
Cost of consultancy (feasibility studies, REF, design, structural investigations, etc)	$200,000
Contingency (30%)	$497,000
Contractor's Prelims and Indirect Costs (25%)	$414,000
Grand Total	$2,781,000

Item: 13.03

Subject: NORTH BROTHER LOCAL CATCHMENTS FLOOD STUDY - RESULTS OF EXHIBITION OF DRAFT OPTIONS ASSESSMENT REPORT

Presented by: Infrastructure, Dan Bylsma

Alignment with Delivery Program

4.2.1 Develop and implement coastal, estuary, floodplain, and bushfire management plans.

RECOMMENDATION

That Council:

1. **Acknowledge the submissions made during the exhibition period and thank those landowners for this input into this ongoing project.**
2. **Advise those landowners who made submissions of the outcome of Council's consideration of this matter,**
3. **Endorse the *North Brother Local Catchments Flood Study Draft Options Assessment Report*, and**
4. **Incorporate the community feedback obtained via the abovementioned exhibition process into the *Floodplain Risk Management Study and Plan* phase of the project.**

Executive Summary

The purpose of this report is to provide details and feedback relating to the submissions received as a result of the public exhibition of the *North Brother Local Catchments Flood Study Draft Options Assessment Report (2020)* (Attachment 1).

At its meeting on 1 July 2020, Council resolved to publicly exhibit the *North Brother Local Catchments Flood Study Draft Options Assessment Report (2020)* report for 28 days from 13 July 2020.

The report was placed on public exhibition from 13 July to 9 August 2020 (28 days), with a total of twenty two (22) submissions being received during that time.

This report documents the outcomes of the public exhibition process and submissions received during this phase, and responds to the queries raised during the exhibition period.

This report ultimately recommends that Council acknowledge the submissions received and thank the landowners for their contributions and utilise the feedback to proceed with the preparation of the *North Brother Local Catchments Floodplain Risk Management Study and Plan.*

PORT MACQUARIE HASTINGS COUNCIL

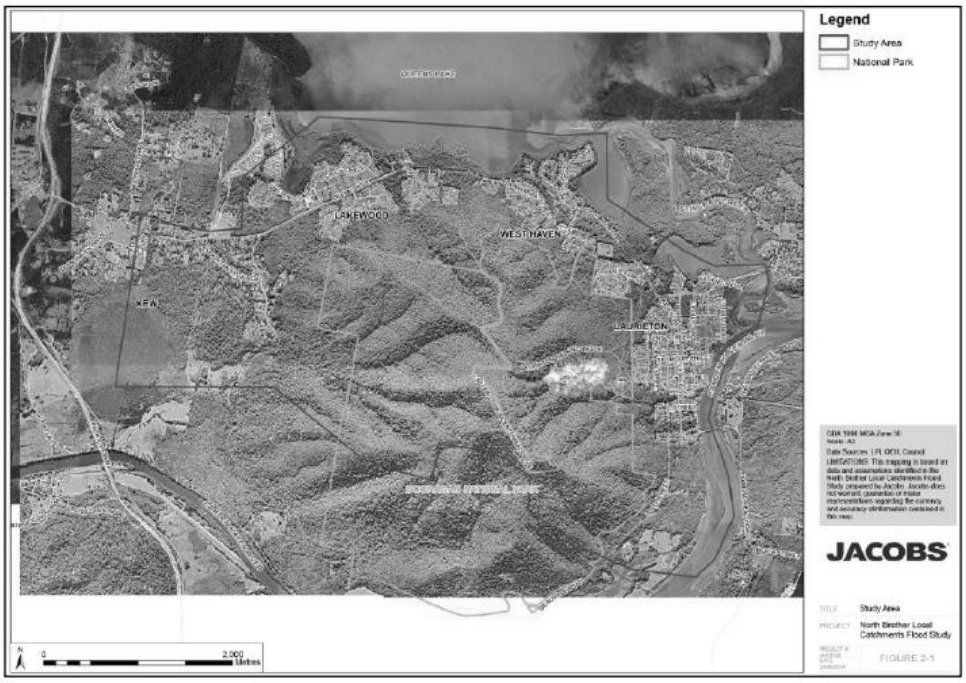
Discussion

Background

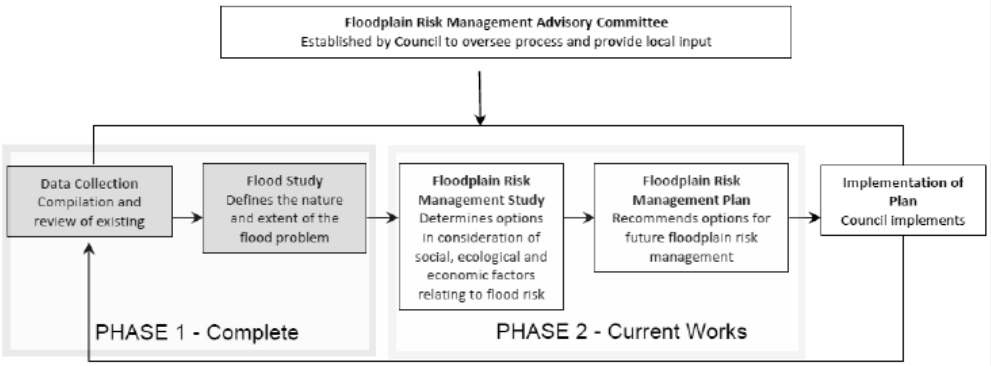
Since early 2017, Port Macquarie-Hastings Council has been working with specialist consultants, Jacobs Group Australia (Jacob's) to undertake the North Brother Local Catchments Flood Study, the Floodplain Risk Management Study and the Floodplain Risk Management Plan project. The focus of the project is to:

- understand the behaviour of local catchment flash flooding from North Brother Mountain and the flood risk that it poses to the community; and,
- Identify and develop measures to manage the impact of flooding and guide strategic planning for future development of the area.

The study covers the villages of Laurieton, West Haven, Lakewood, Kew and Deauville at the Base of the North Brother Mountain, as shown below:



Following the adoption of the North Brother Local Catchments Flood Study by Council at the 17 July 2019 Ordinary Council Meeting, Council has entered Phase 2 of this ongoing project, which is the completion of the Floodplain Risk Management Study (FRMS) and the Floodplain Risk Management Plan (FRMP).



Phase 2 of the project has the following aims.

- Identify, assess and evaluate management options for the floodplain in respect of both existing and proposed developments (FRMS), and
- Adopt a plan of management for the flood risks identified (FRMP).

Options developed for flood risk management will include a mix of both structural (i.e. upgraded infrastructure) and non-structural (i.e. planning controls, policy and management) measures.

The *North Brother Local Catchments Flood Study (Draft Options Assessment Report)* outlines four high risk priority areas for mitigation works within the catchment and the initially identified remedial works options at each location, including results of the hydraulic assessments undertaken for those areas.

These initial options and locations have been identified by Council, and the Coast, Estuary and Floodplain Advisory Committee based on the risks identified by the Flood Study Phase and preliminary analysis undertaken by Jacobs.

In this regard, the *North Brother Local Catchments Flood Study (Draft Options Assessment Report)* was presented to the Coast, Estuary and Floodplain Advisory Sub Committee on 29 May 2020, and recommended to be reported to Council, with a recommendation to be placed on public Exhibition.

The *North Brother Local Catchments Flood Study (Draft Options Assessment Report*) was subsequently reported to the Ordinary Council Meeting on 1 July 2020, where the following resolution was made:

13.02 RECOMMENDED ITEM FROM COAST, ESTUARY AND FLOODPLAIN ADVISORY SUB-COMMITTEE - NORTH BROTHER LOCAL CATCHMENTS FLOOD STUDY - DRAFT OPTIONS ASSESSMENT REPORT

Mayor Pinson declared a Pecuniary Interest in this matter, vacated the Chair and left the room and was out of sight during the Council's consideration, the time being 8:01pm.

The Deputy Mayor assumed the Chair.

RESOLVED: Alley/Griffiths

That Council:

1. Place the North Brother Flood Study - Draft Options Assessment Report on public exhibition for a minimum of 28 days commencing 13 July 2020.
2. Receive a further report detailing the submissions received from the public during the exhibition period at the conclusion of the exhibition period.

CARRIED: 6/0
FOR: Alley, Dixon, Griffiths, Hawkins, Intemann and Turner
AGAINST: Nil

The Mayor returned to the meeting at 8:07pm.

The Deputy Mayor vacated the Chair and the Mayor assumed the Chair.

Public Exhibition

Following receipt of the abovementioned resolution, the North Brother Local Catchments Flood Study (Draft Options Assessment Report) was placed on public exhibition for 28 days commencing Monday 13 July 2020.

During and prior to the commencement of the exhibition process, the following activities were undertaken:

- Prior to commencement of the exhibition process, in excess of 2000 letters were sent to all property owners in the study area to advise that the Draft Options Report was being placed on Public Exhibition. The letter provided landowners with details of how to view the report and provided an invitation to attend an online Zoom Q&A Meeting with Council Staff on 27 July 2020. Furthermore, and in an effort to encourage participation, the letter included a brief hard copy survey on the Draft Option Reports recommendations.
- Similarly, prior to the commencement of exhibition, the two properties identified for Voluntary Acquisition were door knocked and meetings arranged/held with the affected landowners. The intent of this process was to provide those landowners with knowledge and understanding of the process being undertaken, to advise of the exhibition/submission process and to reassure those landowners that the Voluntary Acquisition process identified in the Draft Option Report would only proceed with their agreement (i.e. if residents were not supportive, the option would be 'taken off the table' and alternatives investigated).
- At the commencement of the exhibition period on 13 July 2020, a project 'Have *Your Say'* webpage on the PMHC website was established providing a summary of the Draft Options Report and exhibition process, plus links to download and

view copies of the Draft Options Report, a Q&A document answering typical questions asked, and a link the previously adopted Flood Study.

- The *'Have Your Say'* website also contained an online survey for landowners to complete online and instructions for registering for the planned Zoom meeting on 27 July 2020.
- Hard copies of the Draft Options Report were distributed to Councils Laurieton, Wauchope and port Macquarie Customer Service Offices for viewing by interested residents.
- During the exhibition process, Weekly *'community now'* notices in the Camden Haven Courier and Port News were published.
- In addition, the Camden Haven Courier published an article about the Draft Options Report titled "Flood Study Outlines Risk" on 15 July 2020 (copy attached).
- The Draft Options Report was posted on Council's social media account;
- Numerous face to face meetings were held with residents, businesses and landowners in the study area to respond to questions and provide detailed information on the Draft Options Report and wider Flood Study process being undertaken.
- A Zoom Q&A Meeting was planned and held on 27 July 2020 between 5:30 and 6:30pm to enable residents to learn more about the study and ask questions regarding the report.

Community Engagement and Internal Consultation

Have Your Say
During the public exhibition period, the '*Have Your Say'* page was viewed by 676 times by 235 individual visitors. 61 copies of the Draft Options Report were downloaded by those visitors.

At the close of the public exhibition period 408 people were classified as being *aware*, 203 participants were *informed* and 26 were *engaged* through using the PMHC *Have Your Say* site. As a result, 15 submissions were made via the website.

Online Face-to-Face Zoom Meeting

A Zoom Q&A Meeting was planned and held on 27 July 2020 between 5:30 and 6:30pm to enable residents to learn more about the study and ask questions regarding the report. This meeting was attended by nine residents in addition to two Council Staff. The Zoom meeting consisted of a presentation on the content of the Draft Options Report, a summary of the history of the current Flood Study Process and details of the exhibition process and next steps. Following the presentation, the meeting consisted of a Q&A session, involving very constructive questioning and suggestions from the community members present. A copy of the meeting minutes is attached for reference.

Individual Submissions
During the public consultation period, 15 individual submissions were received via email and hardcopy respectively.

PORT MACQUARIE HASTINGS COUNCIL

A total of 30 submissions were therefore received during the public exhibition phase.

The submissions with Council's responses are included as Attachment 3 to this report.

The submissions, in full, will be provided to Councillors under separate cover to this report.

In addition to the submissions, below is a summary of the resident responses to the predefined questions within the survey posted to residents and included on the *Have Your Say* page (results below combined online and hardcopy submissions):

Question	Response		
	Yes	**No**	**Don't know**
Do you agree that the shortlisted locations for options assessment are High Priorities for the Community?	**76% (16)**	24% (5)	
Please indicate your support for the following non-structural flood mitigation options			
Voluntary Purchase of High Hazard Properties	**42% (8)**	26% (5)	32% (6)
Update Council's LEP to include the North Brother Local Catchments Flood Mapping	**58% (11)**	11% (2)	32% (6)
10.7 Zoning Certificates to include notation regarding flood hazard identified by the Flood Study phase of this project	**60% (12)**	15% (3)	25% (5)
Update Council's Flood Policy to both refer to the North Brother Local Catchments Flood Study and update the policy to include provisions relating to overland flooding	**70% (14)**		30% (6)
Implementation of Flood Depth Signage within the Catchment	**70% (14)**	15% (3)	15% (3)
Development of a Flood Education Program for the Catchment	**80% (16)**		20% (4)
Consultation with high flood risk facilities and occupants of dwellings subject to high flood hazard regarding management of flood risk on the site.	**86% (18)**		14% (3)

As can be seen from the above, based on the surveys completed, a majority of the residents surveyed supported both the high priority structural mitigation works locations and the general concept of the non-structural measures proposed.

Of note is the relatively high number of "Don't know' answers, indicating that the highly technical nature of the report was difficult to understand for many residents.

Whilst we have achieved the aim of exhibiting the Draft Options Report, the feedback summarised above indicates that further work will be required to ensure the community has a good understanding of the content presented at the next phase.

PORT MACQUARIE HASTINGS COUNCIL

In this regard, further consultation is proposed to be undertaken at the following stages of this ongoing project:

- November - December 2020. Following collation of results and feedback from this exhibition period, Jacobs will be undertaking further modelling and detailed assessment of the Structural Mitigation Options culminating with the submission of a Draft Evaluation Report. Engagement with Coast, Estuary and Floodplain Sub Committee and any impacted landowners will be undertaken at this time.
- Following Sub Committee Review, A Draft Floodplain Risk Management Study and Plan will be prepared. In addition to the Structural Mitigation Measures outlined above, this report will contain detail of the proposed draft non-structural mitigation measures and will represent the first opportunity for the community comment on the specifics of this aspect of the plan in detail.
- January - March 2021 - Consultation with the Coast, Estuary and Floodplain Sub Committee, Council and wider community is proposed to be undertaken at this time.
- Following this time, a final Floodplain Risk Management Study and Plan is proposed to be prepared and again reported to the Coast, Estuary and Floodplain Sub Committee and Council.

Options

The NSW State Government's *Flood Prone Lands Policy* and *Floodplain Development Manual (2005)* provides a framework to ensure the sustainable use of floodplain environments. The Policy (among other things) provides a means of ensuring that any new development is compatible with the flood hazard and does not create additional flooding problems in other areas.

Under the Policy, the management of *flood liable land* remains the responsibility of Local Government. The State Government subsidises flood mitigation works to alleviate existing problems to assist Councils in their floodplain management responsibilities, but only where the State Government floodplain management process has been followed.

The draft *North Brother Local Catchments Flood Study and Floodplain Risk Management Planning project* is being undertaken in accordance with the NSW Government's *Flood Prone Lands Policy* and *Floodplain Development Manual (2005).*

It is recommended that Council:

- Endorse the *North Brother Local Catchments Flood Study Draft Options Assessment Report*, and
- Incorporate the community feedback obtained via the abovementioned exhibition process into the *Floodplain Risk Management Study and Plan* phase of the project.

Planning and Policy Implications

The *North Brother Local Catchments Flood Study Draft Options Report* provides a summary of preferred priority structural and non-structural mitigation measured to be

implemented within the study area based on a robust risk assessment of the flooding identified by the Flood Study Phase of this ongoing project.

These flood mitigation measures and the associated community feedback will now be utilised in subsequent stages to guide the development of a Floodplain Risk Management Study and Plan.

Provisional Risk and Hazard mapping has been developed, however this mapping is for information only at this stage and will be further developed with the Floodplain Risk Management Study and Plan phases.

There are no flood planning maps or development controls drafted at this stage of the project, however general support for their development has been obtained and such documents will be developed and drafted in the coming months.

Further consultation with the Coast, Estuary and Floodplain Sub Committee, Council and community is proposed to be undertaken at that time to ensure that all potential impacts can be assessed and incorporated into the planning as required.

Financial and Economic Implications

There are significant financial implications for Council if the Floodplain Risk Management Study and Plan is not continued.

NSW state government grant funding (2:1 funding from State: Council respectively) is funding both the current project and would be available to any future flood related structural works identified by the ultimate Floodplain Risk Management Plan (FPMP). If council does not proceed with the Floodplain Risk Management Study and Plan phase, this funding and future access to funding of resultant works would be forfeited.

Attachments

1. North Brother Local Catchments Flood Study - Draft Options Assessment Report
2. Camden Haven Courier Article - 15 July 2020
3. Community Zoom Meeting Minutes 27 July 2020
4. North Brother Local Catchments Flood Study submissions

JACOBS

North Brother Local Catchments Flood Study

Port Macquarie Hastings Council

Draft Options Assessment Report

Revision A

8 May 2020

IA157500

Draft Options Assessment Report

JACOBS

North Brother Local Catchments Flood Study

Project no:	IA157500
Document title:	Draft Options Assessment Report
Document No.:	1
Revision:	A
Date:	8 May 2020
Client name:	Port Macquarie Hastings Council
Project manager:	Lih Chong
Author:	Lih Chong
File name:	J:\IE\Projects\04_Eastern\IA157500\21 Deliverables\R05_DraftOptionsAssessment\IA157500 NB_R05_DraftOptionsAssessment.docx

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Document history and status

Revision	Date	Description	By	Review	Approved
A	8/05/2020	Draft Options Assessment Report	L Chong	A Hossain	A Hossain

Contents

Foreword

The primary objective of the New South Wales Government's Flood Prone Land Policy is to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods, utilising ecologically positive methods, wherever possible. Under the Policy, the management of flood prone land remains the responsibility of local government.

The policy provides for a floodplain management system comprising the following five sequential stages:

1.	**Data Collection**	Involves compilation of existing data and collection of additional data
2.	**Flood Study**	Determines the nature and extent of the flood problem
3.	**Floodplain Risk Management Study**	Evaluates management options in consideration of social, ecological and economic factors relating to flood risk with respect to both existing and future development
4.	**Floodplain Risk Management Plan**	Involves formal adoption by Council of a plan of management for the floodplain
5.	**Implementation of the Plan**	Implementation of flood, response and property modification measures (including mitigation works, planning controls, flood warnings, flood preparedness, environmental rehabilitation, ongoing data collection and monitoring by Council

Port Macquarie Hastings Council is undertaking this study for the North Brother Local Catchments study area to investigate the existing and future flood risks in accordance with the NSW Government's *Floodplain Development Manual*. The study identifies and assesses potential flood mitigation options and guides land use planning and future development on the floodplain in the study area.

This study represents stages 1 to 4 of the management process and has been prepared for Council by Jacobs. This report is a progress report documenting the draft options assessment of the floodplain risk management stage of the study.

Important note about this report

The sole purpose of this report and the associated services performed by Jacobs is to undertake a flood study for the North Brother Local Catchments study area located in New South Wales in accordance with the scope of services set out in the contract between Jacobs and Port Macquarie Hastings Council (the Client). That scope of services, as described in this report, was developed with the Client.

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the Client and/or from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

Jacobs derived the data in this report from information sourced from the Client, third parties, and/or available in the public domain at the time or times outlined in this report. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report. Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

This report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by Jacobs for use of any part of this report in any other context.

Topographic data used in this study included that sourced from a LiDAR survey and ground survey which were undertaken by third parties. Undertaking independent checks on the accuracy of the data was outside Jacobs's scope of work for this study.

This report has been prepared on behalf of, and for the exclusive use of, Jacobs's Client, and is subject to, and issued in accordance with, the provisions of the contract between Jacobs and the Client. Jacobs accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

1. Introduction

1.1 General

This report discusses the hydraulic assessment results of the draft flood mitigation options for the North Brother local catchments study area for consideration by Port Macquarie Hastings Council and the floodplain advisory sub-committee ("committee"). The options presented in this report were short-listed by Council and the committee from a long-list of options for 16 flooding locations and aim to alleviate flooding at identified flooding trouble spots particularly where properties are at risk to flooding of elevated hazard. The results will assist with further refinement of the options and facilitate consultation with stakeholders and landowners affected by implementation of the options.

This report also investigates non-structural options for managing the flood risk, including property modification and response modification measures.

The content of this report will be included in the subsequent Options Evaluation Report and Draft Floodplain Risk Management Study (FRMS) reports.

1.2 Consultation

The findings in this report are to be discussed with Council, the committee and stakeholders and landowners as a part of the options development process. Public exhibition of this report is also proposed to enable early feedback on the proposed options.

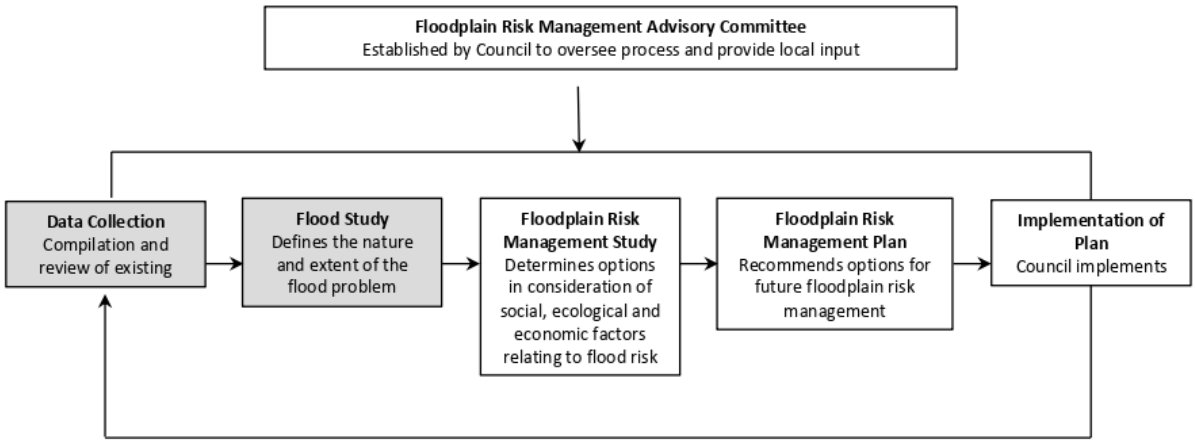
Community consultation is also scheduled to occur on a finalised list of the options during public exhibition.

1.3 Floodplain Risk Management

Council is responsible for managing the existing, continuing and future flood risk for its Local Government Area (LGA). The floodplain risk management planning process, as set out in the *Floodplain Development Manual* (NSW Government, 2005) has a number of steps which are illustrated in Figure 1-1. The current Flood Study phase of this study defines the flooding problem. Once the Flood Study has been endorsed by Council, the study moves to the Floodplain Risk Management Study and Plan phase, which seeks to identify and prioritise feasible options for mitigating the flood risk.

The Floodplain Risk Management Advisory Committee for Council was established in 2018 and includes a number of Council Representatives, staff from the Department of Planning Industry and Environment (DPIE, formerly Office of Environment and Heritage), the State Emergency Services (SES), in addition to local stakeholders including community representatives.

Figure 1-1 Floodplain Risk Management Process



1.4 Structure of this Report

This report is structured by the following sections:

- Section 2 provides background on the existing flood behaviour and flooding problems.
- Section 3 describes the general types of floodplain risk management measures in addition to providing a detailed assessment of the selected structural mitigation options.
- Section 4 provides an appraisal of non-structural flood risk management measures.
- Section 5 provides conclusions and recommendations based on the assessments made in this report.

2. The Existing Flooding Problem

2.1 Description of Flooding Conditions

2.1.1 Flood behaviour

Flooding behaviour was defined based on numerical modelling of hydrology and hydraulics, estimating catchment flood flows and the flooding patterns and behaviour. Modelling was undertaken in DRAINS software (hydrology) and TUFLOW software (hydraulics), as documented in the North Brother Local Catchments Flood Study – Final Flood Study Report (Jacobs, 2020). Flood depth mapping based on the modelling results is presented in Appendix A.

Overland flooding in the steeper parts of the study area, generally upstream of Ocean Drive and Bold Street, is typically a result of runoff from North Brother Mountain concentrating in natural gullies which discharge towards receiving waterways including Queens Lake, Stingray Creek, Camden Haven River and Watsons Taylor Lake. Issues arise when the gullies and flows encounter existing development, which in some instances at the larger gullies have considered the drainage conditions and provided substantial set-back from the gullies such that there is minimal interaction between floodwaters and development.

At most of the smaller gullies and flow paths, attempts have been made to manage the overland flows by use of diversion drains and underground drainage. The natural flow paths have mainly been filled in for development although shallow flow paths may have been retained. The diversion drains and drainage network have limited capacity so begin to surcharge and overflow in relatively frequent flooding events, causing flooding through properties and into buildings with substantial damage. In a number of locations the existing roads form the main flow path for floodwaters.

Most of the overland flow paths cross Ocean Drive and Bold Street, which traverse the foot of the Mountain. The cross drainage culverts are also limited in capacity and prone to blockage by flood debris including rocks and vegetation, causing overflows over the road. These are two main roads in the study area and traffic is significantly impeded or roads become cut-off during floods. The roads are raised which results in ponding upstream of the road crossings.

The areas downstream of Ocean Drive and Bold Street are mainly low-lying and relatively flat. Development patterns have resulted in a number of low points being formed in roads and through properties, causing overland flows to pond to significant depths. In some areas attempts have been made to provide a continuous overland flow path to the receiving waterways, however, their capacity is also limited which causes hazardous flooding through roads and on properties. Underground and open channel drainage systems are present but are often exceeded. Drainage in these low-lying areas may also be impeded by high water levels in the receiving waters due to floods or storm surge, and mainstream flooding may also affect these areas. These issues are expected to worsen with climate change and sea level rise.

2.1.2 Flood Depth

Overland flow depths on properties are typically up to 0.3m in up to the 1% AEP event. Depths exceed 0.5m in a number of locations in the 0.2EY event, and exceed 1m in the 5% and 1% AEP events. Areas of deeper flows include main flow paths and drainage low points in a number of roads.

During the PMF event, property and road flooding exceeding 0.5m depth is widespread, with property and road flooding of 1m depth also common. Depths of flooding exceeding 2m occur on approximately 20 properties in the study area.

The flood depth mapping shows relatively high depths of ponding on the upstream sides of many buildings. In most cases this is due to the model terrain not allowing free drainage of water around the buildings. In real life the ground surface around buildings is usually graded to allow water to drain off and not form trapped points. There may also be property stormwater drainage present which is not included in the model. Some care therefore needs to be taken in the review of the flood depth mapping.

2.1.3 Duration of Flooding

Overland flooding in the study area is generally a result of intense short-duration rainfall events. As a result, the duration of inundation of roads and built areas is typically short, limited to 1 – 2 hours in up to the 0.5% AEP event. Storage areas such as road sag points in Sirius Drive and Lilli Pilli Close in Lakewood may be inundated for longer durations of up to 3hrs due to constrained capacity of stormwater drainage servicing these areas.

Durations of inundation are likely to be up to 4 hours in the PMF event particularly in some flood storage locations, affecting roads including Botanic Drive and Ocean Drive west of Lakewood shopping centre.

Note that the duration of flooding for depths greater than 0.3m, at which stage floodwaters become impassable for most passenger vehicles, is generally limited to approximately 1 hour duration in most roads.

A river flooding event may occur shortly after overland flooding in the study area, in which case the lower-lying areas of the study area may experience more extensive durations of flooding. River flooding was not assessed in this study.

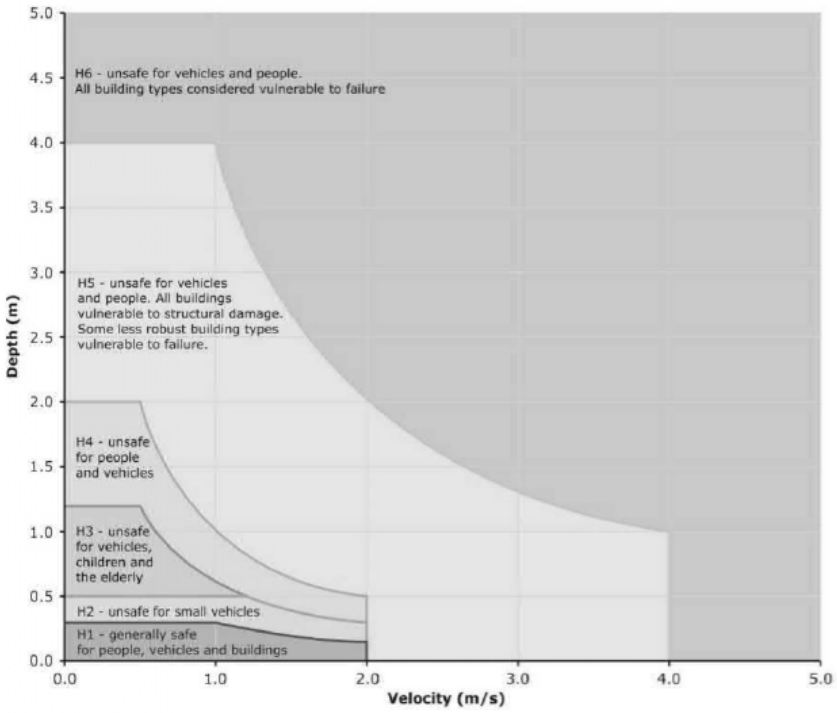
Flood hazard mapping was prepared for the 1% AEP event for current climate conditions and for the 1% AEP event under the adopted climate change scenario (increased rainfall intensity by 10% and with 0.9m sea level rise). Recent research has been undertaken into the hazard that flooding poses and the vulnerability of the public and assets when interacting with floodwaters. A combined flood hazard classification is presented in *Australian Disaster Resilience Handbook 7. Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia* (AIDR, 2017a) and *Guideline 7-3 Flood Hazard* (AIDR, 2017b) based on this research, and is illustrated in Figure 2-1. The flood hazard categories according to the AIDR definition are:

- H1 – Generally safe for people, vehicles and buildings;
- H2 – Unsafe for small vehicles;
- H3 - Unsafe for vehicles, children and the elderly;
- H4 - Unsafe for people and vehicles;
- H5 - Unsafe for people and vehicles. Buildings require special engineering design and construction; and
- H6 – Unsafe for people or vehicles. All buildings types considered vulnerable to failure.

The flood hazard classification is more discrete and provides guidance on flood hazard thresholds to different members of the community (e.g. children and elderly) and different assets (small versus larger vehicles, standard versus specialised engineered buildings). The AIDR flood hazard definition potentially provides a more suitable guideline for assessing flood hazard on the floodplain from an emergency management perspective.

The flood hazard mapping is provided in Appendix A and is denoted provisional. The provisional mapping is based on direct flood modelling outputs and was not updated to reflect the “true” flood hazard to take into consideration evacuation, isolation and other emergency management aspects. There are numerous areas of high flood hazard (>H5) typically reflect the swift overland flows in watercourses and flow paths including roadways.

Figure 2-1 General flood hazard vulnerability curves, Australian Institute for Disaster Resilience (AIDR) definition. Reproduced from Figure 6 in *Guideline 7-3: Flood Hazard* (AIDR, 2017b)



2.1.4 Provisional Hydraulic Categories Mapping

Three flood hydraulic categories identified in the *Floodplain Development Manual* (NSW Government, 2005). These are also defined in Council's Flood Policy (2015):

- Floodway, where significant discharge of water occurs during floods and blockage could cause redirection of flows. Generally characterised by relatively high flow rates; depths and velocities;
- Flood storage, characterised by relatively deep areas of floodwater and low flow velocities. Floodplain filling of these areas can cause adverse impacts to flood levels in adjacent areas; and
- Flood fringe, areas of the floodplain characterised by shallow flows at low velocity.

There is no firm guidance on hydraulic parameter values for defining these hydraulic categories, and appropriate parameter values may differ from catchment to catchment. For example, the minimum threshold flows and depths which might define a floodway in an overland flow catchment may be markedly lower than those for a large lowland river due to the different scale of flooding. The category definition adopted in the Hastings River Flood Study (PBP, 2006) and Hastings River Floodplain Risk Management Study (Worley Parsons, 2012) was initially considered for this study. For the Hastings River the floodways were defined as areas in the 1% AEP flood with flows greater than 2m, velocities greater than 0.5m/s and velocity x depth greater than $1m^2/s$. This does not agree with the flooding conditions in the North Brother study area, where 1% AEP flows are generally less than 1.5m deep. Hence, an alternative hydraulic category system is required.

Howells et. al. (2003) suggest that consideration of flow depths, velocities and velocity x depth of flood flows can be used to help define the hydraulic category areas. Various combinations of flow, depth and velocity were trialled for appropriate threshold values for the hydraulic categories. For the purposes of this study, the hydraulic categories were defined as per the criteria in Table 2-1, which were selected following trials of different criteria values and categorisation methods. These criteria are consistent with those adopted by a number of other councils in NSW for overland flooding.

Table 2-1 Hydraulic Categories Criteria

Hydraulic Category	Criteria
Floodway	Area within the flood extent where: • Velocity x Depth > 0.3m^2/s AND • Velocity > 0.5m/s AND • Depth > 0.15m.
Flood Storage	Remaining area within 1% AEP flood extent where Depth > 0.15m
Flood Fringe	Remaining area in the floodplain (i.e. area within PMF extent) outside the Floodway and Flood Storage areas.

The provisional hydraulic categories mapping is presented in Appendix A for both the 1% AEP design flood for current climate, and for the 1% AEP event with climate change. The mapping is treated as provisional and may need to be considered in further detail to ensure a continuous floodway strip (where appropriate) and to remove/reclassify isolated areas which currently meet the floodway criteria to either flood storage or flood fringe categories. This would be achieved by manual inspection and adjustment of the mapped floodway areas.

Floodway areas are generally located within the natural watercourses and flow paths, although there are a number of roads which contain floodways throughout the study area. Floodways pass through properties on Black Swan Terrace, Koonwarra Street, Pelican Court, Elouera Place, Flinders Drive, St Joseph's School, Peach Grove, Gow Place, Kew Road and in Laurieton between Quarry Place and Bold Street, among others.

2.2 Summary of Flood Problem Areas

Flooding hot spots are identified in the flood study, confirming problem areas previously identified by Council. The hot spots are summarised in Table 2-2 below. Critical areas with consideration of high flood depths, velocities or hazard are highlighted with orange cell or text shading. In summary, the identified critical locations include:

- Black Swan Terrace, West Haven.
- Kirmington Terrace, Koonwarra Street, Captain Cook Bicentennial Drive villas and Ocean Street property and Pelican Court, West Haven.
- Bold Street, Laurieton
  - Laurieton Hotel and adjoining areas
  - Harbourside Crescent villas.
- Lake Street property, Laurieton. Corner Seymour Street.
- St Joseph's School, Laurieton.
- Lilli Pilli Close, Lakewood (road flooding).
- Sirius Drive, Honeysuckle Avenue and Mahogany Close, Lakewood (road flooding).
- Ocean Drive between Fairwinds Avenue and Mission Terrace (road flooding).
- Pelican Court, West Haven (road flooding).
- Waterview Crescent, Kirmington Terrace and Koonwarra Drive, West Haven (road flooding).
- Bold Street between Laurie Street and Mill Street (road flooding).
- Lord Street at Seymour Street, Laurieton (road flooding).

Table 2-2 Description of Flooding Hot Spots

Location	Description
Property flooding	
Black Swan Terrace, West Haven	Flow depths on properties up to 0.5m in the 0.2EY event and up to 0.7m in the 1% AEP event. Swift flows of 2m/s. Flood hazard up to H5 rating in the 1% AEP event.
Ringtail Cl, Lakewood	Overflows from open channel onto properties with flooding in backyards to depths 0.2 – 0.3m in the 1% AEP event. Relatively low flooding impact.
Lilli Pilli Cl, Lakewood	Flooding in backyards to depths of 0.3 – 0.5m in the 1% AEP event from open drain overflows. Flooding in cul-de-sac to depths up to 0.8m. Also significant flooding of car park around Lakewood shopping centre.
Mission Terrace, Lakewood	Overflows with depths of 0.1 – 0.3m in the 1% AEP event from cul-de-sac onto downhill property. Overflows from the overland flow path running through properties on the uphill side of the road with depths up to 0.2m
Kirmington Terrace to Pelican Court, West Haven	Flows through properties on low side of Koonwarra Street of 0.3m in the 0.2EY event and exceeding 0.5m in the 1% AEP event. Velocities up to 2m/s in the 1% AEP event. Flood hazard up to H4 (some localised H5) rating in the 1% AEP event. Flow depths 0.5m in the 0.2EY event and up to 0.8m in the 1% AEP event on Captain Cook Bicentennial Drive villas and Ocean Drive property, at dwellings. Flood hazard up to H4 rating in the 1% AEP event. Flood depths of 0.6 – 0.8m in the 0.2EY event within Pelican Court roadway and pedestrian walkway. Depths up to 0.6m at dwellings in 1% AEP event. Flood hazard up to H4 rating on properties and H5 on roadway in the 1% AEP event. Groundwater springs occur in this area but are not directly related to the surface water flood risk. These springs appear to be a spatially random occurrence.
Flinders Dr Estate, Laurieton	Overflows from drainage easement swale onto properties with depths to 0.3m in the 0.2EY event and 0.5m in the 1% AEP event. Overflows from Reliance Crescent sag point onto properties to depths of 0.2m in the 0.2EY event and 0.4m in the 1% AEP event.
Bold Street area, Laurieton	Significant flows through Laurieton Hotel with H4 hazard rating. Trapped drainage point on western side of commercial properties with significant depths, though local drainage may be present which would mitigate the flood depths. Overflows down fire trail at Norman Street/ Mill Street affecting properties with depths up to 0.3m in the 1% AEP. Overflows onto units on Harbourside Crescent from trunk drainage channel to depths exceeding 0.5m in the 1% AEP event, with H5 hazard rating.

Quarry Way, Laurieton	Overflows from flow diversion drain to depths of 0.5m in the 1% AEP event on properties. The drain is reported to be affected by significant debris blockage.
Lake Street, Laurieton	Flood depths up to 1m in the 1% AEP event affecting dwelling on the corner of Lake Street and Seymour Street. Overflows from Lake Street onto properties between Ocean Drive and Castle Street to depths of 0.3m in the 1% AEP.
St Joseph's School, Laurieton.	Swift flows in overland flow paths to depths of 0.8m and velocities exceeding 2m/s in the 1% AEP event. Flows between buildings are 0.4m in the 0.2EY event and 0.6m in the 1% AEP event, with velocities up to 2m/s. Flood hazard rating of H4 in pedestrian walkways and H5 in overland flow paths in the 1% AEP event.
Properties adjacent to Stingray Creek and Camden Haven River, Laurieton	Numerous properties on low-lying land at risk of oceanic inundation during storm surge events. Estimated depths on the flood mapping expected to be conservative due to likely attenuation of ocean inflows through the river mouth.
Blackbutt Crescent and Peach Grove, Laurieton	Overflows from flow diversion drain to depths of 0.5m in the 1% AEP event on properties. The drain cross-sectional profile and capacity significantly reduces near its discharge point onto Peach Grove at Tunis Street. Flows into the drain originate from natural watercourse further uphill, which is significantly affected by rubble and debris blockage.
Elouera Place, West Haven	Overflows from watercourse and diversion drain. Depths over 0.3m in the 0.2EY event and 0.5m in the 1% AEP event.
Sirius Drive, Honeysuckle Avenue and Mahogany Close, Lakewood	Flood depths on properties 0.3 – 0.5m in the 1% AEP event, built up from road ponding areas.
Sirius Drive and Oak Close, Lakewood	Depths 0.3 – 0.4m and velocities 1m/s in the 1% AEP event.
Sandpiper Close	Overflows from concrete channel along Ocean Drive. Depths 0.3 – 0.4m and velocities 1m/s in the 1% AEP event.
Properties on lower side of Ocean Drive, 200m east of Hoschke Road, West Haven	Road low point overflows onto properties with depths of 0.5m and velocities of 1m/s in the 1% AEP event.
Roads	
Ocean Drive west of Lakewood shopping centre	5% AEP event flood depths of 0.4m 1% AEP event flood depths of 0.5m, H3 hazard rating
Botanic Drive, Lakewood	1% AEP event flood depths of 0.4m, H2 hazard rating
Lilli Pilli Close, Lakewood	5% AEP event flood depths of 0.6m 1% AEP event flood depths of 0.7m, H3 hazard rating
Ocean Drive east of Lakewood shopping centre	5% AEP event flood depths of 0.3m 1% AEP event flood depths of 0.35m, >H4 hazard rating
Sirius Drive, Honeysuckle Avenue and Mahogany Close, Lakewood	0.2EY event flood depths of 0.6 – 0.7m 1% AEP flood depths 1m, H3 hazard rating
Ocean Drive between Fairwinds Avenue and Mission Terrace	0.2EY event flood depths of 0.5m 1% AEP event flood depths of 0.7m, >H4 hazard rating
Ocean Drive and Mission Terrace intersection	0.2EY event flood depths of 0.4m

	1% AEP event flood depths of 0.6m, H3 hazard rating
Ocean Drive near Waterview Crescent	5% AEP event flood depths of 0.2 – 0.3m 1% AEP event flood depths of 0.3m, low hazard rating but long section of flooding
Ocean Drive near Pelican Court	5% AEP event flood depths of 0.3m 1% AEP event flood depths of 0.4m, H3 hazard rating
Pelican Court, West Haven	0.2EY event flood depths 0.6m 1% AEP event flood depths of 1m, H5 hazard rating
Waterview Crescent, Kirmington Terrace and Koonwarra Drive, West Haven	0.2EY event flood depths of 0.2m with 2m/s velocity; max 0.6m depths (low velocity) 1% AEP event flood depths up to 0.7m, H5 – H6 hazard rating
Ocean Drive east of Hoshcke Road	0.2EY event flood depths of 0.4m 1% AEP event flood depths of 0.5m, H3 hazard rating
Ocean Drive east of Flinders Drive	5% AEP event flood depths of 0.3m 1% AEP event flood depths of 0.4m, H3 hazard rating
Kew Road/Bold Street near Tunis Street, Laurieton	1% AEP event flood depths of 0.5m, H2 hazard rating
Bold Street between Laurie Street and Mill Street	0.2EY event flood depths over 0.5m 1% AEP event flood depths 0.6 – 0.8m, H5 hazard rating
Bold Street north of Hanley Street, Laurieton	0.2EY event flood depths of 0.3m with 1m/s velocity 1% AEP event flood depths up to 0.5m, H3 hazard rating
Lord Street at Seymour Street, Laurieton	0.2EY event flood depths of 0.5m 1% AEP event flood depths up to 0.7m, H3 hazard rating
Flinders Drive, Laurieton Tunis Street, Laurieton Rosewood Court and Mission Terrace, Lakewood Diamentina Way, Lakewood	H5 hazard rating on steep sections of road (1% AEP event)

2.3 Above-Floor Property Flooding

A floor level survey was undertaken in October 2019 for selected properties in the study area, which were identified based on presence of high hazard flooding at the dwelling in the 1% AEP event. The minimum habitable floor level was surveyed at a total of approximately 270 buildings. Floor levels for the remaining 2,000 (approximately) properties in the study area were estimated based on an assumed 0.2m height above the maximum ground level at the dwelling.

Above-floor flooding in the 0.2EY, 5%, 2% and 1% AEP and PMF flood events is mapped on Figure 2-2. The buildings shown on the map were selected as those affected by main flow paths and bodies of flooding, and exclude those affected by minor ponding. This selection process was done for each flood AEP and was also used in the flood damages assessment (see Section 2.6).

Above-floor flooding is expected to incur significantly greater flood damages to the building and contents compared to yard (i.e. below floor level) flooding. The map indicates the spatial distribution of properties with above-floor flooding and their relative vulnerability, with properties affected in frequent events such as the 0.2EY event being more vulnerable than those affected only in rarer events such as the 1% AEP event.

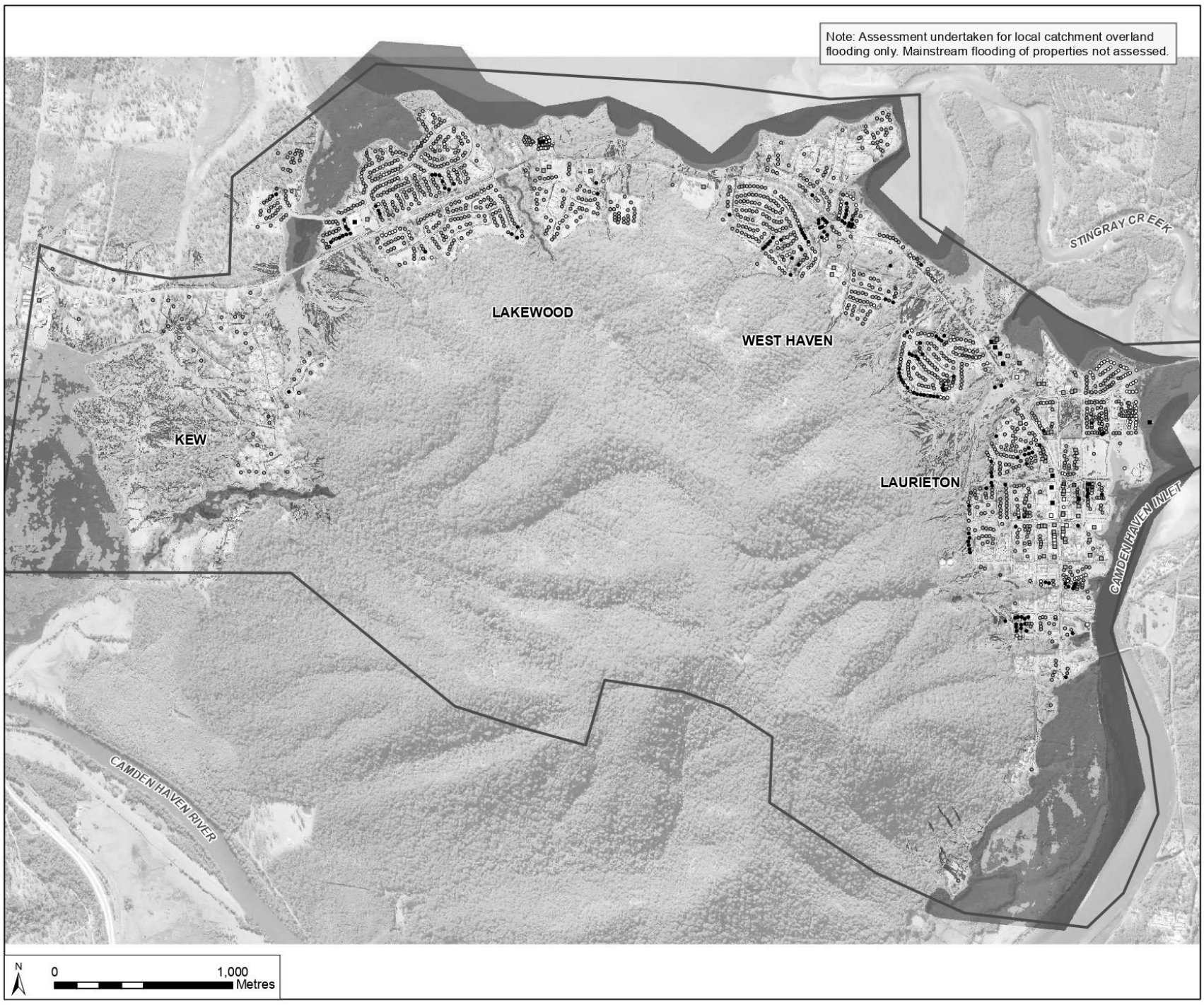
2.4 Very High Hazard Residential Properties

A count of properties with very high hazard flooding conditions at the dwelling was undertaken based on the flood hazard mapping in Appendix A, with the review identifying 20 residential properties with a flood hazard rating of H5 or H6 in the 1% AEP event, whereby damage to the building may result due to floodwaters. The properties are located within the flood problem areas as discussed in 2.2 and may be candidates for management measures including voluntary purchase and redevelopment by Council, as discussed in Section 4.1.1 and Section 4.1.4, respectively.

2.5 Sensitive Properties and Critical Infrastructure

Sensitive properties and critical infrastructure have been identified in the catchment. Certain types of properties may require specific evacuation considerations due to the vulnerability of their occupants, such as schools and pre-schools, and aged care facilities. Critical infrastructure impacted by flooding may have effects on the recovery and functioning of the community following a flood event.

The sensitive properties and critical infrastructure are mapped on Figure 2-3. The flood hazard in the PMF event is mapped on the figure. Note that centrally-operated facilities are listed. Properties which include apartments, villa estates etc. have not been identified.



Legend

Design Flood when Floor Becomes Inundated

- 0.2EY
- 5% AEP
- 2% AEP
- 1% AEP
- PMF

Property Type

- Residential
- Non-residential

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area

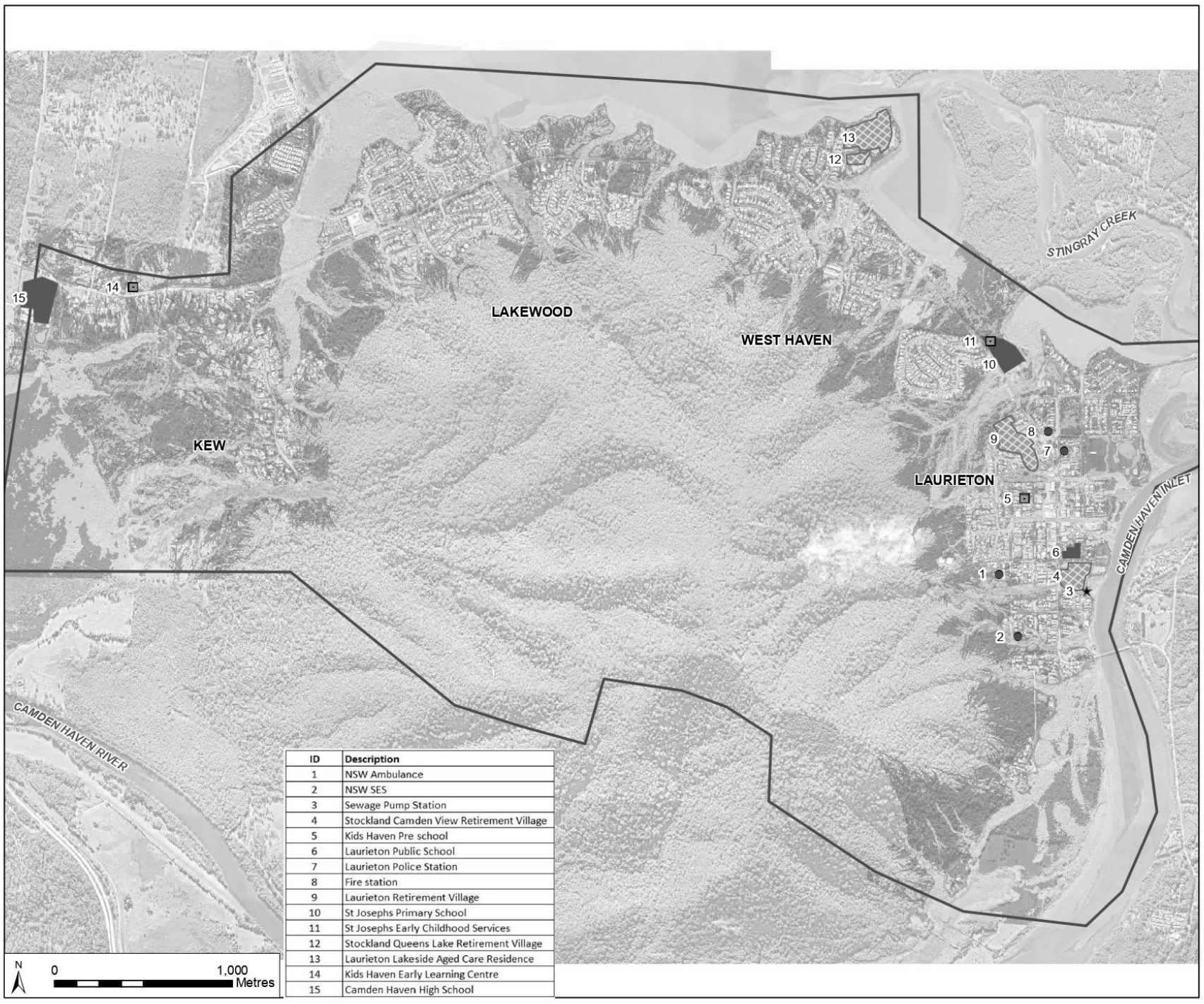
GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

JACOBS

TITLE	Above-Floor Flooding at Dwellings
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	FIGURE 2-2
DATE 3/12/2019	



ID	Description
1	NSW Ambulance
2	NSW SES
3	Sewage Pump Station
4	Stockland Camden View Retirement Village
5	Kids Haven Pre school
6	Laurieton Public School
7	Laurieton Police Station
8	Fire station
9	Laurieton Retirement Village
10	St Josephs Primary School
11	St Josephs Early Childhood Services
12	Stockland Queens Lake Retirement Village
13	Laurieton Lakeside Aged Care Residence
14	Kids Haven Early Learning Centre
15	Camden Haven High School

Legend

- Child Care Centre
- Critical Infrastructure
- Emergency Services
- School
- Aged Care Facility
- Study Area

Flood Hazard Category

- H1 - Generally safe for vehicles, people and buildings.
- H2 - Unsafe for small vehicles.
- H3 - Unsafe for all vehicles, children and the elderly.
- H4 - Unsafe for all people and all vehicles.
- H5 - Unsafe for all people and all vehicles. Buildings require special engineering design and construction.
- H6 - Unsafe for Vehicles and people. All building types considered vulnerable to failure.

GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	Sensitive Properties and Critical Infrastructure
PROJECT	North Brother Local Catchments Flood Study
PROJECT #	IA157500
DATE	9/12/2019

FIGURE 2-3

The sensitive properties and critical infrastructure identified as being directly affected by overland flooding are summarised in Table 2-3 with the flood hazard on each site indicated. Note that the list is based on the overland flood modelling in this study, and a number of sites are impacted by mainstream flooding which is not assessed.

Table 2-3 List of flood-affected sensitive properties and critical infrastructure

Name	Overland Flow Flood Hazard* (Existing case, no climate change)		Hydraulic Category (1% AEP, climate change)
	1% AEP	PMF	
Sensitive Properties			
Stockland Camden View Retirement Village	Mostly H1/H2 Up to H5	H6	Flood Fringe/Flood Storage/Floodway
Kids Haven Pre School	H1	H1	Flood Fringe
Laurieton Public School	H1	H4	Flood Fringe
Laurieton Retirement Village	Mostly H1 – H2 Localised H3	H6	Mostly Flood Fringe/Flood Storage. Some Floodway areas
St Josephs Primary School	Mostly H1/H2 Up to H5	H5-H6	Flood Fringe/Flood Storage/Floodway
St Josephs Early Childhood Services	Mostly H1/H2 Up to H4	H5	Flood Fringe/Flood Storage/Floodway
Stockland Queens Lake Retirement Village	Mostly H1/H2	H4	Mostly Flood Fringe. Some Flood Storage areas
Laurieton Lakeside Aged Care Residence	Mostly H1	Mostly H1- H3	Flood Fringe
Kids Haven Early Learning Centre	H1	H1	Flood Fringe
Camden Haven High School	Mostly H1	Mostly H1, up to H4 in low-lying southern part of school	Mostly Flood Fringe
Critical Facilities and Infrastructure			
NSW Ambulance Laurieton	H1	H3	Flood Fringe/Flood Storage
NSW SES Camden Haven unit	H1	H3	Flood Fringe
Laurieton Police Station	H1	H2	Flood Fringe
Fire station Laurieton	H3	H4	Flood Fringe/Flood Storage
Laurieton sewage pumping station	H4	H6	Flood Storage/Floodway

* Note, overland flood hazard indicated. Some properties are also affected by mainstream flooding.

2.6 Flood Damages Assessment

2.6.1 Overview

Flood events may cause damage to property with significant costs to property owners and insurers. The damage may occur due to floodwaters affecting the building façade and interior (weatherboard exterior, gyprock interior walls, carpets), electrical wiring and building contents and other property outside the dwelling (vehicles,

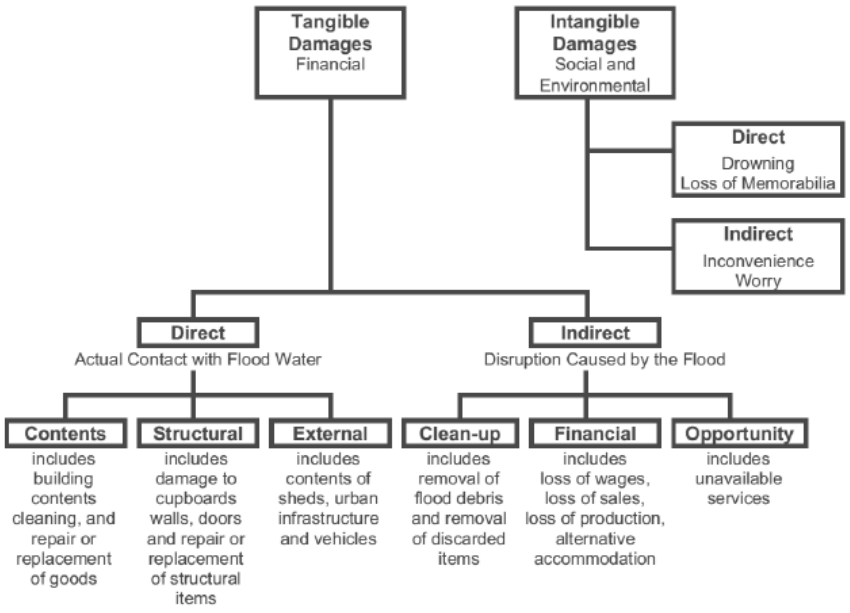
contents of sheds and garages, etc). Structural damage to the dwelling can also occur due to extreme flood hazard conditions.

The cost of flooding is estimated to identify the magnitude of the event to a community, and subsequently provide a benchmark for the viability of potential measures for mitigating the impacts of flooding. This section describes the estimation of flood damage costs in the study area, focussing on residential and commercial properties.

2.6.2 Flood Damages Categories

The type of damages associated with floods is shown in Figure 2-4 (*Floodplain Development Manual¸ NSW Government 2005*). The cost of damage caused by floods may include tangible and intangible components. Tangible damage costs include the direct material damage and rebuilding costs to existing homes, property and infrastructure, and also the indirect costs associated with the social disruption of the floods, such as: clean-up; lost income during and after the flood event; and the cost of alternative accommodation for people displaced by the floods. A monetary value can be readily placed on the direct damages, which are the focus of this assessment.

Figure 2-4 Types of Flood Damage



Other social and environmental damages to which a monetary value cannot readily be placed are intangible damages, which include emotional stress of the flood event, injury and loss of life. While these damages cannot readily be incorporated into an economic feasibility assessment of mitigation options, it is still important to consider the potential for these intangible damages, particularly if there is an elevated risk of loss of life.

2.6.3 Estimation of Direct Tangible Flood Damage Costs

2.6.3.1 Property Information

Residential and commercial properties were identified and characterised based on knowledge and site observations of the study area.

Residential house types in the study area are generally a mixture of one and two storey houses, in addition to a number of villa and apartment complexes. In floodplains with deep flooding (riverine floodplains) two storey

houses would experience a second increment of flood damages as floodwaters rise and affect the second storey. While some properties in the low-lying areas adjacent to the rivers and lakes would be affected by riverine flooding, the focus of this study is on overland flows from the local catchments, affecting up to the first storey of the house only. For the purposes of this assessment all houses were assumed to be single storey.

Flood damages are estimated based on flood level in relation to building floor level, with the damages increasing as the flood levels increase. The floor levels of approximately 270 buildings, selected based on high hazard flooding in the 1% AEP event, were surveyed. The floor levels of remaining buildings were estimated based on LiDAR ground levels plus and assumed 0.2m above the highest ground level at the building.

Affected buildings for the flood damages assessment were selected based on interpretation of overland flood extents from the flood mapping, to include only those properties affected by main flow paths and significant ponding shown on the mapping so as not to overestimate the flood damages. The affected properties were selected for each event assessed in the flood damages estimation, i.e. the 0.2EY, 5%, 2% and 1% AEP and PMF events. This approach was taken so as not to overestimate the flood damages.

2.6.3.2 Residential Property Damages

Residential flood damages guidelines and a calculation spreadsheet was developed by the NSW Office of Environment and Heritage (OEH, 2016b). The calculation spreadsheet includes a representative stage-damage curve derived for typical house types in the study area to estimate structural, contents and external damage. The amount of damage is based on the flood inundation depth, for a suite of annual exceedance probability events ranging from the 20% AEP event up to the PMF. These values are then summed to provide a total damage for each flood event analysed. The AEP of the PMF in the study area is assumed to be 1 in 10,000,000.

The stage-damage curves assume some flood damages for flood levels below the floor level. A minimum damage value of $12,060 (2018 dollars) is assumed to occur at a level 0.5m below the floor level. This approach accounts for flood damages to parts of the dwelling and property below the floor level and ensures that damages are not underestimated.

Various input parameters are used to define the flooding and location characteristics which derive a location specific damage curve. The parameters adopted for the study area are presented in Table 2-4.. Unless otherwise stated, default parameters have been used (as recommended in the *Residential Flood Damage Guidelines* (OEH, 2016b)).

The DECCW stage-damage curves within the spreadsheet are derived for late 2001, and have been updated using an Average Weekly Earnings (AWE) factor to the current day values. AWE is used to update residential flood damage curves rather than the inflation rate measured by the Consumer Price Index (CPI). The most recent AWE value from the Australian Bureau of Statistics (ABS, 2019) at the time of the assessment was November 2018, however, this resulted in a multiplication factor on 2001 dollars of 2.37, which was significantly out of step from the factor value derived from November 2017 AWE of 1.76 and from previous recent years. On this basis, a factor of 1.9 was assumed for up to August 2019 to keep in trend with AWE increases for the years prior to November 2017.

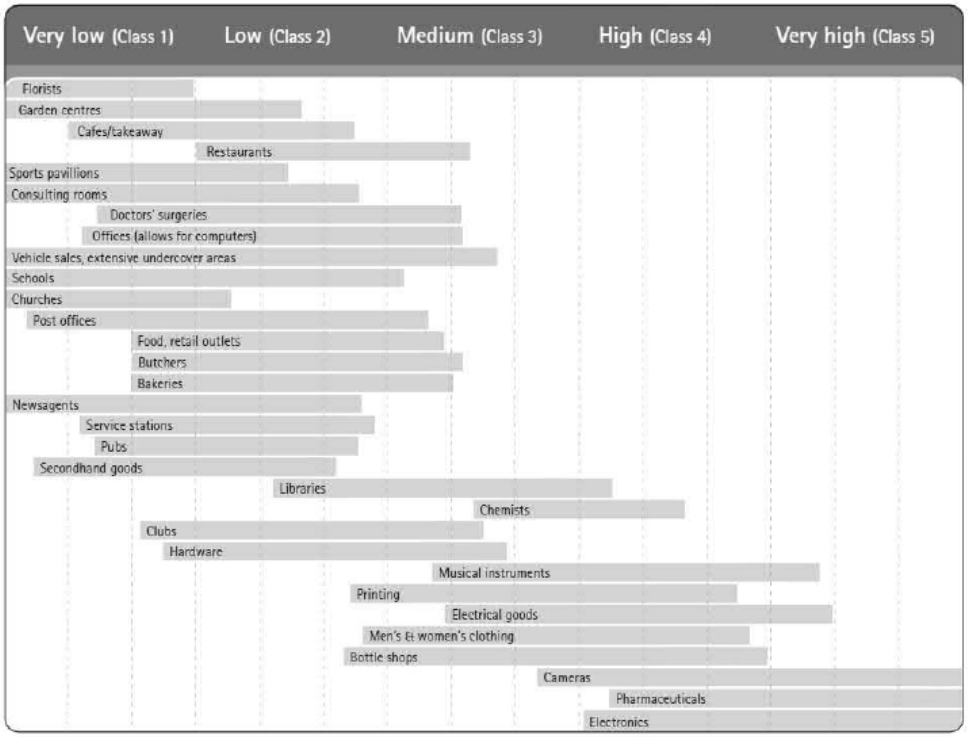
Table 2-4 Input parameters for damage calculations

Parameter	Value	Comment
Regional Cost Variation Factor	1.0	Appropriate value for a major city (Sydney) and surrounds. Similar value assumed for major regional city.
Post flood inflation factor	1.15	
Typical duration of immersion	1 hour	
Building damage repair limitation Factor	0.85	Represents short duration flood (<12 hours) where some materials can recover from short periods of flooding and may not need replacement
Typical free-standing house size	240m²	
Contents damage repair limitation Factor	0.75	Guidelines suggest a value of 0.75 for short duration floods
Effective warning time (hrs)	0	Only marginal improvement in damages cost when effective warning time is increased to 1 hour as a sensitivity assessment
Level of flood awareness	Low	Flood warning times are nil, and it is assumed that residents are typically not aware of potential damage of flood waters and the measures to minimise damages (e.g. elevated storage of goods).

2.6.3.3 Commercial Property Damages

No information on commercial property flood damage costs in NSW was found during a literature search. The most relevant information obtained was published in the Queensland Government Natural Resources and Management Department's *Guidance on the Assessment of Tangible Flood Damages* (2002). This document contains flood damage curves for commercial properties over a range of property footprint areas and degrees of susceptibility to flooding and is based on information published in *ANUFLOOD: A Field Guide* (Centre for Resource and Environmental Studies (Australian National University), 1992). Different types of commercial and non-residential properties were assigned a susceptibility rating, as illustrated in Figure 2-5.

Figure 2-5 Damage categories for commercial properties (reproduced from *Guidance on the Assessment of Tangible Flood Damages* (Qld. Government, 2002)



The stage-damage data were factored up by a value of 1.9 from late 2001 dollars to current values based on Average Weekly Earnings (AWE), similar to the approach adopted for the residential flood damages.

An additional multiplication factor of 1.6 was applied based on guidance in *Rapid-Appraisal Method (RAM) for Floodplain Management* (Victorian Government Natural Resources and Environment, 2000), which suggests that the ANUFLOOD values are underestimated and should be increased by 60%.

A total of 89 commercial and non-residential premises/buildings which are potentially flood-affected were identified. Detached buildings on non-residential properties were assessed individually e.g. on school grounds. Individual shops within an overall commercial building complex were also assessed separately where possible. The results of the commercial and non-residential property flood damages assessment are provided in Section 2.6.3.5.

2.6.3.4 Damages to Utilities and Infrastructure

Utilities and infrastructure in the study area which are susceptible to flooding may include roads and other public infrastructure such as sewage pumping stations, electrical transformer boxes, etc.

The potential cost of damage to roads is difficult to estimate for the study area, as the nature of flooding in a significant portion of study area is typically due to relatively shallow, short-duration flows, although road damage is possible for roads conveying higher velocity flows.

The roads damages guidance published in the references cited in this study are based on longer-duration mainstream flooding damages and hence are likely to overestimate the flood damages to roads in the study area. Hence these costs have not been included in this assessment.

2.6.3.5 Damage Assessment Results

The most convenient way to express flood damage for a range of flood events is by calculating the Annual Average Damage (AAD). The AAD is equal to the total damage caused by all floods over a long period of time divided by the number of years in that period. The AAD for the existing case then provides a benchmark by which to assess the merit of flood management options.

The AAD value is determined by multiplying the damages that can occur in a given flood by the probability of that flood actually occurring in a given year and then summing across a range of floods. This method allows smaller floods, which occur more frequently to be given a greater weighting than the rarer catastrophic floods.

Table 2-5 summarises the residential damages and the commercial and non-residential damages. The residential and commercial property flood damages include direct damages to property such as structural, external and contents damage, and indirect damages such as clean up costs and accommodation/ loss of rent costs. Infrastructure damage, vehicular damage and intangible damages are not included.

The OEH (2016b) guidelines recommend that the adopted freeboard in the flood planning level (0.5m) be considered in the flood damages estimation. This gives the "Protection Level" which reduces the floor level relative to the flood levels in the calculations which are adopted as the damages estimates. Calculations of damages based on floor level (no freeboard adjustment applied) are also provided as a sensitivity check.

The flood damages here are "potential flood damages", which may be reduced with increased flood awareness and preparedness in the community. The Net Present Value of the flood damages assumes a 7% discount rate over a 50 year life, as per the OEH (2016b) guidelines. The damages are in 2019 dollar values

Table 2-5 Estimated Tangible Flood Damages due to Overland Flooding

Event	Based on Floor Level*		Based on Protection Level (Floor Levels minus Freeboard)*	
	Number of properties flooded above floor level	Estimated Flood Damage	Number of properties flooded above protection level	Estimated Flood Damage
Residential				
20% AEP	161	$18.9M	344	$40.3M
5% AEP	222	$25.6M	429	$50.8M
2% AEP	380	$42.7M	679	$80.6M
1% AEP	492	$54.1M	839	$100.0M
PMF	1,616	$193.9M	2,062	$274.5M
AAD		**$8.9M**		**$17.6M**
Commercial/Non-Residential				
20% AEP	10	$1.0M	34	$4.4M
5% AEP	16	$1.5M	44	$6.1M
2% AEP	27	$2.3M	59	$8.3M
1% AEP	31	$2.5M	63	$8.9M
PMF	83	**$12.9M**	98	$22.7M
AAD		**$0.5M**		**$1.9M**

* Damages estimate based on Protection Level is to be adopted. Estimate based on floor level used as a sensitivity check.

2.6.4 Application of Flood Damage Curves to the Study Area

It should be noted that the flood damages estimated for the study area need to be considered with care. The OEH residential stage-damage curves recommended for use in NSW have been developed based on flood damages from low-land mainstream/ flooding, where flood surface gradients are relatively flat and the depth of flooding within a dwelling is fairly uniform. Due to the steep terrain in parts of the study area and the generally shallow nature of overland flows (particularly in the more frequent flood events), flood levels may vary greatly on a property and damage may be concentrated on one side of a dwelling. Flood depths are also relatively shallow so the damage incurred may be less than those suggested by the curves. Nevertheless, the stage-damage curves provide the best guidance available for estimating flood damages given the scarcity of actual flood damage data to residential properties on overland flow paths and have been adopted for this study.

2.6.5 Summary

Flood damages in the study area is primarily attributed to residential dwellings that are impacted by overland flooding. The estimates based on Protection Level are adopted. The flood damages estimates were based on properties selected based on their impact from main areas of flooding, and excludes those affected by localised minor ponding. The residential AAD for the study area is $17.6 million. The non-residential AAD is $1.9 million.

There are 523 residential and non-residential properties that are estimated to experience above floor flooding (not protection level) for the 1% AEP event. In the PMF, 1,699 properties are estimated to experience above floor flooding.

While flood damage estimates for the study area are indicative only, they are useful in the evaluation of flood management options, aimed at reducing flood damage estimates while being economically viable to implement.

3. Floodplain Risk Management Measures

3.1 Overview

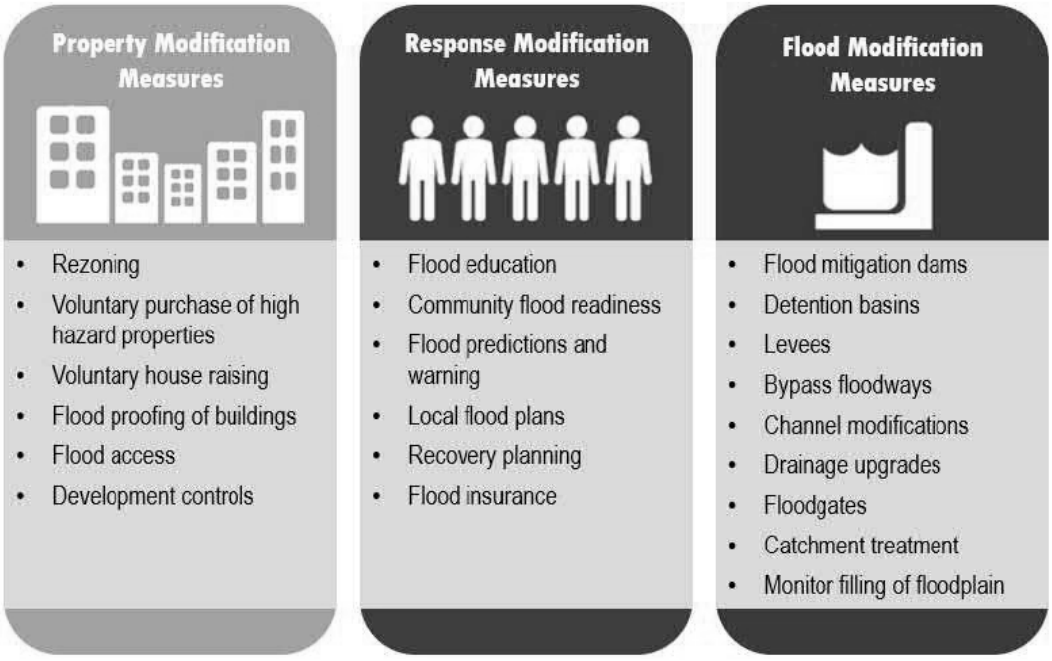
One of the objectives of this Floodplain Risk Management Study is to identify and compare various floodplain risk management options to deal with existing and future flood risk in the study area, considering and assessing their social, economic, ecological and cultural impacts and their ability to mitigate flood impacts.

The *Floodplain Development Manual* (NSW Government, 2005) describes floodplain risk management measures in three broad categories as described below:

- Property modification measures involve modifying existing properties (for example, house-raising) and/or imposing controls on new property and infrastructure development (for example, floor height restrictions);
- Response modification measures involve modifying the response of the population at risk to better cope with a flood event (for example improving community flood readiness); and
- Flood modification measures involve modifying the behaviour of the flood itself (for example, construction of a levee to exclude floodwaters from an area or flood retarding/detention basins to store floodwaters and reduce peak outflows).

Examples of measures falling under the three categories are outlined in Figure 3-1. Some of these measures may or may not be appropriate in a particular catchment, depending on factors such as the flooding behaviour and patterns of development.

Figure 3-1 Floodplain Risk Management Measures *(Source: Floodplain Development Manual, 2005)*



3.2 Considerations in Options Identification and Prioritisation

In determining the nature and priority of potential options for further detailed assessment, the following factors have been considered:

- The identified mitigation options are aimed at improving flooding conditions due to local catchment flooding. Riverine flood levels exceed the local catchment flood levels by a substantial amount particularly in the 1% AEP event and inundate low-lying areas of the study area. The local catchment flood mitigation options in these areas should be designed not to worsen the susceptibility of these areas to riverine flooding. For example, substantial lowering of raised berms may allow overtopping of river floodwaters in more frequent events.
- Design river tailwater conditions due to elevated ocean levels are up to 2.1m AHD in the 1% AEP event. Some low-lying areas on properties and roads have a ground level of approximately 2.6m AHD and would be difficult to drain via underground pipes.
- The effectiveness of mitigation options during future climate change scenario is to be considered. The design river tailwater conditions due to elevated ocean levels would increase to 3.0m AHD in the 1% AEP event in a climate change scenario, with 0.9m of sea level rise.
- The design riverine flood levels are 2.3 – 2.4m AHD in the 5% AEP event and 2.9 – 3.0m AHD in the 1% AEP event in the current climate. The flood levels in a climate change scenario are expected to increase by up to 0.8m in the 1% AEP event as a result of 0.9m sea level rise and 10% increase in rainfall (Patterson Britton and Partners, 2013).
- Given the low elevation of a number of identified sites for potential mitigation, it is expected that the effectiveness of the mitigation options would be reduced if local overland flooding coincided with a mainstream flood peak. Some contingency will be incorporated into the options modelling with adoption of elevated, but not peak, river tailwater levels.

3.3 Selection of Options for Detailed Assessment

A description and qualitative evaluation of identified works-based flood modification options at 16 locations was provided in the Working Draft Options Report, dated 9 December 2019. The identified options aim to mitigate flooding at the locations summarised in Table 2-2, in particular property flooding. A short-list of six combinations of options were selected by Council and the committee, and have been analysed in the TUFLOW model for hydraulic performance. The results of the modelling are described in this section.

Property and response modification measures will be addressed in the draft FRMS.

3.4 Assessed Flood Modification Measures

The short-listed options were tested in the TUFLOW model for the 0.2EY, 5%, 2% and 1% AEP events and the 1% AEP with climate change event to assess the improvements to flooding conditions. Existing underground utilities were considered in the configuration of the options based on Dial Before You Dig searches.

The assessed options are described, and their modelled performance is summarised for the 0.2EY, 5% and 1% AEP events in the following sections.

3.4.1 Black Swan Terrace, West Haven

Council commissioned, separately from this study, a design for an improved trunk drainage pipe inlet arrangement and high-flow diversion to the street. Additional works in the street including raising of the road verge and driveways are proposed. Details of the design were provided following the final flood study, hence it has not been incorporated into the design flood modelling and mapping. Since the design development of mitigation works at this location are already well-advanced, further mitigation options are not proposed in this study.

The pre-developed conditions at Black Swan Terrace have been retained in the mitigation case modelling. Post-development hydraulic modelling for this option is being undertaken by others on behalf of Council. Flow conditions in Koonwarra Street, downstream of the works, are not expected to be significantly changed as a result of the works, hence omission of the works from the mitigation case modelling should not affect the assessment of other mitigation options.

3.4.2 Kirmington Terrace to Pelican Court, West Haven

This area is identified as a critical flood problem area with significant flooding of properties in Koonwarra Street, Captain Cook Bicentennial Drive villas, Ocean Drive and Pelican Court. The flood hazard is high to very high (H4, some H5) on properties and on roads in the 1% AEP event. The area is highly affected in frequent events such as the 0.2EY event.

Flooding originates from three separate overland flow paths, including one from Black Swan Terrace, a second near Kirmington Terrace and a third from near Hoschke Road. Flow paths 1 and 2 converge in Koonwarra Street and then flow path 3 converges at Pelican Court. Overland flows are about 15m^3/s in flow paths 1 and 2 in total in the 1% AEP event downstream of Koonwarra Street, and 20m^3/s in combined flow paths 1, 2 and 3 in Pelican Court. Existing pipe flows in Pelican Court are 3m^3/s in the 1% AEP event in addition to the overland flows. The existing pipes in the network run full in the 0.2EY event. Flow paths 1 and 2 affect a number of properties throughout this area.

Flow path 3 directly affects two dwellings on Ocean Drive (numbers 384 and 386) near Hoschke Road in addition to contributing to flows in Pelican Court. It includes a 2m wide drainage channel through properties on the higher side of Ocean Drive, draining to a 2.4m x 0.9m box culvert under Ocean Drive, which is the main flow constraint. The culvert conveys 3.7m^3/s in the 1% AEP while another 3.7m^3/s overflows over Ocean Drive. it discharges to the formed swale on the low side of the road before the flows enter Pelican Court.

Floodwaters pond in Pelican Court and flow overland via an access road in addition to through properties to discharge to Queens Lake.

3.4.2.1 Option 4A+4B+4C

Description

The following options were assessed in combination (Options 4A+4B+4C):

- Option 4A – voluntary acquisition of one property in Koonwarra Street (number 53) which has floodway and H5 flood hazard conditions. Regrade the site to form a flow path to relieve flood conditions in the road and on adjacent properties.
- Option 4B – new additional trunk drainage line 2x 1200mm diameter pipes, intercepting flows at downstream end of channel on Captain Cook Bicentennial Drive villas, cross Ocean Drive and run under The Gateway and discharge to receiving waterway to the north of Pelican Court. This proposed pipe capacity would be approximately 5m^3/s which would reduce the total overland flow in Pelican Court by about 25% in the 1% AEP event. An inlet basin/rock debris trap similar to that proposed at Black Swan Terrace may be required.
- Option 4C – voluntary acquisition of one property, 7 Pelican Court, adjacent to the access road to form a larger flow path and provide additional capacity for flows out of Pelican Court sag.

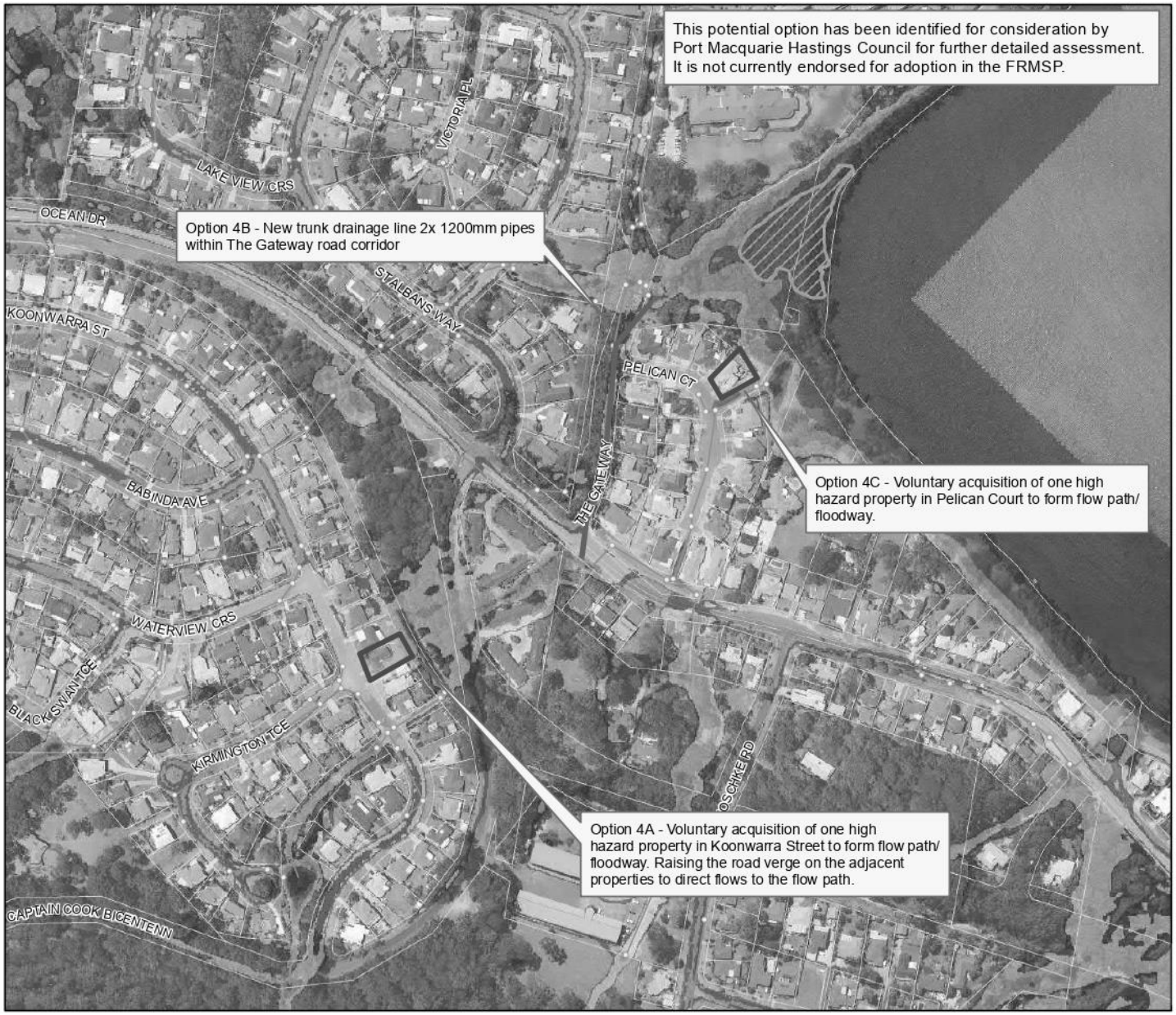
Refer to Figure 3-2 for illustration of options.

Constraints assessment

- High property prices (~$500K each) plus demolition and disposal costs.
- Existing underground utilities in Ocean Drive and The Gateway (Telstra, Optus, NBN, power, stormwater).
- Substantial number of trees in western verge of The Gateway, require removal if running new trunk drainage in the verge.

- Limited space to widen existing channel running through Captain Cook Bicentennial Drive villas and then turning at Ocean Drive. Presence of existing driveway crossing over channel into Ocean Drive property.
- Minimal space for rock debris trap at new trunk drainage inlet structure. Requires more detailed site assessment for potential rock debris loads. There are a number of informal traps upstream (e.g. road crossings) and a discontinuous flow path running off the mountain, so rock debris loads may be low.

Based on the site constraints it is assumed that the new trunk drainage line would run under the western side of The Gateway in order to minimise the number of underground services which need to be crossed and/or protected.



Legend

- Stormwater Pit/Node
- Pipes and Culverts
- National Park
- EECs and SEPP14

1% AEP Existing Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0

0 25 50 100 Metres

JACOBS

Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

GDA 1994 MGA Zone 56

TITLE
Option 4A+4B+4C Koonwarra Street to Pelican Court, West Haven Assessed Options

PROJECT
North Brother Local Catchments Flood Study

PROJECT #	MAP #
IA157500	FIGURE 3-2
DATE	
26/03/2020	

Hydraulic performance

Flood impact maps, showing the change in flood levels, are presented in Figure 3-3 to Figure 3-5 for the 0.2EY, 5% and 1% AEP events, respectively. The hydraulic performance of Options 4A+4B+4C is summarised in Table 3-1.

Table 3-1 Hydraulic performance of Options 4A+4B+4C

Event AEP	Changes in flood conditions
0.2EY	• Koonwarra Street – flood levels reduced by up to -0.04m at three properties adjacent to new floodway • Pelican Court – flood levels reduced by -0.2 to -0.4m in roadway and alleyway. Localised reductions only on properties up to -0.1m. • Reduced flood hazard from very high (H5) to mostly low (H1, H2) in Pelican Court, some moderate H3 in alleyway.
5% AEP	• Koonwarra Street – flood levels reduced by -0.04m to -0.2m at four properties adjacent to new floodway. • Pelican Court – flood levels reduced by -0.2 to -0.7m in roadway and alleyway. Reductions on properties typically to -0.1m, up to -0.4m on two properties. • Reduced extent of very high flood hazard (H5) in Pelican Court.
1% AEP	• Koonwarra Street – flood levels reduced by -0.04m to -0.4m at four properties adjacent to new floodway • Minor localised increase of +0.02m on Captain Cook Bicentennial Drive villas • Pelican Court – flood levels reduced by -0.2 to -0.7m in roadway and alleyway. Reductions on properties typically to -0.1m, up to -0.4m on two properties. • Eliminated occurrence of high - very high flood hazard (H4-H5) at two dwellings in Koonwarra Street (one through acquisition of property). • Reduced flood hazard on Ocean Drive from up to very high (H5) to low (H2). Note that road may be cut-off in other locations. • Reduced extent of H3-H5 hazard in Pelican Court.
1% AEP plus climate change	Similar performance to 1% AEP, in terms of reductions in flood levels in mitigated versus existing development case (with climate change). No reduction in performance due to sea level rise.

Summary

Options 4B and 4C appear to be effective at reducing flood levels and flood hazard (magnitude and extent) on Ocean Drive and Pelican Court including up to 20 dwellings.

Option 4A reduces the number of properties at risk to high hazard flooding and to flood damages due to the property purchase. However, the reductions in flood levels on adjacent properties is generally minor, with the more substantial reductions limited to one property. The likely high cost of this option (property purchase price plus demolition costs and earthworks) may make this option more challenging to justify purely from an economic standpoint. Notwithstanding, the removal of a household subject to high flood hazard should be considered in the subsequent multi-criteria evaluation of this option.


This potential option has been identified for consideration by Port Macquarie Hastings Council for further detailed assessment. It is not currently endorsed for adoption in the FRMSP.
LAKE VIEW CRS
ST ALBANS WAY
PELICAN CT
THE GATEWAY
BABINDA AVE
CAPTAIN COOK BICENTENN
WATERVIEW CRS
OCEAN DR
KIRMINGTON TCE
KOONWARRA ST
HOSCHKE RD
Legend
Change in Flood Level (m)
< -0.5
-0.5 - -0.3
-0.3 - -0.1
-0.1 - -0.01
-0.01 - 0.01
0.01 - 0.1
0.1 - 0.3
0.3 - 0.5
> 0.5
Change in Flood Extent
Was Wet Now Dry
Was Dry Now Wet
0 25 50 100
Metres
JACOBS
Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.
GDA 1994 MGA Zone 56
TITLE
Option 4A+4B+4C
Change in Flood Level
0.2EY Event
PROJECT
North Brother Local Catchments Flood Study
PROJECT #
IA157500
MAP #
FIGURE 3-3
DATE
25/03/2020

Legend

Change in Flood Level (m)

- < -0.5
- -0.5 - -0.3
- -0.3 - -0.1
- -0.1 - -0.01
- -0.01 - 0.01
- 0.01 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- > 0.5

Change in Flood Extent

- Was Wet Now Dry
- Was Dry Now Wet

0 25 50 100 Metres

JACOBS

Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

GDA 1994 MGA Zone 56

TITLE
Option 4A+4B+4C
Change in Flood Level
5% AEP Event

PROJECT
North Brother Local Catchments Flood Study

PROJECT # IA157500

MAP # FIGURE 3-4

DATE 25/03/2020


This potential option has been identified for consideration by Port Macquarie Hastings Council for further detailed assessment. It is not currently endorsed for adoption in the FRMSP.
LAKE VIEW CRS
STALBANS WAY
PELICAN CT
THE GATEWAY
BABINDA AVE
CAPTAIN COOK BICENTENN
WATERVIEW CRS
OCEAN DR
HOSCHKE RD
KIRMINGTON TCE
KOONWARRA ST
Legend
Change in Flood Level (m)
< -0.5
-0.5 - -0.3
-0.3 - -0.1
-0.1 - -0.01
-0.01 - 0.01
0.01 - 0.1
0.1 - 0.3
0.3 - 0.5
> 0.5
Change in Flood Extent
Was Wet Now Dry
Was Dry Now Wet
0 25 50 100
Metres
JACOBS
Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.
GDA 1994 MGA Zone 56
TITLE
Option 4A+4B+4C
Change in Flood Level
1% AEP Event
PROJECT
North Brother Local Catchments Flood Study
PROJECT #
IA157500
MAP #
FIGURE 3-5
DATE
25/03/2020

3.4.3 Tunis Street Overland Flow Path, Laurieton

This overland flow path originates above Blackbutt Crescent and Peach Grove, where a natural gully overflows into a constructed diversion channel which skirts around properties on Blackbutt Crescent and conveys flows through an easement to Peach Grove at Tunis Street. There is an existing low capacity pipe (375mm diameter) draining the flows in the easement to the existing drainage system. Flows in excess of the overland flow path spill out onto properties on Peach Grove and contribute to flooding at the main complex at Laurieton retirement village, although flooding at this complex is exacerbated by partially-trapped drainage low points.

The main flow path splits around Gow Place and Norman Street/Tunis Street intersection, with the northern branch flowing through the Laurieton retirement village villas and exiting around Kew Road at Castle Street, and the southern branch draining to the sag point on Bold Street at Tunis Street, and then joining a separate flow path through commercial and residential properties on Bold Street to McLennan Street.

The main stormwater drainage line consists of up to 900mm diameter pipe in Tunis Street, draining to the river.

Peak overland flows in these flow paths are summarised in Table 3-2.

Table 3-2 Peak flood flows at Tunis Street overland flow path

Location	Event AEP		
	0.2EY	5% AEP	1% AEP
Upstream of Peach Grove	5.2	9.4	14.1
Tunis Street at Peach Grove	3.5	6.2	9.2
Gow Street branch	1.8	3.2	5.0
Tunis Street and natural gully at Lord Street	2.1	4.1	7.1

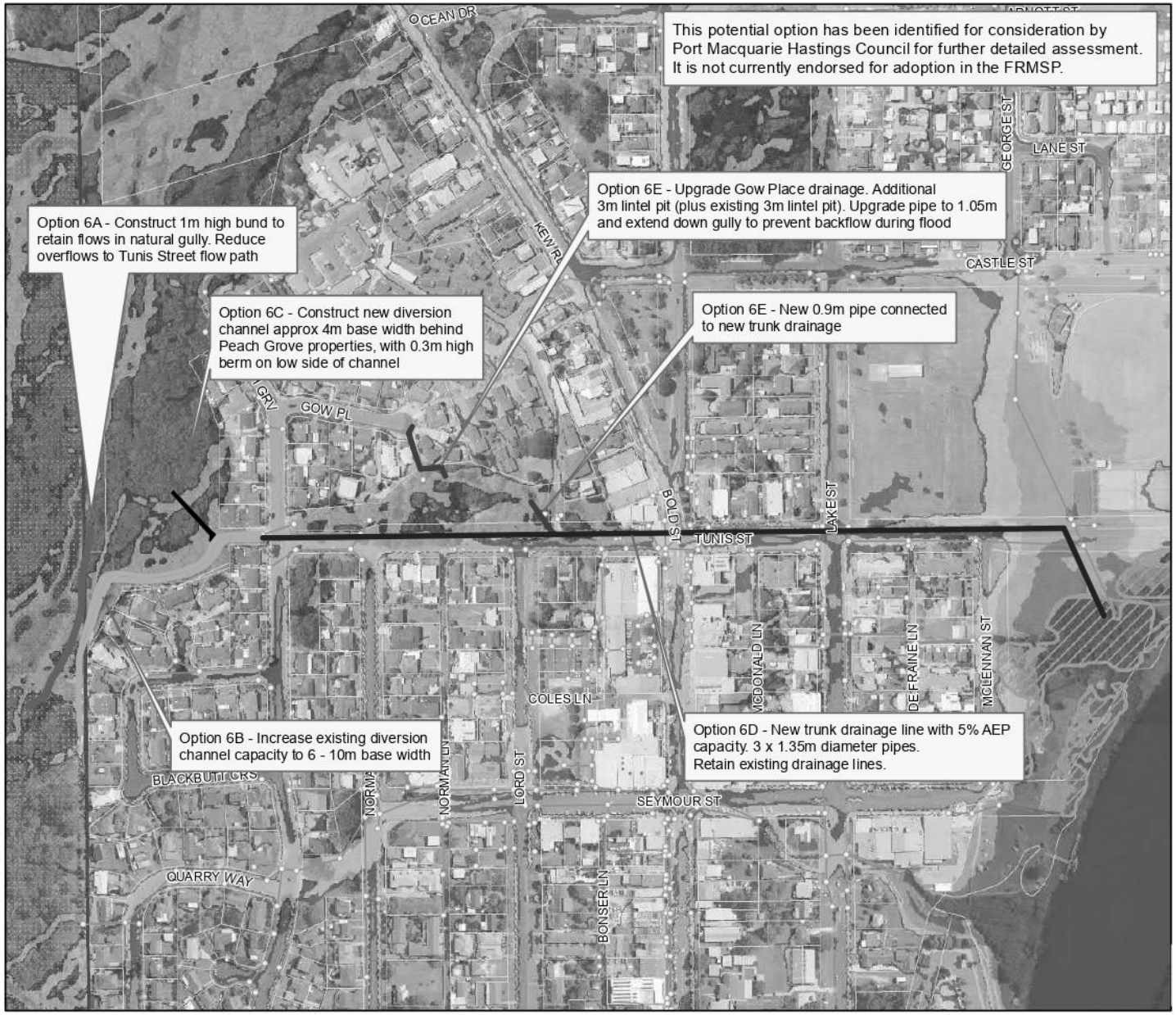
3.4.3.1 Option 6A

Description of Options

Option 6A was assessed individually:

- Option 6A – construct/raise a 160m long berm, up to 1m high above existing ground levels, between the natural flow path and the diversion channel above Blackbutt Crescent to reduce overflows into the diversion channel and hence reduce flows through the properties downstream. However, this option is expected to increase the flows being directed toward St Josephs School.

Refer to Figure 3-6 for illustration of Option 6A. The figure also describes Options 6B to 6E, refer to Section 3.4.3.2 for details.



Legend

- Stormwater Pit/Node
- Pipes and Culverts
- National Park
- EECs and SEPP14

1% AEP Existing Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0

0 25 50 100 Metres

JACOBS

Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

GDA 1994 MGA Zone 56

TITLE
Option 6A to 6E
Tunis Street Flow Path, Laurieton
Assessed Options

PROJECT
North Brother Local Catchments Flood Study

PROJECT # IA157500

MAP # FIGURE 3-6

DATE 25/03/2020

Constraints assessment

- Option 6A would need to be constructed within the national park area, likely requiring removal of a large number of trees for the proposed bund in addition to site access for construction plants.
- The option would be constructed on a natural berm which appears to be formed from flood-flow deposits of rock rubble and other material. Geotechnical conditions may be challenging.
- Periodic maintenance of the proposed bund would be required.

Hydraulic performance

Flood impact maps, showing the change in flood levels, are presented in Figure 3-7 to Figure 3-9 for the 0.2EY, 5% and 1% AEP events, respectively. The hydraulic performance of Option 6A is summarised in Table 3-3.

Table 3-3 Hydraulic performance of Options 6A

Event AEP	Changes in flood conditions
0.2EY	• Reductions in flood levels of -0.05 to -0.1m on Gow Place properties and Laurieton retirement village villas. • Localised reductions of up to -0.4m on Peach Grove properties. • Minor reductions of up to -0.05m on residential and commercial properties on and to the east of Ocean Drive. • Widespread minor increases of +0.02m on St Josephs School grounds.
5% AEP	• Reductions in flood levels of -0.05 to -0.2m on Gow Place properties and Laurieton retirement village villas, some localised areas greater than -0.02m. Reductions of -0.03m at Laurieton retirement village main facility. • Localised reductions of up to -0.4m on Peach Grove properties. One property experiences minor increases of less than +0.02m. • Minor reductions of up to -0.06m on residential and commercial properties on and to the east of Ocean Drive. • Widespread increases of +0.03 to +0.07m on St Josephs School grounds.
1% AEP	• Reductions in flood levels of -0.05 to -0.2m on Gow Place properties and Laurieton retirement village villas, some localised areas greater than -0.02m. Reductions of -0.1m at Laurieton retirement village main facility. • Localised reductions of up to -0.4m on Peach Grove properties. One property experiences minor increases of less than +0.02m. • Minor reductions of up to -0.06m on residential and commercial properties on and to the east of Ocean Drive. • Widespread increases of +0.03 to +0.07m on St Josephs School grounds.
1% AEP plus climate change	Similar performance to 1% AEP, in terms of reductions in flood levels in mitigated versus existing development case (with climate change). No reduction in performance due to sea level rise.

Summary

While there are minor to modest (up to -0.2m) reductions in flood levels on a large number of residential properties, these are offset by minor increases (+0.03 to +0.07m) on St Josephs School. An engineered berm in the national park is likely to result in vegetation impacts and hence requires consultation with NPWS.

Legend

Change in Flood Level (m)

- < -0.5
- -0.5 - -0.3
- -0.3 - -0.1
- -0.1 - -0.01
- -0.01 - 0.01
- 0.01 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- > 0.5

Change in Flood Extent

- Was Wet Now Dry
- Was Dry Now Wet

0 25 50 100 Metres

JACOBS

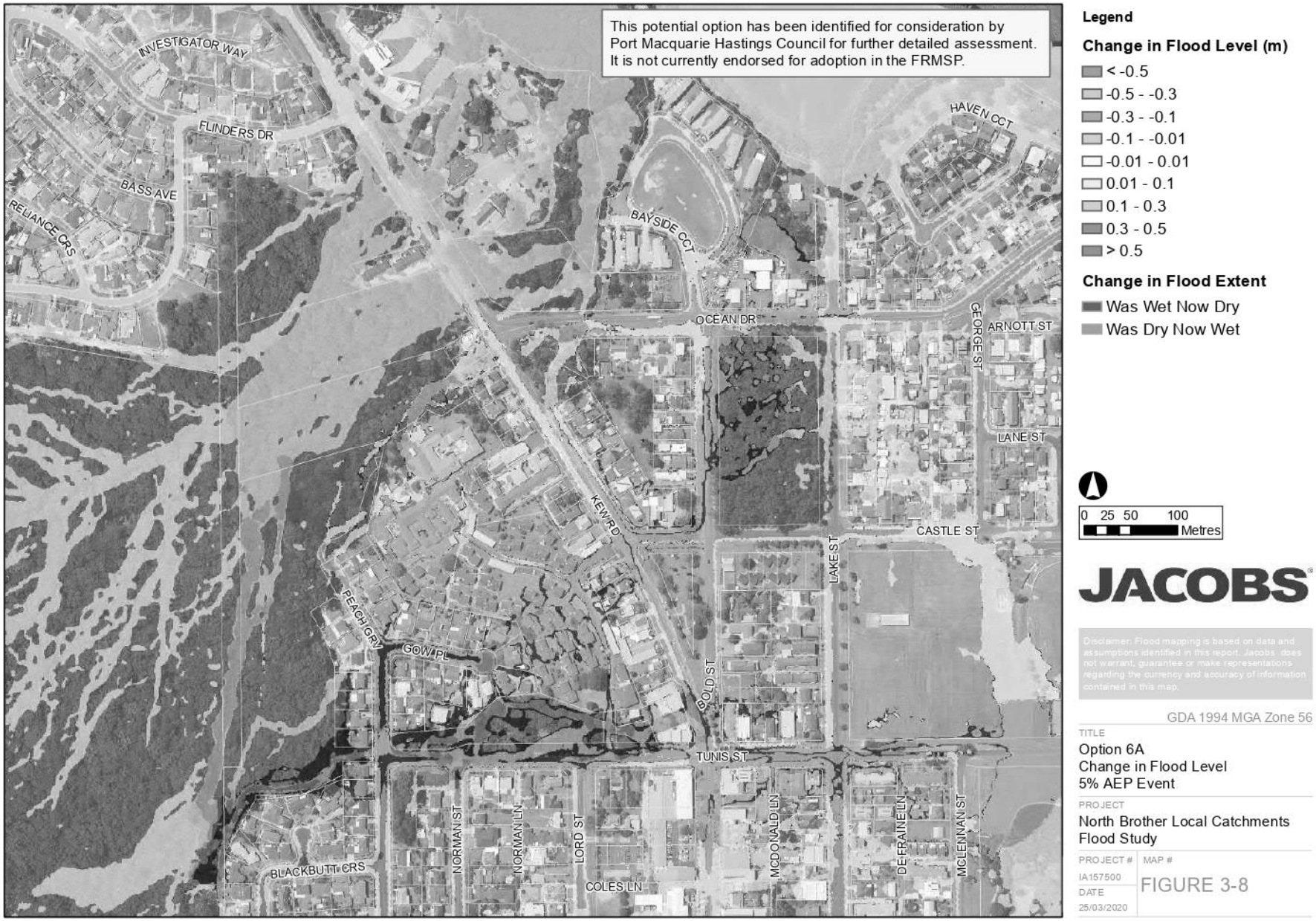
Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

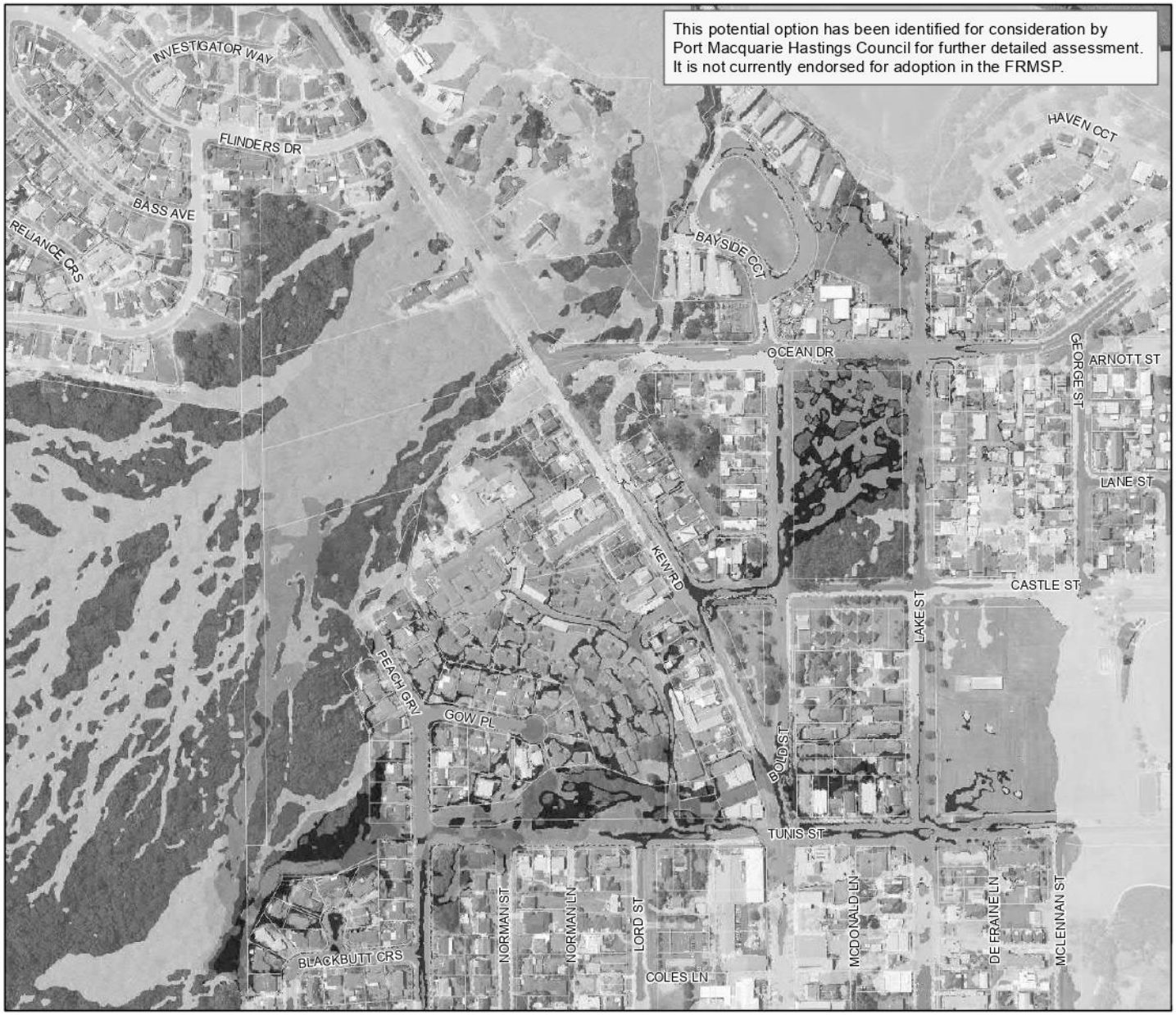
GDA 1994 MGA Zone 56

TITLE
Option 6A
Change in Flood Level
0.2EY Event

PROJECT
North Brother Local Catchments Flood Study

PROJECT #	MAP #
IA157500	FIGURE 3-7
DATE	
25/03/2020	


This potential option has been identified for consideration by Port Macquarie Hastings Council for further detailed assessment. It is not currently endorsed for adoption in the FRMSP.
INVESTIGATOR WAY
FLINDERS DR
BASS AVE
RELIANCE CRS
BAYSIDE CCT
HAVEN CCT
OCEAN DR
GEORGE ST
ARNOTT ST
LANE ST
KEW RD
CASTLE ST
LAKE ST
PEACH GRV
GOWRIE PL
GOLD ST
TUNIS ST
BLACKBUTT CRS
NORMAN ST
NORMAN LN
LORD ST
COLES LN
MCDONALD LN
DE FRAINE LN
MCLENNAN ST
Legend
Change in Flood Level (m)
< -0.5
-0.5 - -0.3
-0.3 - -0.1
-0.1 - -0.01
-0.01 - 0.01
0.01 - 0.1
0.1 - 0.3
0.3 - 0.5
> 0.5
Change in Flood Extent
Was Wet Now Dry
Was Dry Now Wet
0 25 50 100
Metres
JACOBS
Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.
GDA 1994 MGA Zone 56
TITLE
Option 6A
Change in Flood Level
5% AEP Event
PROJECT
North Brother Local Catchments Flood Study
PROJECT # IA157500
MAP # FIGURE 3-8
DATE 25/03/2020



Legend

Change in Flood Level (m)

- < -0.5
- -0.5 - -0.3
- -0.3 - -0.1
- -0.1 - -0.01
- -0.01 - 0.01
- 0.01 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- > 0.5

Change in Flood Extent

- Was Wet Now Dry
- Was Dry Now Wet

0 25 50 100 Metres

JACOBS

GDA 1994 MGA Zone 56

TITLE
Option 6A
Change in Flood Level
1% AEP Event

PROJECT
North Brother Local Catchments Flood Study

PROJECT #	MAP #
IA157500	FIGURE 3-9
DATE	
25/03/2020	

3.4.3.2 Option 6B+6C+6D+6E

Description of Options

The following options were assessed in combination (Options 6B+6C+6D+6E):

- Option 6B – increase the existing diversion channel capacity behind Blackbutt Crescent properties to reduce overflows onto properties, achieved by a combination of widening the existing channel to a base width of 6 – 10m (current base width 3 – 5m, top width 5 – 8m), raising the banks (e.g. block retaining wall along the property boundaries) and clearing of vegetation in the channel.
- Option 6C – construct new diversion channel 3m base width and 1m deep behind Peach Grove properties north of Tunis Street to direct flows south to the easement at the end of Tunis Street. This is outside of the national park. Form a bund on the lower side of the channel to increase capacity.
- Option 6D – install new trunk drainage line from the easement down Tunis Street to discharge to the river (approximately 740m). A new line consisting of 3 x 1.35m diameter pipes has been assessed, having a system capacity of approximately 5% AEP (about 9.5m^3/s) and would reduce the 1% AEP overland flows through downstream properties by about 67%. A rock debris trap/basin would need to be constructed at the trunk drainage inlet to reduce the inlet blockage risk.
- Option 6E – upgrade drainage in Gow Place cul-de-sac to reduce overflows through properties and the retirement village villas. The existing drainage consists of a 450mm pipe which drains through an easement and discharges to open space between Gow Place and Tunis Street. There is an existing 3m lintel pit inlet plus smaller approximately 1m lintel inlets. Replacing one of these smaller inlets with a second 3m lintel is proposed. The existing 450mm pipe is proposed to be upgraded to 1.05m pipe and extended to discharge further down the gully to prevent backflow into the cul-de-sac. A 900mm pipe connection from the gully to the new trunk drainage line is proposed.

Constraints assessment

- Option 6B - Works would need to be undertaken on the edge of the national park land for a 100m section of the upgraded channel. The channel is assumed to be grassed and would need to be maintained to ensure limited vegetation growth.
- Option 6C - The channel is assumed to be grassed and would need to be maintained to ensure limited vegetation growth.
- Option 6D – There are numerous existing underground utilities (Telstra, Optus, NBN, power, stormwater) under Tunis Street and adjoining streets. Approximately 10 crossings of the utilities are identified and would need to be protected. It is assumed that the existing utilities are at sufficiently shallow depth to enable the new trunk drainage to be laid beneath. Trench construction methods are expected to be appropriate for most sections of the alignment. Deep trenching (up to 3m) with temporary shoring is likely to be required for sections of the alignment. Pipe jacking installation is expected to be required in the section between Lord Street and Lake Street (about 200m) to allow the road access to remain open (e.g. Coles loading dock). Design and construction will need to minimise traffic impacts including delivery truck access to Coles Supermarket loading dock. A rock debris trap/basin would need to be constructed at the trunk drainage inlet to reduce the inlet blockage risk.
- A structural assessment was undertaken for Option 6D due to the space constraints related to this option. Relevant findings are summarised below

The existing buildings are single storey and are likely to have shallow foundations. The construction zone of construction access & excavation for the proposed 3x 1.35m diameter pipes would need to extend approx. 3m to 5m from the edge of the new pipes to limit effect to the existing buildings. For open cut sections this construction zone would take up most of the two lanes of Tunis Street and footpaths i.e. 11m to 15m wide. Appropriate traffic diversions would be required.

Vibration due to construction activities can be a concern and a detailed structural inspection of the existing buildings should be conducted to assess if some areas of the existing buildings are more susceptible to such vibration. The construction techniques can then be chosen to limit effects in these vibration sensitive zones.

The soils in this location are likely to be high acid-sulphate. Trial pitting and geotechnical investigation and interpretation should be carried out by to confirm risks and mitigation measures.

Overall, it is considered feasible to construct 3x 1.35m diameter stormwater flood control pipes underground along Tunis Street. The width and depth of excavation for the pipes would be considerable taking up most of Tunis Street and footpaths. Numerous controls would need to be put in place for environmental considerations and for the structural integrity of existing buildings during construction. Consideration could be given to the option for 2x larger pipes to limit the width of excavation and zone of construction activities. The other alternative would be for rectangular box culverts where open cut & cover excavation might be considered – this may offer some advantages in terms of width of excavation but would require a substantial structural cover slab to withstand the vehicular loadings.

Hydraulic performance

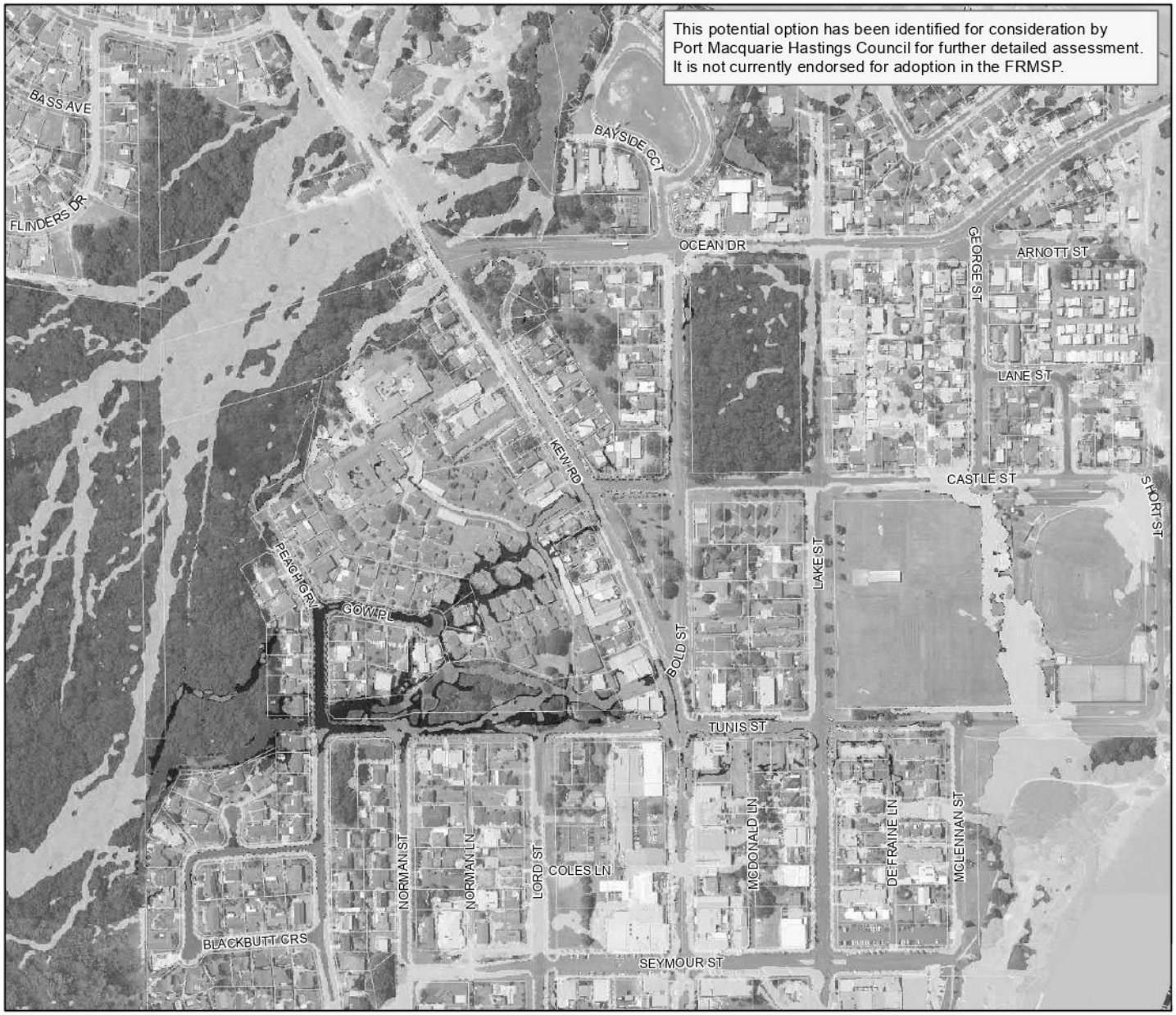
Flood impact maps, showing the change in flood levels, are presented on Figure 3-10 to Figure 3-12 for the 0.2EY, 5% and 1% AEP events, respectively. The hydraulic performance of Option 6B+6C+6D+6E is summarised in Table 3-4.

Table 3-4 Hydraulic performance of Options 6B+6C+6D+6E

Event AEP	Changes in flood conditions
0.2EY	• Reductions in flood levels of up to -0.3m on Gow Place properties and Laurieton retirement village villas, including substantial reductions in flood extent. • Reductions in flood levels of up to -0.4m on Peach Grove properties including reductions in flood extent. • Minor reductions of up to -0.05m on residential and commercial properties on and to the east of Kew Road/Bold Street.
5% AEP	• Reductions in flood levels of up to -0.3m on Gow Place properties and Laurieton retirement village villas, including substantial reductions in flood extent. • Reductions in flood levels of up to -0.5m on Peach Grove properties including reductions in flood extent. • Reductions of -0.05 to -0.1m on residential and commercial properties on and to the east of Ocean Drive, with some localised reductions of -0.2m. • Removal of areas of very high hazard (up to H5) in road and on properties between Peach Grove and to the east of Kew Road/Bold Street.
1% AEP	• Reductions in flood levels of up to -0.4m on Gow Place properties and Laurieton retirement village villas, including some reductions in flood extent. • Reductions in flood levels of up to -0.5m on Peach Grove and Blackbutt Crescent properties including reductions in flood extent. Some localised reductions of up to -0.7m. • Reductions of -0.1 to -0.2m on residential and commercial properties on and to the east of Ocean Drive. • Removal of areas of very high hazard (up to H5) in road and on properties between Blackbutt Crescent/Peach Grove and to the east of Kew Road/Bold Street.
1% AEP plus climate change	Generally similar performance to 1% AEP, in terms of reductions in flood levels in mitigated versus existing development case (with climate change). Slight reduction in performance due to sea level rise in low elevation areas below 3m AHD, where the reductions fall from -0.07m in the current climate case to -0.01m in the climate change scenario.

Summary on performance

The combined options 6B+6C+6D+6E provide substantial reductions in flood levels, extents and hazard as a result of significant drainage capacity upgrades. There are minor reductions in flood levels in low-lying areas as a result of sea level rise in the climate change scenario.



Legend

Change in Flood Level (m)

- < -0.5
- -0.5 - -0.3
- -0.3 - -0.1
- -0.1 - -0.01
- -0.01 - 0.01
- 0.01 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- > 0.5

Change in Flood Extent

- Was Wet Now Dry
- Was Dry Now Wet

0 25 50 100 Metres

JACOBS

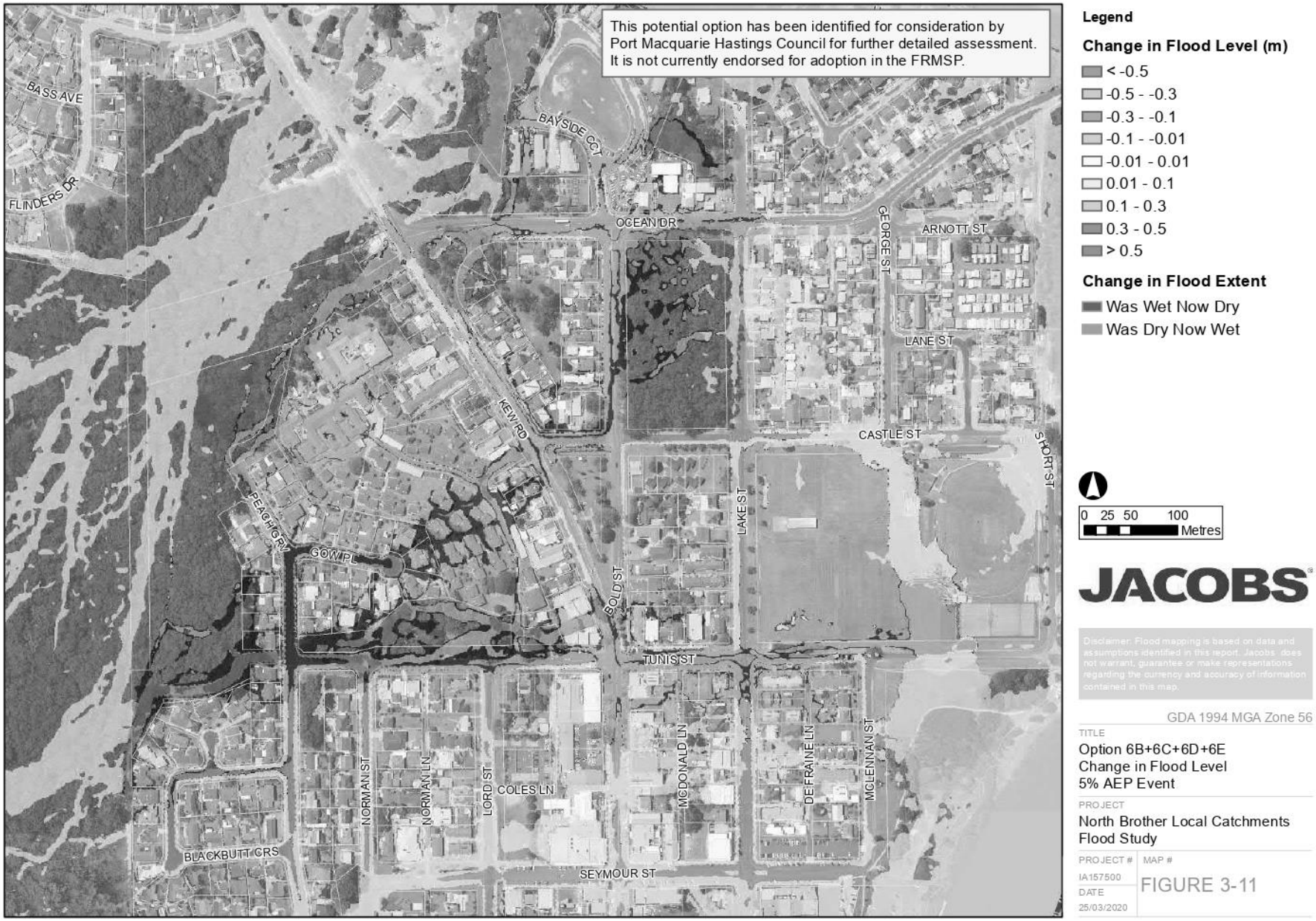
Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

GDA 1994 MGA Zone 56

TITLE
Option 6B+6C+6D+6E
Change in Flood Level
0.2EY Event

PROJECT
North Brother Local Catchments Flood Study

PROJECT #	MAP #
IA157500	FIGURE 3-10
DATE	
25/03/2020	


This potential option has been identified for consideration by Port Macquarie Hastings Council for further detailed assessment. It is not currently endorsed for adoption in the FRMSP.
BASS AVE
FLINDERS DR
BAYSIDE CCT
OCEAN DR
GEORGE ST
ARNOTT ST
LANE ST
CASTLE ST
SHORT ST
KEW RD
PEAGHORN
GOWPL
BOLD ST
LAKE ST
TUNIS ST
NORMAN ST
NORMAN LN
LORD ST
COLES LN
MCDONALD LN
DE FRAINE LN
MCLENNAN ST
BLACKBUTT CRS
SEYMOUR ST
Legend
Change in Flood Level (m)
< -0.5
-0.5 - -0.3
-0.3 - -0.1
-0.1 - -0.01
-0.01 - 0.01
0.01 - 0.1
0.1 - 0.3
0.3 - 0.5
> 0.5
Change in Flood Extent
Was Wet Now Dry
Was Dry Now Wet
0 25 50 100
Metres
JACOBS
Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.
GDA 1994 MGA Zone 56
TITLE
Option 6B+6C+6D+6E
Change in Flood Level
5% AEP Event
PROJECT
North Brother Local Catchments Flood Study
PROJECT #
IA157500
MAP #
FIGURE 3-11
DATE
25/03/2020

Legend

Change in Flood Level (m)

- < -0.5
- -0.5 - -0.3
- -0.3 - -0.1
- -0.1 - -0.01
- -0.01 - 0.01
- 0.01 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- > 0.5

Change in Flood Extent

- Was Wet Now Dry
- Was Dry Now Wet

0 25 50 100 Metres

JACOBS

Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

GDA 1994 MGA Zone 56

TITLE
Option 6B+6C+6D+6E
Change in Flood Level
1% AEP Event

PROJECT
North Brother Local Catchments Flood Study

PROJECT #	MAP #
IA157500	FIGURE 3-12
DATE	
25/03/2020	

3.4.4 Lake Street at Seymour Street, Laurieton

The corner property at this location receives overland flows and trunk drainage flows from the Quarry Way flow path. There is an open channel and flow path through this property, where the dwelling is surrounded by high hazard flooding to depths of over 1m in the 1% AEP event. The floodwaters pond behind the raised road crest in Lake Street before overflowing over the road and around the southern side of the Laurieton United Services Club. It is identified as being affected by above-floor flooding.

The drainage at this location includes 2x 1.5m x 0.75m box culverts at the inlet at the downstream end of the channel through this property, turning into 2x 1200mm pipes crossing Lake Street, which then increase to 2x 1500mm pipes on the low side of the road and discharging to a channel on the southern side of the Services Club.

Flood mitigation works proposed for the Quarry Way flow path as described in Section **Error! Reference source not found.** would mitigate flooding at this location. Further works could be provided for additional mitigation.

3.4.4.1 Option 8B

Description of Options

Option 8B was selected for assessment. The culvert inlet is currently unscreened and has been modelled as 50% blocked due to likely debris blockage. A large-faced debris screen or other debris controls are proposed to retrofit the existing culvert inlet to reduce the risk of blockage. The debris screen is assumed to be effective and has been represented with a reduced blockage factor of 10%.

Refer to **Error! Reference source not found.** for illustration.

Constraints assessment

No major constraints identified for this option. Inspection and maintenance after significant storm events are required to increase reliability.

Hydraulic performance

Flood impact maps, showing the change in flood levels, are presented on Figure 3-14 to Figure 3-16 for the 0.2EY, 5% and 1% AEP events, respectively. The hydraulic performance of Option 8B is summarised in Table 3-5.

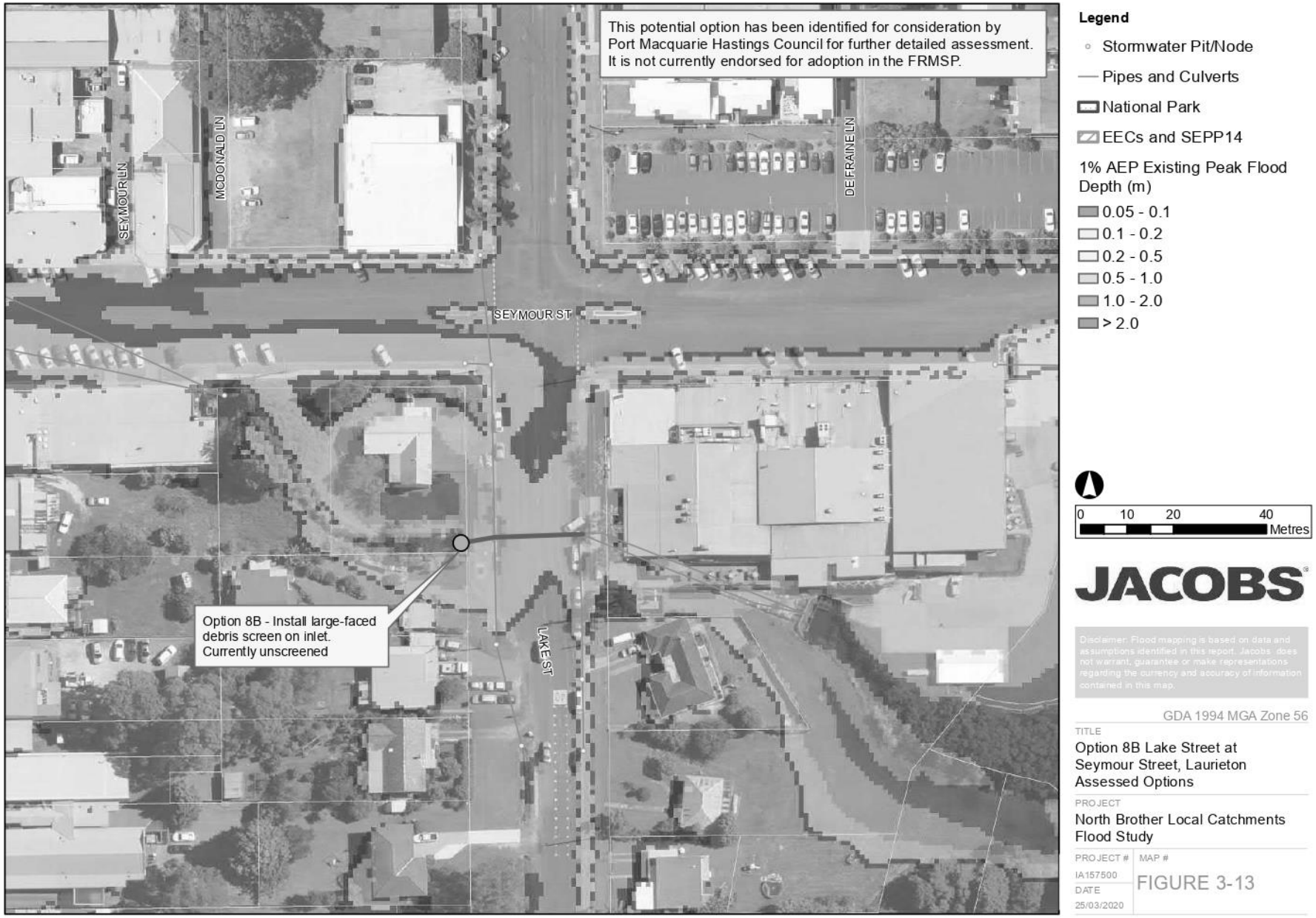
Table 3-5 Hydraulic performance of Options 8B

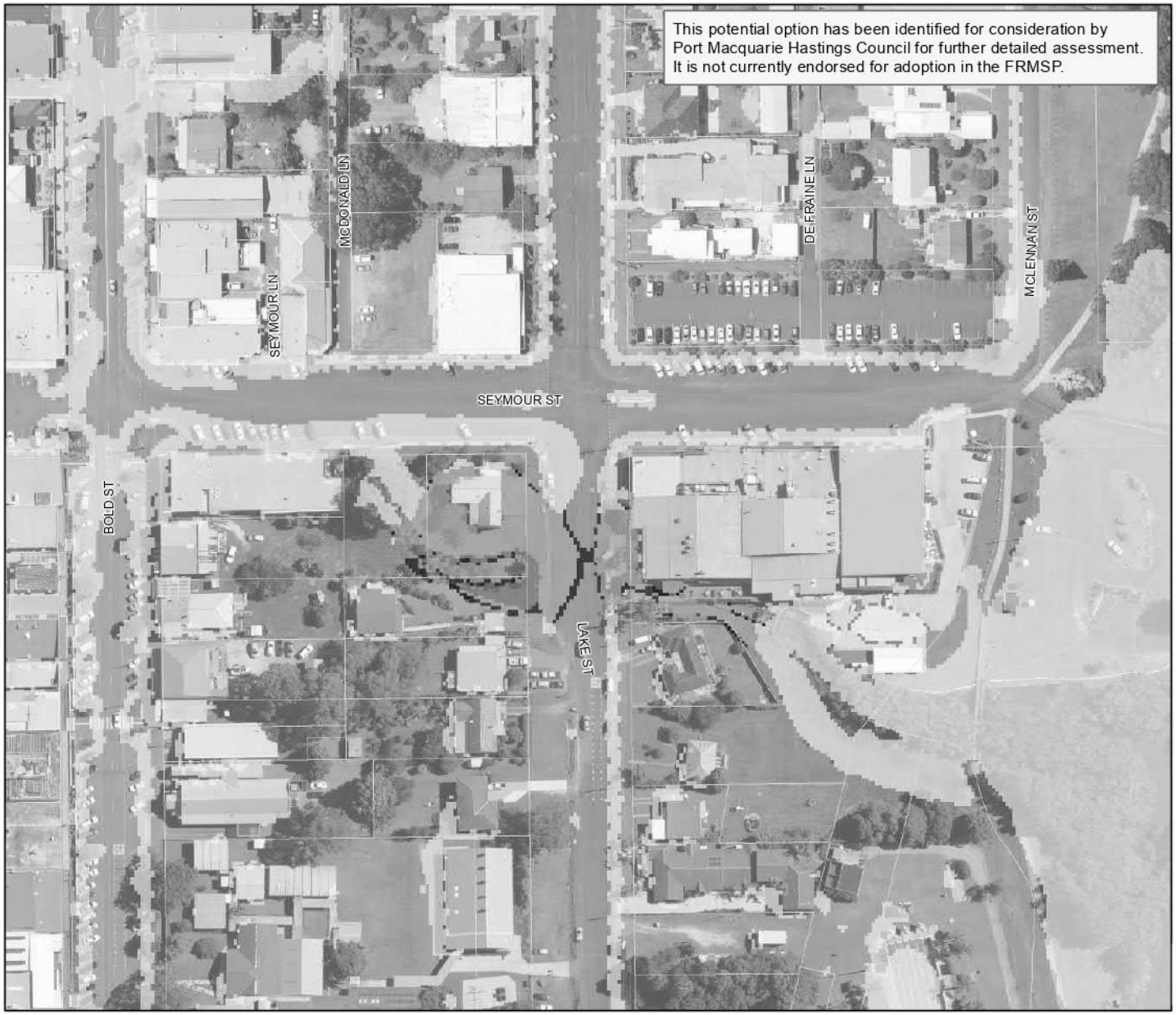
Event AEP	Changes in flood conditions
0.2EY	• Minor reductions of -0.03m on private property dwelling and Laurieton United Services Club side entrance. • Reductions of up to -0.1m on Lake Street
5% AEP	• Reductions of -0.08m on private property dwelling and -0.13m at Laurieton United Services Club side entrance. • Reductions of up to -0.1m on Lake Street • Minor increases of less than -0.02m on some private properties and parts of club property due to reduced drainage capacity of local stormwater drainage branches.
1% AEP	• Reductions of -0.1m on private property dwelling and Laurieton United Services Club side entrance. • Reductions of up to -0.1m on Lake Street. • Minor localised increases of less than -0.02m on some private properties due to reduced drainage capacity of local stormwater drainage branches.
1% AEP plus climate change	Similar performance to 1% AEP, in terms of reductions in flood levels in mitigated versus existing development case (with climate change). No reduction in performance due to sea level rise.

Summary on performance

Option 8B provides minor to modest improvements (up to -0.1m) in flooding conditions with benefits confined to one residential property. The spatial extent of the reductions in flood levels at the Services Club are limited to the western side entrance on Lake Street, while there are no changes in flood levels along the main northern side of the club building. The effect of the proposed inlet debris screen is constrained by the limited capacity of the existing culverts crossing the road.

While the debris screen proposed as Option 8B provides at best modest improvements to flooding conditions to property and the road, it could be considered by Council as a low-cost measure to reduce the risk of severe blockage of the culvert inlet at this and other locations in the study area.


This potential option has been identified for consideration by Port Macquarie Hastings Council for further detailed assessment. It is not currently endorsed for adoption in the FRMSP.
SEYMOUR LN
MCDONALD LN
SEYMOUR ST
DE FRAINE LN
LAKE ST
Option 8B - Install large-faced debris screen on inlet. Currently unscreened
Legend
Stormwater Pit/Node
Pipes and Culverts
National Park
EECs and SEPP14
1% AEP Existing Peak Flood Depth (m)
0.05 - 0.1
0.1 - 0.2
0.2 - 0.5
0.5 - 1.0
1.0 - 2.0
> 2.0
0 10 20 40
Metres
JACOBS
Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.
GDA 1994 MGA Zone 56
TITLE
Option 8B Lake Street at Seymour Street, Laurieton Assessed Options
PROJECT
North Brother Local Catchments Flood Study
PROJECT # IA157500
MAP # FIGURE 3-13
DATE 25/03/2020



Legend

Change in Flood Level (m)

- < -0.5
- -0.5 - -0.3
- -0.3 - -0.1
- -0.1 - -0.01
- -0.01 - 0.01
- 0.01 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- > 0.5

Change in Flood Extent

- Was Wet Now Dry
- Was Dry Now Wet

0 10 20 40 Metres

JACOBS

Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

GDA 1994 MGA Zone 56

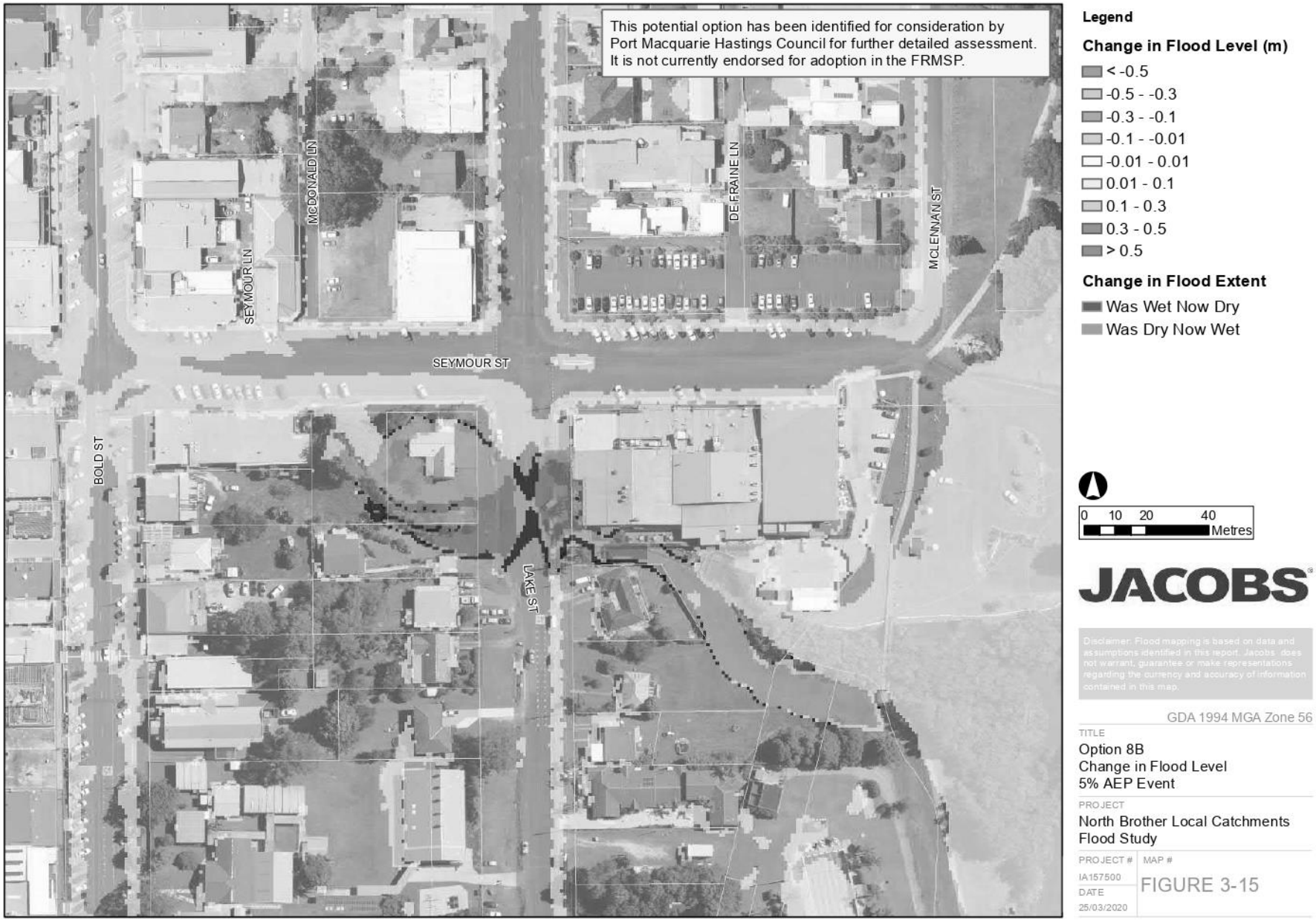
TITLE
Option 8B
Change in Flood Level
0.2EY Event

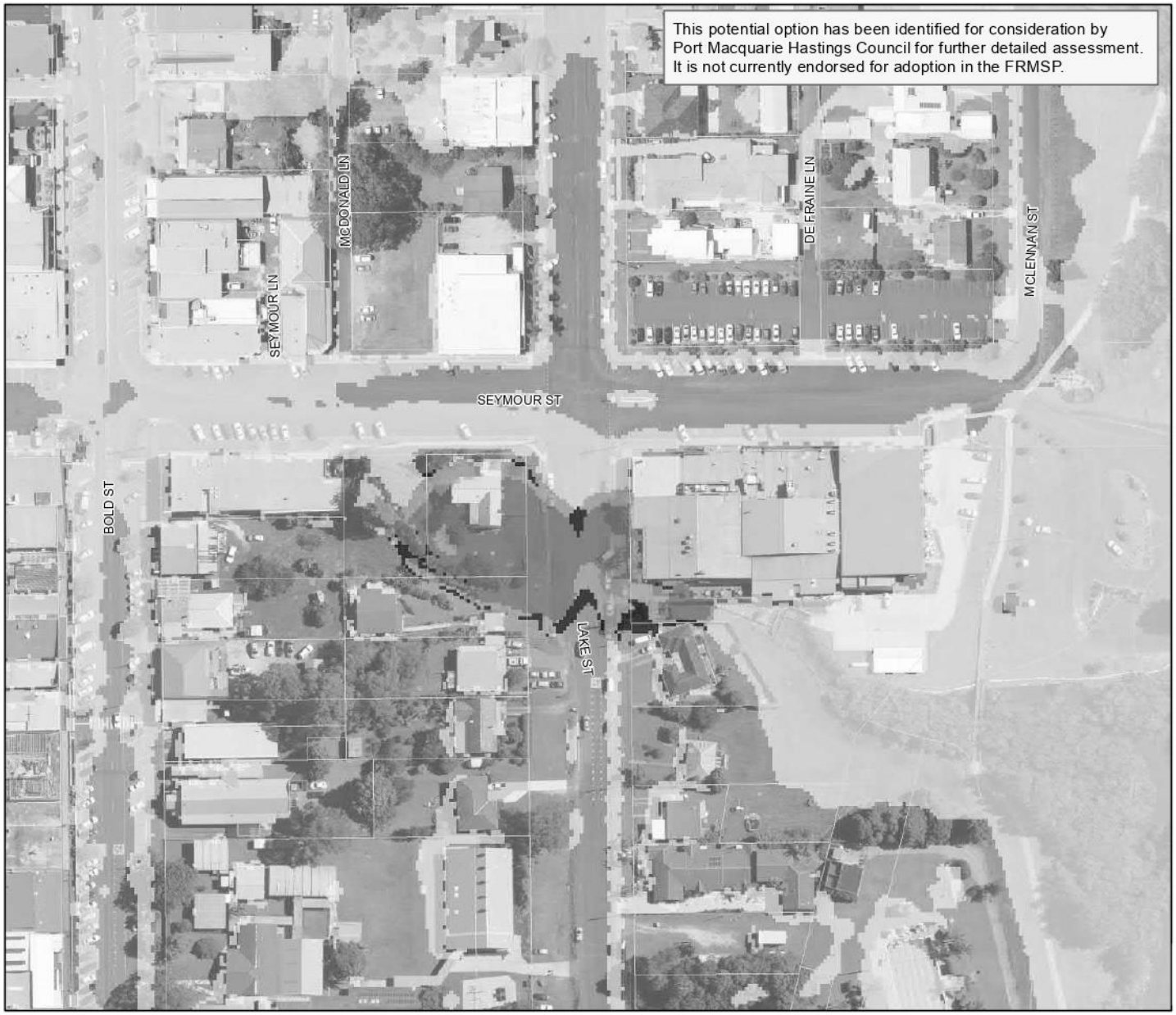
PROJECT
North Brother Local Catchments Flood Study

PROJECT # IA157500

MAP # FIGURE 3-14

DATE 25/03/2020


This potential option has been identified for consideration by Port Macquarie Hastings Council for further detailed assessment. It is not currently endorsed for adoption in the FRMSP.
SEYMOUR ST
BOLD ST
LAKE ST
SEYMOUR LN
MCDONALD LN
DE FRAINE LN
MCLENNAN ST
Legend
Change in Flood Level (m)
< -0.5
-0.5 - -0.3
-0.3 - -0.1
-0.1 - -0.01
-0.01 - 0.01
0.01 - 0.1
0.1 - 0.3
0.3 - 0.5
> 0.5
Change in Flood Extent
Was Wet Now Dry
Was Dry Now Wet
0 10 20 40
Metres
JACOBS
Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.
GDA 1994 MGA Zone 56
TITLE
Option 8B
Change in Flood Level
5% AEP Event
PROJECT
North Brother Local Catchments Flood Study
PROJECT #
IA157500
MAP #
FIGURE 3-15
DATE
25/03/2020


This potential option has been identified for consideration by Port Macquarie Hastings Council for further detailed assessment. It is not currently endorsed for adoption in the FRMSP.
SEYMOUR ST
BOLD ST
SEYMOUR LN
MCDONALD LN
DE FRAINE LN
MCLENNAN ST
LAKE ST
Legend
Change in Flood Level (m)
< -0.5
-0.5 - -0.3
-0.3 - -0.1
-0.1 - -0.01
-0.01 - 0.01
0.01 - 0.1
0.1 - 0.3
0.3 - 0.5
> 0.5
Change in Flood Extent
Was Wet Now Dry
Was Dry Now Wet
0 10 20 40
Metres
JACOBS
Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.
GDA 1994 MGA Zone 56
TITLE
Option 8B
Change in Flood Level
1% AEP Event
PROJECT
North Brother Local Catchments Flood Study
PROJECT #
IA157500
MAP #
FIGURE 3-16
DATE
25/03/2020

3.4.5 St Joseph's School, Laurieton

Flooding at the school results from natural flow paths being directed down to Ocean Drive to three culvert crossings. The culverts discharge on the low side of the road and along with road overflows, overland flooding passes through the school in three main flow paths, including one through the main cluster of school administration and classroom buildings. Council's stormwater drainage spatial layer does not show an existing underground trunk drainage conveying flows though the school grounds, although from review of aerial photography there appears to be drainage pits connected to a privately-owned system. Flows exceed 0.5m deep in the 1% AEP event with areas of very high (H5) flood hazard.

Peak overland flows in these flow paths are summarised in Table 3-6.

Table 3-6 Peak flood flows in overland flow paths at St Joseph's School

Location	Event AEP		
	0.2EY	5% AEP	1% AEP
Northern flow path (admin bldg.)	4	5.5	8
Middle flow path	5.5	6.5	8.5
Southern flow path	8.5	10	12.5
Total	17.5	22	29

Refer to Figure 3-17 for illustration of options.

Legend

- Stormwater Pit/Node
- Pipes and Culverts
- National Park
- EECs and SEPP14

1% AEP Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0

0 25 50 100 Metres

JACOBS

Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

GDA 1994 MGA Zone 56

TITLE
Options 9A and 9B
St Joseph's School, Laurieton
Assessed Options

PROJECT
North Brother Local Catchments Flood Study

PROJECT #	MAP #
IA157500	FIGURE 3-17
DATE	
15/04/2020	

3.4.5.1 Option 9A

Description of Option

Option 9A was assessed, involving widening and reconstruction of a landscaped open channel in the southern flow path. The southern flow path and road cross culvert is the main flow path and there is a formalised open channel provided for this flow path. The proposed channel would have an 8m base width (about 10m top width) and a depth of 1 – 1.5m. The existing channel has an approximately 6 – 8m top width with variable base width.

Box culverts were originally proposed for this site to fit under the existing channel, however, elevations are too low to fit such a culvert option while maintaining a surface flow path.

A rock debris trap/basin would need to be constructed at the Ocean Drive culvert inlet to reduce the inlet blockage risk.

Constraints assessment

There are a number of existing structures and features including buildings, footbridges, car parks and paths which would be potentially affected or considered in the design of Option 9A. The minimum clearance between buildings or other existing structures is about 19m.

The existing buildings are single storey and are likely to have shallow foundations. Additionally, one of the building is an existing old church building believed to be around 120 years old. The construction access & excavation zone for the proposed channel widening would need to extend approximately 3 – 5m from the edge of the channel to limit effect to the existing buildings.

Vibration due to construction activities can be a concern and a detailed structural inspection of the existing buildings should be conducted to assess if some areas of the existing buildings are more susceptible to such vibration. The final alignment of the proposed culvert can then be chosen to avoid these vibration sensitive zones.

The sediments adjacent to the school may be mildly contaminated. The soils in this location are likely to be high acid-sulphate. Trial pitting and geotechnical investigation and interpretation should be undertaken to confirm risks and mitigation measures.

There will be numerous building stormwater drains discharging into the existing open channels in the school grounds and these will need to be surveyed and coordinated with the design of the modified open channel.

The existing channel and its banks appear to be landscaped with well-established gardens, which are likely to be of high value to the school and adjacent church. The option needs to include landscaping to re-establish the gardens.

There are existing utilities along Ocean Drive (Optus, Telstra, NBN, power) which cross the existing culverts under the road. It is assumed that sufficient clearance from the utilities can be maintained if the upgraded culverts are installed at a similar elevation.

The channel through the mangrove/wetland areas would need to be widened downstream to Stingray Creek to accommodate increased flood flows and this would have localised impacts on sensitive habitats (EECs/SEPP 14 wetlands). Additionally, the school grounds have dense tree coverage which will inhibit construction access. Existing trees will need to be protected during the construction works. It is anticipated that that a REF will be required and would need a flora and fauna study.

Hydraulic performance

Flood impact maps, showing the change in flood levels, are presented on Figure 3-18 to Figure 3-20 for the 0.2EY, 5% and 1% AEP events, respectively. The hydraulic performance of Option 9A is summarised in Table 3-7.


This potential option has been identified for consideration by Port Macquarie Hastings Council for further detailed assessment. It is not currently endorsed for adoption in the FRMSP.
OCEAN DR
HENRY KENDALL DR
FLINDERS DR
BAYSIDE CCT
Legend
Change in Flood Level (m)
< -0.5
-0.5 - -0.3
-0.3 - -0.1
-0.1 - -0.01
-0.01 - 0.01
0.01 - 0.1
0.1 - 0.3
0.3 - 0.5
> 0.5
Change in Flood Extent
Was Wet Now Dry
Was Dry Now Wet
0 10 20 40
Metres
JACOBS
Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.
GDA 1994 MGA Zone 56
TITLE
Option 9A
Change in Flood Level
0.2EY Event
PROJECT
North Brother Local Catchments Flood Study
PROJECT #
IA157500
MAP #
FIGURE 3-18
DATE
25/03/2020


This potential option has been identified for consideration by Port Macquarie Hastings Council for further detailed assessment. It is not currently endorsed for adoption in the FRMSP.
OCEAN DR
HENRY KENDALL DR
FLINDERS DR
BAYSIDE CCT
Legend
Change in Flood Level (m)
< -0.5
-0.5 - -0.3
-0.3 - -0.1
-0.1 - -0.01
-0.01 - 0.01
0.01 - 0.1
0.1 - 0.3
0.3 - 0.5
> 0.5
Change in Flood Extent
Was Wet Now Dry
Was Dry Now Wet
0 10 20 40
Metres
JACOBS
Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.
GDA 1994 MGA Zone 56
TITLE
Option 9A
Change in Flood Level
5% AEP Event
PROJECT
North Brother Local Catchments Flood Study
PROJECT #
IA157500
MAP #
FIGURE 3-19
DATE
25/03/2020

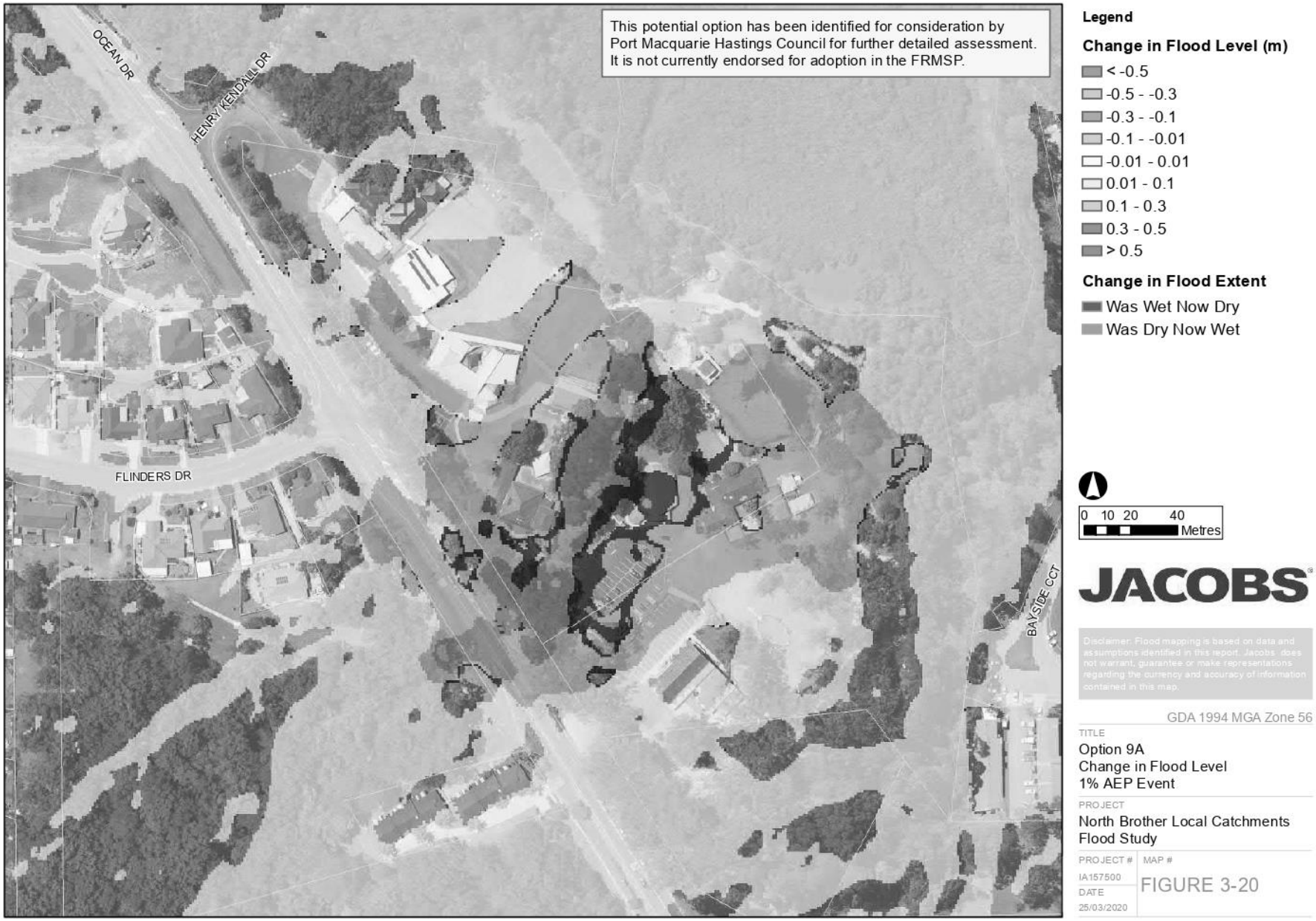

This potential option has been identified for consideration by Port Macquarie Hastings Council for further detailed assessment. It is not currently endorsed for adoption in the FRMSP.
OCEAN DR
HENRY KENDALL DR
FLINDERS DR
BAYSIDE CCT
Legend
Change in Flood Level (m)
< -0.5
-0.5 - -0.3
-0.3 - -0.1
-0.1 - -0.01
-0.01 - 0.01
0.01 - 0.1
0.1 - 0.3
0.3 - 0.5
> 0.5
Change in Flood Extent
Was Wet Now Dry
Was Dry Now Wet
0 10 20 40
Metres
JACOBS
Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.
GDA 1994 MGA Zone 56
TITLE
Option 9A
Change in Flood Level
1% AEP Event
PROJECT
North Brother Local Catchments Flood Study
PROJECT #
IA157500
MAP #
FIGURE 3-20
DATE
25/03/2020

Table 3-7 Hydraulic performance of Options 9A

Event AEP	Changes in flood conditions
0.2EY	• Maximum decreases of -0.4 to -0.5m in the channel (southern flow path) upstream and downstream of Ocean Drive culvert crossing, with reductions in flood extent • Decrease of -0.02 to -0.06m at and between school buildings, minimal reduction in flood extent • Some reduction in high-very high hazard extent in southern and middle flow paths including on walkways, minimal reduction in flood hazard around school office (only localised high hazard in existing case and mostly low hazard)
5% AEP	• Maximum decreases of -0.3 to -0.4m in the channel (southern flow path) upstream and downstream of Ocean Drive culvert crossing, with reductions in flood extent • Decrease of -0.02 to -0.08m at and between school buildings, minimal reduction in flood extent • Some reduction in high-very high hazard extent in southern and middle flow paths including on walkways, minimal reduction in flood hazard around school office (only localised high hazard in existing case and mostly low hazard)
1% AEP	• Maximum decreases of -0.3 to -0.4m in the channel (southern flow path) upstream and downstream of Ocean Drive culvert crossing, with reductions in flood extent • Decrease of -0.02 to -0.08m at and between school buildings, minimal reduction in flood extent • Some reduction in high-very high hazard extent in southern and middle flow paths including on walkways, minimal reduction in flood hazard around school office (only localised high hazard in existing case and mostly low hazard)
1% AEP plus climate change	Similar performance to 1% AEP, in terms of reductions in flood levels in mitigated versus existing development case (with climate change). No reduction in performance due to sea level rise.

3.4.5.2 Option 9B

Description of Option

An alternative option to 9A is option 9B, consisting of installation of box culverts beneath the middle flow path. There is an existing shallow overland flow path through this alignment and it was assumed that this could be retained. The culverts would need to fit between existing school buildings. A rock debris trap/basin would need to be constructed at the Ocean Drive culvert inlet to reduce the inlet blockage risk.

Constraints assessment

The culverts would need to fit between two existing buildings and require reconstruction of a vehicle access driveway to one of the buildings. There is 16m clearance between the buildings. The existing buildings are single storey and are likely to have shallow foundations. The construction access and excavation zone for the proposed culverts would need to extend approximately 3 – 5m from the edge of the proposed culverts to limit effect to the existing buildings.

Vibration due to construction activities can be a concern and a detailed structural inspection of the existing buildings should be conducted to assess if some areas of the existing buildings are more susceptible to such vibration. The final alignment of the proposed culvert can then be chosen to avoid these vibration sensitive zones. Overall, the excavation for the proposed 1.2m deep box culverts can be located at least 5m from the existing structures which should, subject to investigations, not interfere with the existing building foundations.

The sediments adjacent to the school may be mildly contaminated. The soils in this location are likely to be high acid-sulphate. Trial pitting and geotechnical investigation and interpretation should be carried out by to confirm risks and mitigation measures.

There will be numerous building stormwater drains discharging into the existing open channels in the school grounds and these will need to be surveyed and coordinated with the design of the modified open channel.

There appears to be an existing pit and pipe drainage line beneath the middle flow path, which may need to be relocated for installation of the box culverts. This line should be maintained for local drainage.

There are existing utilities along Ocean Drive (Optus, Telstra, NBN, power) which cross the existing culverts under the road. It is assumed that sufficient clearance from the utilities can be maintained if the upgraded culverts are installed at a similar elevation.

The channel through the mangrove/wetland areas would need to be widened downstream to Stingray Creek to accommodate increased flood flows and this would have localised impacts on sensitive habitats (EECs/SEPP 14 wetlands). Appropriate rock scour protection would be required at the culvert outlet. It is anticipated that that an REF will be required and would need a flora and fauna study.

Hydraulic performance

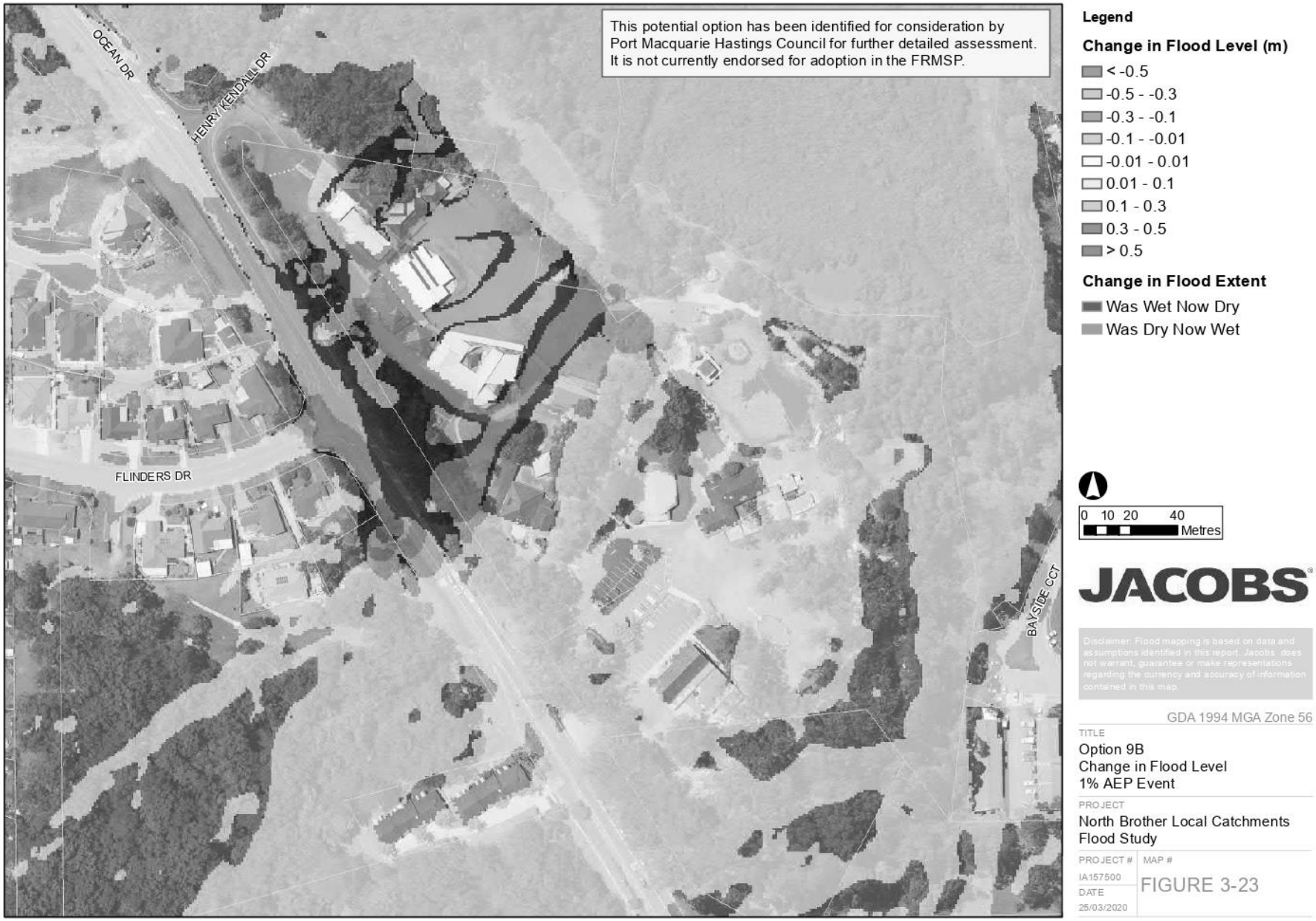
Flood impact maps, showing the change in flood levels, are presented on Figure 3-21 to Figure 3-23 for the 0.2EY, 5% and 1% AEP events, respectively. The hydraulic performance of Option 9B is summarised in Table 3-8.

Table 3-8 Hydraulic performance of Options 9B

Event AEP	Changes in flood conditions
0.2EY	• Maximum decreases of -0.2 to -0.3m in the middle flow path and adjacent buildings through the school, with substantial reductions in flood extent • Decrease of up -0.2m around school office and adjacent buildings, with substantial reduction in flood extents • Reductions in flood depths on Ocean Drive around Flinders Drive of up to -0.2m. reductions in flood levels/depths around Ocean Drive culvert crossing (middle flow path) of up to -0.3m with substantial reduction in flood extents • Reductions from high-very high hazard (up to H5) in the middle flow path in the existing case including on walkways, down to all low hazard (H1) in mitigation case • Reductions from localised high hazard (up to H4) around the school office in the existing case including on walkways, down to low hazard (H1, some localised H2) in mitigation case.
5% AEP	• Maximum decreases of -0.2 to -0.3m in the middle flow path and adjacent buildings through the school, with substantial reductions in flood extent • Decrease of up -0.2m around school office and adjacent buildings, with substantial reduction in flood extents • Reductions in flood depths of -0.1 to -0.2m. on Ocean Drive around Flinders Drive and reductions of up to -0.3m at culvert crossing • Reductions from high-very high hazard (up to H5) in the middle flow path in the existing case including on walkways, down to all low hazard (H1) in mitigation case • Reductions from localised high hazard (up to H4) around the school office in the existing case including on walkways, down to low hazard (H1, some localised H2) in mitigation case.
1% AEP	• Maximum decreases of -0.2 to -0.3m in the middle flow path and adjacent buildings through the school, with substantial reductions in flood extent • Decrease of up -0.2m around school office and adjacent buildings, with some reduction in flood extents • Reductions in flood depths on Ocean Drive around Flinders Drive of -0.1 to -0.2m. reductions in flood levels/depths around Ocean Drive culvert crossing (middle flow path) of up to -0.3m with substantial reduction in flood extents • Reductions from very high hazard (H5) in the middle flow path in the existing case including on walkways, down to mostly low hazard (H1-H2) in mitigation case • Reductions from high-very high hazard (H4-H5) around the school office in the existing case including on walkways, down to mostly low hazard (H1-H2, some localised H3-H4) in mitigation case.
1% AEP plus climate change	Similar performance to the 1% AEP event, in terms of reductions in flood levels in mitigated versus existing development case (with climate change). No reduction in performance due to sea level rise.


This potential option has been identified for consideration by Port Macquarie Hastings Council for further detailed assessment. It is not currently endorsed for adoption in the FRMSP.
OCEAN DR
HENRY KENDALL DR
FLINDERS DR
BAYSIDE CCT
Legend
Change in Flood Level (m)
< -0.5
-0.5 - -0.3
-0.3 - -0.1
-0.1 - -0.01
-0.01 - 0.01
0.01 - 0.1
0.1 - 0.3
0.3 - 0.5
> 0.5
Change in Flood Extent
Was Wet Now Dry
Was Dry Now Wet
0 10 20 40
Metres
JACOBS
Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.
GDA 1994 MGA Zone 56
TITLE
Option 9B
Change in Flood Level
0.2EY Event
PROJECT
North Brother Local Catchments Flood Study
PROJECT #
IA157500
MAP #
FIGURE 3-21
DATE
25/03/2020


This potential option has been identified for consideration by Port Macquarie Hastings Council for further detailed assessment. It is not currently endorsed for adoption in the FRMSP.
OCEAN DR
HENRY KENDALL DR
FLINDERS DR
BAYSIDE CCT
Legend
Change in Flood Level (m)
< -0.5
-0.5 - -0.3
-0.3 - -0.1
-0.1 - -0.01
-0.01 - 0.01
0.01 - 0.1
0.1 - 0.3
0.3 - 0.5
> 0.5
Change in Flood Extent
Was Wet Now Dry
Was Dry Now Wet
0 10 20 40
Metres
JACOBS
Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.
GDA 1994 MGA Zone 56
TITLE
Option 9B
Change in Flood Level
5% AEP Event
PROJECT
North Brother Local Catchments Flood Study
PROJECT #
IA157500
MAP #
FIGURE 3-22
DATE
25/03/2020


This potential option has been identified for consideration by Port Macquarie Hastings Council for further detailed assessment. It is not currently endorsed for adoption in the FRMSP.
OCEAN DR
HENRY KENDALL DR
FLINDERS DR
BAYSIDE CCT
Legend
Change in Flood Level (m)
< -0.5
-0.5 - -0.3
-0.3 - -0.1
-0.1 - -0.01
-0.01 - 0.01
0.01 - 0.1
0.1 - 0.3
0.3 - 0.5
> 0.5
Change in Flood Extent
Was Wet Now Dry
Was Dry Now Wet
0 10 20 40
Metres
JACOBS
Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.
GDA 1994 MGA Zone 56
TITLE
Option 9B
Change in Flood Level
1% AEP Event
PROJECT
North Brother Local Catchments Flood Study
PROJECT #
IA157500
MAP #
FIGURE 3-23
DATE
25/03/2020

3.5 Summary of Options

The assessed options are summarised in Table 3-9. A description, constraints/impacts, hydraulic performance, improvements to property flooding and estimated savings in flood damages are provided. The savings in flood damages are a comparison of the net present value of average annual flood damages between the mitigated and existing cases, based on a 0.5m protection level, over an assumed 50 year life of the option and assuming a 7% discount rate.

For the flood damage assessment, the PMF was assumed not be changed by the mitigation options given the magnitude of the flood event. The AAD is not sensitive to this assessment given the rarity of the PMF event.

The flood damages also only consider overland flooding and do not account for damages due to peak mainstream flooding.

Further detailed assessment will include cost estimation and benefit-cost assessment and multi-criteria assessment, incorporating refinements to the options where appropriate.

Table 3-9 Summary of assessed flood modification options performance

Option	Location	Description	Constraints and Impacts Plus other comments	Hydraulic Benefits (1% AEP event unless otherwise noted) *And Negative Impacts if Any*	Savings in Flood Damages (50 years life, 7% Discount Factor)	Cost of Works	Benefit Cost Ratio
4A+4B +4C	Koonwarra Street to Pelican Court, West Haven	• Voluntary acquisition of 53 Koonwarra Street. Regrade the site to form a flow path • New additional trunk drainage line 2x 1200mm diameter pipes, intercepting flows at downstream end of channel on Captain Cook Bicentennial Drive villas, cross Ocean Drive and run under The Gateway. Inlet debris trap basin required. • Voluntary acquisition of 7 Pelican Court. Regrade the site to form a flow path	• High property prices (~$500K each) plus demolition and disposal costs • Existing underground utilities in Ocean Drive and The Gateway (Telstra, Optus, NBN, power, stormwater). • Substantial number of trees in western verge of The Gateway, require removal if running new trunk drainage in the verge. • Limited space to widen existing channel running through Captain Cook Bicentennial Drive villas and then turning at Ocean Drive. Presence of existing driveway crossing over channel into Ocean Drive property. • Minimal space for rock debris trap at new trunk drainage inlet structure. Requires more detailed site assessment for potential rock debris loads.	• Koonwarra Street – flood levels reduced by -0.04m to -0.4m at four properties • *Minor localised increase of +0.02m on Captain Cook Bicentennial Drive villas* • Pelican Court – flood levels reduced by -0.2 to -0.7m in roadway and alleyway. Reductions on properties typically to -0.1m, up to -0.4m on two properties. • Eliminated occurrence of H4-H5 flood hazard at two dwellings in Koonwarra Street (one through acquisition of property). • Reduced flood hazard on Ocean Drive from up to H5 to H2. Note that road may be cut-off in other locations. • Reduced extent of H3-H5 hazard in Pelican Court. • 0.2EY event: Reduced flood hazard from H5 to H1-H2 in Pelican Court, some H3 in alleyway • Number of above-floor flooded properties reduced by 6 in the 1% AEP event. Options 4B and 4C reduce flood levels and hazard on Ocean Drive and Pelican Court including up to 20 dwellings. Option 4A reduces the number of properties at risk due to the property purchase. However, the reductions in flood levels on adjacent properties is generally minor. The substantial reductions are limited to one property. The likely high cost of this option may make this option more challenging to justify purely from an economic standpoint. Notwithstanding, the removal of a household subject to high flood hazard should be considered in the subsequent multi-criteria evaluation of this option	$3,876,000	TBC	TBC

Option	Location	Description	Constraints and Impacts Plus other comments	Hydraulic Benefits (1% AEP event unless otherwise noted) *And Negative Impacts if Any*	Savings in Flood Damages (50 years life, 7% Discount Factor, with 0.5m protection level)	Cost of Works	Benefit Cost Ratio
6A	Tunis Street Overland Flow Path, Laurieton	Construct/raise berm between the natural flow path and the diversion channel above Blackbutt Crescent to reduce overflows into the diversion channel	• Works fully within national park area, likely requiring removal of a large number of trees for the proposed bund in addition to site access for construction plants. • The option will be constructed on a natural berm which appears to be formed from flood-flow deposits of rock rubble and other material. Geotechnical conditions may be challenging. • Periodic maintenance of the proposed bund would be required.	• Reductions in flood levels of -0.05 to -0.2m on Gow Place properties and Laurieton retirement village villas, some localised areas greater than -0.02m. Reductions of -0.1m at Laurieton retirement village main facility. • Localised reductions of up to -0.4m on Peach Grove properties. One property experiences minor increases of less than +0.02m. • Minor reductions of up to -0.06m on residential and commercial properties on and to the east of Ocean Drive. • *Widespread increases of +0.03 to +0.07m on St Josephs School grounds* • Number of above-floor flooded properties reduced by 19 (residential) in the 1% AEP event.	$2,265,000 net	TBC	TBC
6B+6C +6D+ 6E	Tunis Street Overland Flow Path, Laurieton	• Increase existing diversion channel capacity behind Blackbutt Crescent properties. Widen and remove/maintain vegetation • Construct new diversion channel behind Peach Grove properties north of Tunis Street • Install new 3 x 1.35m trunk drainage line from the easement down Tunis Street to discharge to the river (approximately 740m). Inlet debris trap basin required. • Upgrade and extend drainage in Gow Place to 1.05m dia pipe. Upgrade pit inlets. Install new 900mm pipe connection from the gully to the new trunk drainage line.	• Works would need to be undertaken in part in the national park. • Upgraded diversion channels are to be grassed and require maintenance to limit vegetation growth. • Close proximity to existing buildings likely to have shallow foundations. Wide construction footprint for trenching likely to take up most of road corridor. Appropriate traffic diversions would be required. • Vibration due to construction activities may be a concern. • Acid sulphate soils in this location. • Numerous existing underground utilities (Telstra, Optus, NBN, power, stormwater) under Tunis Street and adjoining streets. Approximately 10 crossings of the utilities are identified and would need to be protected. It is assumed that the existing utilities are at sufficiently shallow depth to enable the new trunk drainage to be laid beneath. • Design and construction will need to minimise traffic impacts including delivery truck access to Coles Supermarket loading dock. Pipe jacking likely required for this section • A rock debris trap/basin would need to be constructed at the trunk drainage inlet to reduce the inlet blockage risk.	• Reductions in flood levels of up to -0.4m on Gow Place properties and Laurieton retirement village villas, including some reductions in flood extent. • Reductions in flood levels of up to -0.5m on Peach Grove and Blackbutt Crescent properties including reductions in flood extent. Some localised reductions of up to -0.7m. • Reductions of -0.1 to -0.2m on residential and commercial properties on and to the east of Ocean Drive. • Removal of areas of very high hazard (up to H5) in road and on properties between Blackbutt Crescent/Peach Grove and to the east of Kew Road/Bold Street. • Climate change scenario: the option generally has similar performance to 1% AEP, in terms of reductions in flood levels. Slight reduction in performance due to sea level rise in low elevation areas below 3m AHD, where the reductions fall from -0.07m in the current climate case to -0.01m in the climate change scenario. • Number of above-floor flooded properties reduced by 36 in the 1% AEP event (34 residential, 2 commercial).	$15,680,000	TBC	TBC

Option	Location	Description	Constraints and Impacts Plus other comments	Hydraulic Benefits (1% AEP event unless otherwise noted) *And Negative Impacts if Any*	Savings in Flood Damages (50 years life, 7% Discount Factor, with 0.5m protection level)	Cost of Works	Benefit Cost Ratio
8B	Lake Street at Seymour Street, Laurieton	Install debris control structure at existing or proposed upgraded culvert inlet	• No significant constraints • Inspection and maintenance after storm events required to increase reliability	• Reductions of -0.1m on private property dwelling and Laurieton United Services Club side entrance. • Reductions of up to -0.1m on Lake Street. • *Minor localised increases of less than -0.02m on some private properties due to reduced drainage capacity of local stormwater drainage branches.*	$8,000	TBC	TBC
9A	St Joseph's School, Laurieton	Upgrade Ocean Drive culvert crossing. Inlet rock debris trap basin required. Widen existing open channel in southern flow path to 10m top width (8m base width)	• Minimum clearance between buildings and other features is 19m. Existing buildings are single storey and are likely to have shallow foundations. One building believed to be around 120 years old. Vibration due to construction activities can be a concern and a detailed structural inspection of the existing buildings should be conducted to assess if some areas of the existing buildings are more susceptible to such vibration. The final alignment of the proposed culvert can then be chosen to avoid these vibration sensitive zones. • Sediments may be mildly contaminated and high acid-sulphate. • Existing drainage needs to be surveyed and coordinated with the design of the modified open channel. • The existing channel and its banks appear to be landscaped with well-established gardens, which are likely to be of high value to the school and adjacent church. The option needs to include landscaping to re-establish the gardens. • Existing utilities along Ocean Drive (Optus, Telstra, NBN, power). • Sensitive habitats downstream. Possible localised impacts from expanded channel draining to Stingray Creek. Review of Environmental Factors likely required.	• Maximum decreases of -0.3 to -0.4m (up to -0.5m in 0.2EY event) in the channel (southern flow path) upstream and downstream of Ocean Drive culvert crossing, with reductions in flood extent • Decrease of -0.02 to -0.08m at and between school buildings, minimal reduction in flood extent • Some reduction in high-very high hazard extent in southern and middle flow paths including on walkways, minimal reduction in flood hazard around school office (only localised high hazard in existing case and mostly low hazard)	$145,000	TBC	TBC

Option	Location	Description	Constraints and Impacts Plus other comments	Hydraulic Benefits (1% AEP event unless otherwise noted) *And Negative Impacts if Any*	Savings in Flood Damages (50 years life, 7% Discount Factor, with 0.5m protection level)	Cost of Works	Benefit Cost Ratio
9B	St Joseph's School, Laurieton	Install 2x 3m x 1.2m box culvert in the middle flow path, including upgrade of Ocean Street culvert crossing. Inlet rock debris trap basin required	• Minimum clearance between buildings and other features is 16m • Existing buildings are single storey and are likely to have shallow foundations. One building believed to be around 120 years old. Vibration due to construction activities can be a concern and a detailed structural inspection of the existing buildings should be conducted to assess if some areas of the existing buildings are more susceptible to such vibration. The final alignment of the proposed culvert can then be chosen to avoid these vibration sensitive zones. • Sediments may be mildly contaminated and high acid-sulphate. • Existing drainage need to be surveyed and coordinated with the design of the modified open channel. Reconstruction of existing driveway required. • Existing utilities along Ocean Drive (Optus, Telstra, NBN, power). • Sensitive habitats downstream. Possible localised impacts from expanded channel draining to Stingray Creek. Review of Environmental Factors likely required.	• Maximum decreases of -0.2 to -0.3m in the middle flow path and adjacent buildings through the school, with substantial reductions in flood extent • Decrease of up -0.2m around school office and adjacent buildings, with some reduction in flood extents • Reductions in flood depths on Ocean Drive around Flinders Drive of -0.1 to -0.2m. Reductions in flood levels/depths around Ocean Drive culvert crossing (middle flow path) of up to -0.3m with substantial reduction in flood extents • Reductions from H5 hazard in the middle flow path in the existing case including on walkways, down to mostly H1-H2 • Reductions from H4-H5 hazard around the school office in the existing case including on walkways, down to mostly H1-H2 hazard, some localised H3-H4 in mitigation case. Reductions from H4 down to H1-H2 in up to 5% AEP event.	$500,000	TBC	TBC

4. Non-Structural Measures

4.1 Property Modification Measures

4.1.1 Voluntary Purchase of High Hazard Properties

Voluntary purchase of high flood hazard properties may be considered in order to eliminate the potentially high risk of loss of life and damage to property from these areas by physically removing the dwellings at risk to hazardous flood conditions.

OEH has prepared Guidelines for Voluntary Purchase Schemes (OEH, 2013b). This describes the eligibility criteria for NSW Government funding for VP schemes, which include:

- no other feasible flood risk management options are available to address the risk to life at the property;
- residential properties and not commercial and industrial properties;
- buildings were approved and constructed prior to 1986;
- properties are located either 1) within high hazard areas where there is a significant risk to life for occupants and those who may have to evacuate or rescue them, 2) within a floodway where the removal of the house may be part of a floodway clearance program aimed to reduce the significant impacts caused by the existing development on flood behaviour elsewhere in the floodplain, or 3) within the footprint of a proposed flood mitigation measure or where a flood mitigation measure may result in a significant increase in flood risk to a house that cannot be protected.

Two high flood hazard properties have been nominated for voluntary purchase in order to form a floodway to relieve flooding semi-trapped points in Koonwarra Street and Pelican Court, refer to Options 4A and 4C in the flood modification measures (Section 3.4.2.1).

In total, there are 19 residential properties affected by high hazard flooding, considered as being H5 or higher, in the 1% AEP event which may be eligible for voluntary purchase. This excludes any villas, units or strata buildings. There are limits to the funding available for a voluntary purchase program and additional eligibility criteria may apply. Feasibility of a voluntary purchase program is likely to be limited by the relatively high property prices in the study area. Further assessment needs to be undertaken with the finalised structural mitigation options and whether these eliminate the high flood hazard conditions to particular properties.

4.1.2 Voluntary House Raising

Voluntary house raising has long been a traditional response to flooding in New South Wales, as demonstrated by the number of raised houses in frequently flooded urban areas such as Lismore and Fairfield (Floodplain Development Manual, 2005). There are advantages associated with house raising which are noted as follows (Frost and Rice, 2003).

- A reduction of flood damages due to personal items being stored above the nominated flood level
- A reduction in danger to personal safety and a reduction in the cost of potentially needing to evacuate residents
- Potentially cost-effective alternative to voluntary purchase, with positive social outcomes (i.e. home owners who have strong sentimental value on their properties can remain in the same location).

Some of the disadvantages include:

- Residents' concern over security and privacy due to an open, exposed ground floor
- Accessibility issues for the elderly or people with a disability
- Following raising, residents may develop a false sense of security from impacts. This can result in a belief that they will not be impacted by flooding or reluctance to evacuate when required.

- Over time and when flooding has not occurred, residents may be inclined to utilise the ground floor and converting it to a habitable area.

OEH has prepared *Guidelines for Voluntary House Raising Schemes* (OEH, 2013a). This describes the eligibility criteria for NSW Government funding of VHR schemes including:

- not located in floodways;
- limited to areas of low flood hazard;
- the suitability of individual houses for raising;
- residential properties and not commercial and industrial properties;
- buildings were approved and constructed prior to 1986;
- properties cannot be benefiting substantially from other floodplain mitigation measures;
- VHR should generally return a positive net benefit in damage reduction relative to its cost (benefit–cost ratio greater than 1).

Inclusion of a property in a voluntary house raising scheme places no obligation on the owner to sell the property or on the council or NSW Government to fund the purchase of the property. Owner participation in the scheme is voluntary and there are limitations on the availability of funding.

Whilst house raising can be considered for a range of building types, it is easiest and cheapest for timber-framed houses clad with non-masonry materials. A large proportion of houses in the study area which area flood-affected are of single or double brick construction which are considered costly and impractical for raising.

Due to the factors outline above, house raising is not considered feasible as a mitigation measure for dwellings within the study area.

4.1.3 Planning and development controls

4.1.3.1 General

Land use planning and development controls are an essential element in managing flood risk and the most effective way of ensuring future flood risk is managed appropriately. Planning controls including flood planning levels, flood related development control plans and restrictions on permissible types of development in different parts of the floodplain are recommended to ensure that development in the study area occurs in an appropriate manner in relation to flooding.

4.1.3.2 Amendments to LEP

The *Port Macquarie Hastings Local Environmental Plan 2011* (LEP 2011) provides land use controls for the LGA and has been developed to be consistent with the FDM. Part 7.3 of the LEP 2011 contains clauses on flood planning. Excepts of this clause are provided below:

(1) The objectives of this clause are as follows:

(a) to minimise the flood risk to life and property associated with the use of land,

(b) to allow development on land that is compatible with the land's flood hazard, taking into account projected changes as a result of climate change,

(c) to avoid significant adverse impacts on flood behaviour and the environment.

(2) This clause applies to:

(a) land that is identified as "Flood planning area" on the Flood Planning Map*, and*

(b) other land at or below the flood planning level.

(3) Development consent must not be granted to development on land to which this clause applies unless the consent authority is satisfied that the development:

(a) is compatible with the flood hazard of the land, and

(b) is not likely to significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties, and

(c) incorporates appropriate measures to manage risk to life from flood, and

(d) is not likely to significantly adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses, and

(e) is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding.

(4) A word or expression used in this clause has the same meaning as it has in the Floodplain Development Manual (ISBN 0 7347 5476 0) published by the NSW Government in April 2005, unless it is otherwise defined in this clause.

The LEP includes mapping of known flood liable lands, where there are flood studies completed for those areas. It currently does not include the overland flood areas of the North Brother local catchments.

While the LEP does require consideration of the compatibility of development to the "flood hazard of the land", it only makes reference to the flood liable lands and flood planning area. It does not make reference to the actual flood hazard rating, that being governed by flood depth, velocity and/or velocity-depth product, or to the hydraulic category of the floodplain (floodway, flood storage etc.).

Recommendation

The following updates to LEP 2011 and the Section 10.7 certificates are recommended:

- Amendment of LEP 2011 to include the North Brother local catchments flood mapping on the LEP Flood Planning Map. The current flood prone land mapping and flood planning area mapping does not include this study area.
- The Section 10.7 certificates should provide flood information for properties such as flood levels and flood planning levels across the lot, in addition to the flood hazard and hydraulic categories present on each lot.

4.1.3.3 Amendments to Flood Policy

Overview

Council's Flood Policy (2015) outlines the development controls to be applied to proposed developments to manage flood risk to occupants and minimise flood damages to the development and flood impacts to adjacent properties. Development controls include flood planning level categories and provisions for different types of development (permissible development types, minimum floor levels), considerations for filling, fencing, boundary adjustments, rezoning and subdivision in the different hydraulic zones in the floodplain. The flood policy draws on the design flood information borne from Council's existing flood studies

Prescriptive Controls

Prescriptive controls that apply to a particular Flood Risk include:

- Floor Level
- Flood Proofing
- Flood Impact on Other Properties
- Site Access and Flood Evacuation Requirements.

The Flood Policy provides requirements for different types of development in relation to these prescriptive controls. These requirements vary depending on the hydraulic classification and flood hazard conditions on the property.

Hydraulic Classifications

The flood policy provides definitions for the different hydraulic classifications of the floodplain, including floodway, flood storage and flood fringe areas. It outlines the type and nature of development which is allowed according to the hydraulic classifications on the property. Generally, new development is not allowed in floodway areas. There may be circumstances in which certain types of limited or Minor Development (including infill development, redevelopment, replacement development or minor extensions) could proceed, subject to a range of considerations.

Flood Hazard

The flood policy provides guidance on how proposed developments are to comply with the prescribed development controls and provisions. One of these is consideration of the flood hazard on the property. The flood hazard categorisation system adopted in the flood policy differs from the hazard categorisation system recommended in Australian Rainfall and Runoff 2019, which is based on recent research and which is presented in *Australian Disaster Resilience Handbook 7. Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia* (AIDR, 2017a) and *Guideline 7-3 Flood Hazard* (AIDR, 2017b). The flood hazard mapping prepared in this study for the North Brother Local Catchments follows the ARR 2019 system.

Flood Planning Levels

The Flood Policy defines the adopted flood planning levels for various types of proposed development. Council has adopted a 0.5m freeboard across the whole LGA, including both mainstream and overland flood areas. The different flood planning level categories define the minimum levels for floor levels, flood proofing, flood impacts to other properties and site access (e.g. roads) and evacuation routes for different types of development.

Table 4-1 Flood Planning Level (FPL) Categories

Category Proposed	FPL Category Description
FPL1	20 year ARI Flood level (No allowance for Climate Change, No Freeboard)
FPL2	100 year ARI Flood level + Climate Change Allowance (No Freeboard)
FPL3	100 year ARI Flood level + Climate Change Allowance + 500mm Freeboard
FPL4	Probable Maximum Flood (PMF)

Comments and Recommendations

- The Flood Policy should be updated to refer to this North Brother Local Catchments Flood Study and the flood mapping and other design flood data following adoption of this study by Council.
- Design flood events are referred to in the Flood Policy in terms of Average Recurrence Interval (ARI) which is not in line with current floodplain management best practice of referring to events by Annual Exceedance Probability (AEP). Update to the Flood Policy should include reference to AEP terminology and/or definitions on conversion in its glossary (i.e. 5% AEP = 20 year ARI, and 1% AEP = 100 year ARI).
- The Flood Policy has been developed mainly in the context of mainstream flooding. For example, in relation to reliable site access for new residential developments, the Flood Policy states that Council will only support development where "Effective Warning Time and reliable access is available for evacuation. Developments will be required to demonstrate that evacuation through low hazard conditions during the early warning period of a Flood is achievable. A minimum 8 hours Effective Warning Time must be available to a particular site". For overland flooding such warning time is not available (usually the warning time is less than 1 hour). Therefore, it is recommended to update the Flood Policy to provide exemptions or modified conditions for development of properties subject to overland flooding.
- Continuing from the item above, mapping should be provided and included/cited in the Flood Policy which indicates the areas subject to mainstream flooding (as defined by the riverine flood studies) and those subject to overland flooding (as defined in this and subsequent overland flood studies and which are above the extent of mainstream flooding). This mapping will be prepared as a part of this study, for the North Brother study area.
- The Flood Policy needs to state that both the mainstream and overland flooding conditions need to be considered for development and re-development of properties.
- Consider incorporation of the ARR 2019 flood hazard categorisation system into the Flood Policy to reflect the current best practice in defining flood hazard conditions.
- "High flood hazard" could be considered as H3 or higher hazard (ARR 2019 hazard categories). The lower threshold for H3 hazard is similar or slightly lower than the high and transitional hazard categories in the *Floodplain Development Manual* method.

4.1.3.4 Rezoning

Rezoning could be considered where there is an incompatibility of the flood hazard or hydraulic category on the property compared to the type of land use. Section 2.4 identifies sensitive properties and critical facilities which are affected by high hazard flooding and floodway (as well as flood storage and flood fringe) areas. Unlike mainstream flooding, the high hazard and floodway areas are generally localised in the 1% AEP event. Rezoning of entire properties, especially larger premises occupied by schools, nursing homes etc. to preclude those land uses is likely to result in the suitable parts of the properties being underutilised.

Properties with larger areas of high hazard up to H5/H6 in PMF include:

- St Josephs school
- Laurieton Retirement Village
- Stockland Camden View Retirement Village.

Rezoning of these properties in response to flood hazard in the PMF could be considered, although many of these sensitive properties are large facilities and there is an absence of large vacant lots to which these facilities could be relocated, and relocation would be an expensive and complex exercise. Other measures and development controls may be appropriate to manage redevelopment of these properties. Therefore, rezoning of the identified affected sensitive properties and critical facilities is generally not recommended, based on the overland flood conditions presented in this study. Rezoning in response to mainstream flood conditions has not been assessed.

4.1.4 Council Redevelopment

This measure is an alternative to voluntary purchase (refer Section 4.1.1) whereby Council would still purchase high-impacted flooded properties on a voluntary basis but instead of rezoning the land, the property is redeveloped with new dwellings designed to withstand the high hazard flooding conditions on the property and resist flood damages. The intention is for the redeveloped property to be resold with a break-even financial outcome, which offsets the high property purchase costs which tend to make voluntary purchase unfeasible.

However, initial assessment identifies a number of issues with this approach:

- It would be in conflict with Council's Flood Policy in addition to other planning policies which preclude (re)development in floodway and high flood hazard areas.
- This approach may need to be fully funded by Council.
- Specialised building design and engineering would be required to withstand high to extreme hazard flood forces (H5 and H6 hazard rating) in the 1% AEP event and rarer, which adds to the cost of this option.
- This approach would not reduce the risk of flooding on the population in the PMF.
- There is a high upfront cost to be borne by Council for each redevelopment.
- There may also be probity issues in the case of Council acquiring the property, redeveloping and reselling the property.
- The generally older characteristics of the local population may mean that there is a reduced capacity for the residents of properties to move elsewhere. There may be reluctance to sell-off the properties in this regard. Conversely, however, there may be increased uptake in this option for residents who are frequently affected by flooding.

Recommendation

Further consideration by Council is required to determine if these issues can be addressed to make this a viable approach. Development controls such as floor levels above the PMF for flood refuge would need to be assessed for suitability in a town planning context.

4.1.5 Flood Proofing and Flood Compatible Design of Individual Buildings

Flood compatible design refers to the design and construction of buildings with appropriate water-resistant materials such that flood damage to the building itself (structural damage) and possibly its contents, is minimised should the building be inundated. *Reducing Vulnerability of Buildings to Flood Damage* (Hawkesbury-Nepean Floodplain Management Steering Committee, 2007) provides a comprehensive discussion of the various options for building design to minimise the impact of flooding. These include structural and architectural design and building materials, in addition to design considerations such as setting of electrical equipment above flood levels to reduce risk of their damage.

Flood compatible and flood proofing design measures are prescribed for different types of development in Council's Flood Policy (2015), including the minimum elevations in the development which the flood compatible materials must reach in all parts of proposed buildings.

Promotion of types of flood proofing measures should also be undertaken as a part of flood awareness and readiness improvement programs (refer Section 4.2.3).

Flood proofing of residential properties can also refer to implementing external measures such as walls or landscaping to redirect flows away from and around vulnerable parts of the house, such as doorways and other entry points. It is generally a measure that can be pursued by individual property owners in low hazard areas to prevent above floor inundation but may result in diversion of flows to neighbouring properties and resultant impacts. A flood impact assessment may be required by Council as per the Flood Policy to ensure adverse flood impacts to adjacent properties are prevented.

Recommendation

Promotion of flood proofing measures should also be included in flood education and awareness programs.

4.2 Response Modification Measures

4.2.1 Flood Warning Systems

The study area includes local catchments and overland flow paths where flash flooding may occur. Flash flood catchments are those defined as catchments in which less than six hours may elapse between heavy rainfall and flooding. Flash flooding usually results from relatively short intense bursts of rainfall, commonly from thunderstorms. This is problematic in urban areas where drainage systems may not cope. Flash floods tend to be quite local and it is difficult to provide effective warning because of their rapid onset. The reasons for this have been identified for flash flood catchments as follows (McKay, 2004, 2008):

- Flash floods are less predictable than larger scale flooding. Rainfall over small catchments is usually not well predicted by numerical weather prediction models
- For flash floods, there is insufficient time to develop reliable flood warnings and for effective the dissemination and response to the flood warnings. More rapid user response is required, which necessitates specialised communication systems and a high level of public flood awareness
- A reliance on rainfall triggers increases the frequency of false alarms
- The use of water level triggers does not allow sufficient time for response.

It is not possible for BOM to issue specific predictions for flash flood catchments based on their regional rainfall gauging network. More importance is placed on the role of the SES and other agencies to interpret the regional warnings which are provided by BOM to warn the community of the potential road closures and damage as a result of predicted storms and flash floods.

Flash flood warning systems have been proposed for some catchments, such as the Avalon overland flood areas on the Northern Beaches of Sydney. However, the time to peak for critical storm events in the Avalon area is about 1 hour from the start of the storm, and about 30 minutes after peak rainfall rates in the design storm event (MHL, 2016), which offers a short warning time. The critical duration in that area for the 1% AEP event is the 2 hour event.

In contrast, although some of the lower areas in North Brother study area have a critical storm duration of up to 2 hours, the critical duration for most of the study area is generally the 30 minute duration event. Time to peak in many flow paths, especially on known problem areas further up the mountain, is in the range of 15 minutes. Due to the steepness of the local catchments the overland flooding is expected to peak almost instantaneously (5 to 10 minutes) in response to high intensity rainfall. Therefore, there would be minimal to no warning provided for many locations in the study area. Potential delays in analysis of rainfall data and subsequent dissemination of warnings via phone or text systems would further erode the warning time.

Given the issues and challenges discussed above, the development of a flash flood warning system for the study area is not recommended. Greater emphasis should be placed on the importance of flood education and awareness in the community. Local residents have a role in being able to understand how the issued weather warnings and actual occurrences of intense rainfall during a storm may translate to flooding impacts to their properties, and in addition, be aware of ways to prepare their properties to reduce flood damages and risk to life.

4.2.2 Flood Depth Signage on Roads

A number of road crossings are affected by significant flooding. Flood depth signage is recommended for key locations primarily to warn drivers of the flood hazard during a flood event and reduce occurrences of people driving into floodwaters. Flood depth signage may also act as a passive reminder to residents of the potential for flooding in their neighbourhood streets. Nominated locations are where H3 or higher flood hazard occurs in the 1% AEP event, including:

- Ocean Drive 70m east of Sirius Drive
- Ocean Drive 380m east of Fairwinds Avenue
- Ocean Drive 30m east of The Gateway
- Bold Street sag between Laurie Street and Mill Street
- Bold Street sag between Mill Street and Hanley Street.

While there are other roads affected by high hazard flooding conditions, Ocean Drive and Bold Street are higher-trafficked roads and crossed by major flow paths with a higher risk of vehicles being washed off the road.

Recommendation

It is recommended that flood depth signage be installed at key road crossings as a warning of the flood hazard during a flood event and reduce occurrences of people driving into floodwaters, in addition as a passive reminder of flooding risk.

4.2.3 Flood Education, Awareness and Readiness

Flood education and awareness should be promoted throughout the study area. Measures may include information brochures in English and multi-lingual including promotion of NSW SES FloodSafe brochures and website (http://www.floodsafe.com.au/). Additionally, Council or SES may run educational workshops or distribute information sheets to help people plan and prepare for a flood.

Section 10.7 certificates issued by Council could be used to inform property owners about flood risk to their properties, where there are flood studies completed within Port Macquarie Hastings LGA.

Additionally, Council's floodplain management web page and social media could be further developed to enhance the messaging on flood risk and flood preparation, particularly in relation to overland flooding. This may include flood mapping on an interactive mapping portal on the website itself rather than links to the flood study reports and mapping, where it can be difficult for community members to navigate through often lengthy technical reports. Information on, or links to external websites (SES, floodsafe, etc), should be included for advice for residents on how to prepare for flooding.

During flood events, Council should a list of road closed to flooding (and roads recently opened as the flooding recedes) on their website and social media. This will encourage road users to find alternative routes and reduce the number of drivers encountering flooded roads and potentially driving into floodwaters.

A flood education and awareness program should be developed by Council which outlines and schedules various flood education methods to be implemented (e.g. brochures, news articles highlighting previous flooding, SES events, Council web pages etc.). The program should be reviewed after each significant flood event to assess the effectiveness of the program, reinvigorate flood awareness in the community and plan the roll-out of new flood information as it becomes available.

As a part of an overall flood education and awareness program for the study area, Council should consult with operators of sensitive properties and facilities to provide information on the flood risk on the property and

promote the development of a flood management plan for the properties (refer to Section 4.2.5 for further details).

Recommendation

It is recommended that Council develops a flood education program to promote flood awareness and readiness in the community. Measures may include:

- Promotion of FloodSafe brochures to help residents understand the flood risk and prepare their property and personal plans for a flooding event.
- Flood depth signage on key roads affected by flooding.
- List of road closures and roads recently opened on website/social media page during flood events
- Section 10.7 certificates to inform property owners about flood risk to their properties
- Provide flood mapping on an interactive mapping portal on Council's website for easier viewing
- Promotion and support for SES information events
- Enhanced messaging on flood risk and flood preparedness on Council's floodplain management webpage particularly for overland flooding.
- Consult with operators of sensitive properties and occupants of dwellings affected by high flood hazard to provide information on the flood risk and promote the development of a flood management plan for the properties.

The program should be reviewed after each significant flood event.

4.2.4 Improved flood evacuation response and procedures

Flood evacuation is under the control of the SES and the SES needs to update the current evacuation planning based on information presented in this report, including flood depth and hazard mapping.

Recommendation

It is recommended that the SES updates the current emergency planning, such as development of a Local Flood Plan or update of the EMPLAN, based on information presented in this study.

4.2.5 Development of Flood Management Plans

A flood management plan is a document which outlines and discusses the measures to help manage the flood risk on a particular property, and its occupants and visitors to the site. The purposes of the plan are:

- To address existing, future and continuing flood risks on the site;
- To promote a satisfactory awareness of expected flood behaviour and risks;
- To identify measures to become flood prepared, and
- To recommend a course of action during and after flood events.

Flood management plans can be likened to a fire evacuation plan or a bushfire emergency plan and should be tailored specifically for a particular property. It outlines procedures for prior, during and after a flood event and the roles and responsibilities, generally of facility staff, in enacting the flood management plan. It may also describe evacuation routes and refuge places.

Several facilities are affected by very high to extreme (H5, up to H6) flood hazard in the PMF. Development of a flood management plan for the facilities should be considered to manage the flood risk to occupants. Council and SES should also consider encouraging and helping occupants of private dwellings to prepare their own flood management plans. Council should consult with the facility operators and occupants of dwellings subject to high flood hazard as a part of an overall flood education and awareness program for the study area and promote the development of a flood management plan for the properties.

As a part of the development of a flood management plan, evacuation from the site may be identified as a suitable option. This would require safe evacuation routes to be identified or otherwise new safe evacuation access installed (see Section 1.1.1). If sheltering-in-place in facility buildings is identified as a more suitable approach, an assessment of the structural stability of the buildings in the flood conditions should be undertaken.

Recommendation

Council should consult with high flood risk facilities and occupants of dwellings subject to high flood hazard regarding management of flood risk on the site. Development of a flood management plan for the site should be considered by the facility operators with the assistance of Council/SES.

5. Conclusions and Recommendations

5.1 Conclusions

Six selected structural options and combinations of options have been assessed in the TUFLOW hydraulic model for the North Brother local catchments. The options were selected by Council and the floodplain risk management committee from a long-list of options for 16 locations in the study area. The hydraulic performance, site constraints and improvements in flood damages have been confirmed for the selected options. The following options have high merit in terms of reductions in flood damages and improvements in flood hazard:

- Option 4A+4B+4C
- Option 6B+6C+6D+6E
- Option 9B.

Subsequent costing of these options in addition to cost benefit an multi-criteria analyses will confirm the economic feasibility and viability of these options.

In addition, a range of non-structural options have been evaluated for the study area. These include measures related to planning and policy, property modification and flood emergency management and response modification. Recommendations have been made in relation to these measures with consideration of the flood behaviour in the study area.

5.2 Recommendations

- Council and the committee are to review and consider the findings on the hydraulic and damages assessment for the selected options. Feedback is sought on the assessment, including any refinements to the options.
- Consultation with stakeholders, landowners and community is to be undertaken on the short-listed options.
- The hydraulic modelling will be subsequently updated based on proposed refinements to the options following Council/committee and stakeholder consultation. The flood damages will be updated, and costing of options undertaken for input into a cost-benefit analysis. A multi-criteria analysis will also be undertaken to consider other aspects of the options.
- A floodplain risk management study and plan will be formed based on the subsequent outcomes, for community consultation and approval by Council.

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- Victorian Government (2002) Rapid-Appraisal Method (RAM) for Floodplain Management. Department of Natural Resources and Environment.

7. Glossary

Annual Exceedance Probability (AEP)

The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. In this study AEP has been used consistently to define the probability of occurrence of flooding. It is to be noted that design rainfalls used in the estimation of design floods up to and including 100 year ARI (ie. 1% AEP) events was derived from 1987 Australian Rainfall and Runoff. The following relationships between AEP and ARI applies to this study (AR&R, 2016).

Frequency Descriptor	EY	AEP (%)	AEP (1 in x)	ARI
Very frequent	**12**			
	6	99.75	1.002	0.17
	4	98.17	1.02	0.25
	3	95.02	1.05	0.33
	2	86.47	1.16	0.50
Frequent	**1**	**63.2**	1.58	1.00
	0.69	**50.00**	2	1.44
	0.5	39.35	2.54	2.00
	0.22	**20.00**	5	4.48
	0.2	18.13	5.52	5.00
Infrequent	0.11	**10.00**	10.00	9.49
	0.05	**5.00**	20	20.0
	0.02	**2.00**	50	50.0
	0.01	**1.00**	**100**	100
Rare	0.005	0.50	**200**	200
	0.002	0.20	**500**	500
	0.001	0.10	**1000**	1000
Extremely Rare	0.0005	0.05	**2000**	2000
	0.0002	0.02	5000	5000
			↓	
Extreme			PMP	

Australian Height Datum (AHD)

A common national surface level datum approximately corresponding to mean sea level.

Average Annual Damage (AAD)

Depending on its size (or severity), each flood will cause a different amount of flood damage to a flood prone area. AAD is the average damage per year that would

	occur in a nominated development situation from flooding over a very long period of time.
Average Recurrence Interval (ARI)	The long-term average number of years between the occurrences of a flood as big as or larger than the selected event. For example, floods with a discharge as great as or greater than the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.
Catchment	The land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.
DRAINS	DRAINS is a computer program which is used to simulate local catchment rainfall-runoff and stormwater system hydraulics and is widely used across Australia.
Development	Is defined in Part 4 of the EP&A Act In fill development: refers to the development of vacant blocks of land that are generally surrounded by developed properties and is permissible under the current zoning of the land. Conditions such as minimum floor levels may be imposed on infill development. New development: refers to development of a completely different nature to that associated with the former land use. Eg. The urban subdivision of an area previously used for rural purposes. New developments involve re-zoning and typically require major extensions of exiting urban services, such as roads, water supply, sewerage and electric power. Redevelopment: refers to rebuilding in an area. Eg. As urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large scale. Redevelopment generally does not require either re-zoning or major extensions to urban services.
Effective Warning Time	The time available after receiving advise of an impending flood and before the floodwaters prevent appropriate flood response actions being undertaken. The effective warning time is typically used to move farm equipment, move stock, raise furniture, evacuate people and transport their possessions.
Exceedances per Year (EY)	The number of times an event is likely to occur or be exceeded within any given year.
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.
Flood fringe areas	The remaining area of flood prone land after floodway and flood storage areas have been defined.

Flood liable land	Is synonymous with flood prone land (i.e.) land susceptibility to flooding by the PMF event. Note that the term flooding liable land covers the whole floodplain, not just that part below the FPL (see flood planning area)
Floodplain	Area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is flood prone land.
Floodplain risk management options	The measures that might be feasible for the management of particular area of the floodplain. Preparation of a floodplain risk management plan requires a detailed evaluation of floodplain risk management options.
Floodplain risk management plan	A management plan developed in accordance with the principles and guidelines in this manual. Usually include both written and diagrammatic information describing how particular areas of flood prone land are to be used and managed to achieve defines objectives.
Flood plan (local)	A sub-plan of a disaster plan that deals specifically with flooding. They can exist at state, division and local levels. Local flood plans are prepared under the leadership of the SES.
Flood planning levels (FPLs)	Are the combination of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans. FPLs supersede the "designated flood" or the “flood standard” used in earlier studies.
Flood proofing	A combination of measures incorporated in the design, construction and alteration of individual buildings and structures subject to flooding, to reduce or eliminate flood damages.
Flood readiness	Readiness is an ability to react within the effective warning time.
Flood risk	Potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk in this manual is divided into 3 types, existing, future and continuing risks. They are described below. Existing flood risk: the risk a community is exposed to as a result of its location on the floodplain. Future flood risk: the risk a community may be exposed to as a result of new development on the floodplain. Continuing flood risk: the risk a community is exposed to after floodplain risk management measures have been implemented. For a town protected by levees, the continuing flood risk is the consequences of the levees being overtopped. For an area without any floodplain risk management measures, the continuing flood risk is simply the existence of its flood exposure.
Flood storage areas	Those parts of the floodplain that are important for the temporary storage of floodwaters during passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the

	severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas
Floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels.
Freeboard	Provides reasonable certainty that the risk exposure selected in deciding on a particular flood chosen as the basis for the FPL is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. Freeboard is included in the flood planning level.
Hazard	A source of potential harm or situation with a potential to cause loss. In relation to this manual the hazard is flooding which has the potential to cause damage to the community.
Local overland flooding	Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.
m AHD	Metres Australian Height Datum (AHD)
m/s	Metres per second. Unit used to describe the velocity of floodwaters.
m^3/s	Cubic metres per second or "cumecs". A unit of measurement of creek or river flows or discharges. It is the rate of flow of water measured in terms of volume per unit time.
Mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.
Modification measures	Measures that modify either the flood, the property or the response to flooding.
Overland flow path	The path that floodwaters can follow as they are conveyed towards the main flow channel or if they leave the confines of the main flow channel. Overland flow paths can occur through private property or along roads.
Probable Maximum Flood (PMF)	The largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation couplet with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain.
Probable Maximum Precipitation (PMP)	The PMP is the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends (World Meteorological Organisation, 1986). It is the primary input to PMF estimation.
Risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of the manual it is the likelihood of

	consequences arising from the interaction of floods, communities and the environment.
Runoff	The amount of rainfall which ends up as a streamflow, also known as rainfall excess.
Stage	Equivalent to water level (both measured with reference to a specified datum)
TUFLOW	TUFLOW is a computer program which is used to simulate free-surface flow for flood and tidal wave propagation. It provides coupled 1D and 2D hydraulic solutions using a powerful and robust computation. The engine has seamless interfacing with GIS and is widely used across Australia.

Appendix A. Flood Mapping

Legend

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area
- Limit of Mapping

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and Lakes System Flood Study (2013) for riverine flooding mapping.

GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	0.2EY Design Flood Peak Flood Depths
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-1(A)
DATE 28/11/2018	

Legend

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area
- Limit of Mapping

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and Lakes System Flood Study (2013) for riverine flooding mapping.

GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

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JACOBS

TITLE	0.2EY Design Flood Peak Flood Depths
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-1(B)
DATE 28/11/2018	

Legend

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area
- Limit of Mapping

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and Lakes System Flood Study (2013) for riverine flooding mapping.

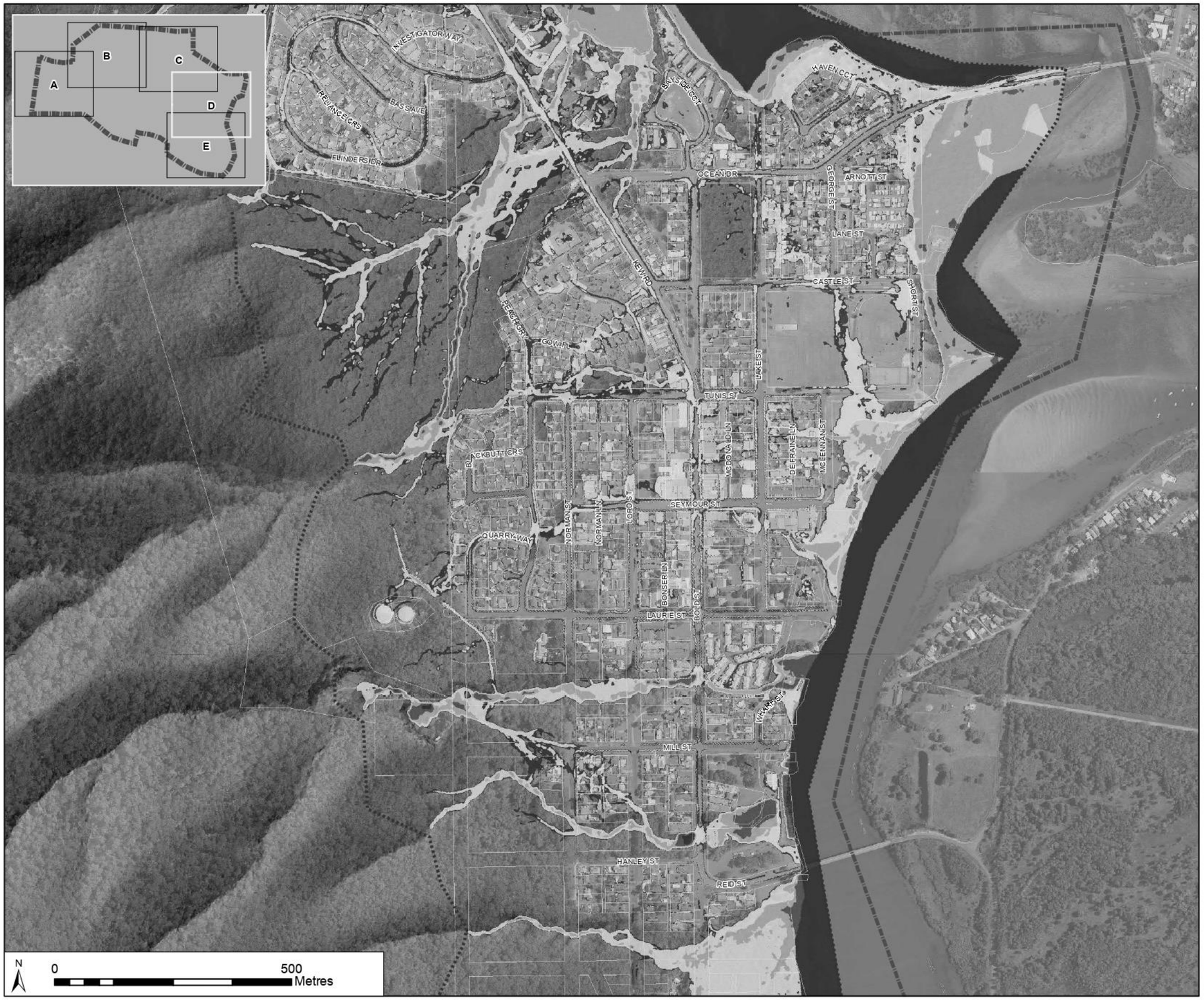
GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	0.2EY Design Flood Peak Flood Depths
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-1(C)
DATE 28/11/2018	



Legend

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area
- Limit of Mapping

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and Lakes System Flood Study (2013) for riverine flooding mapping.

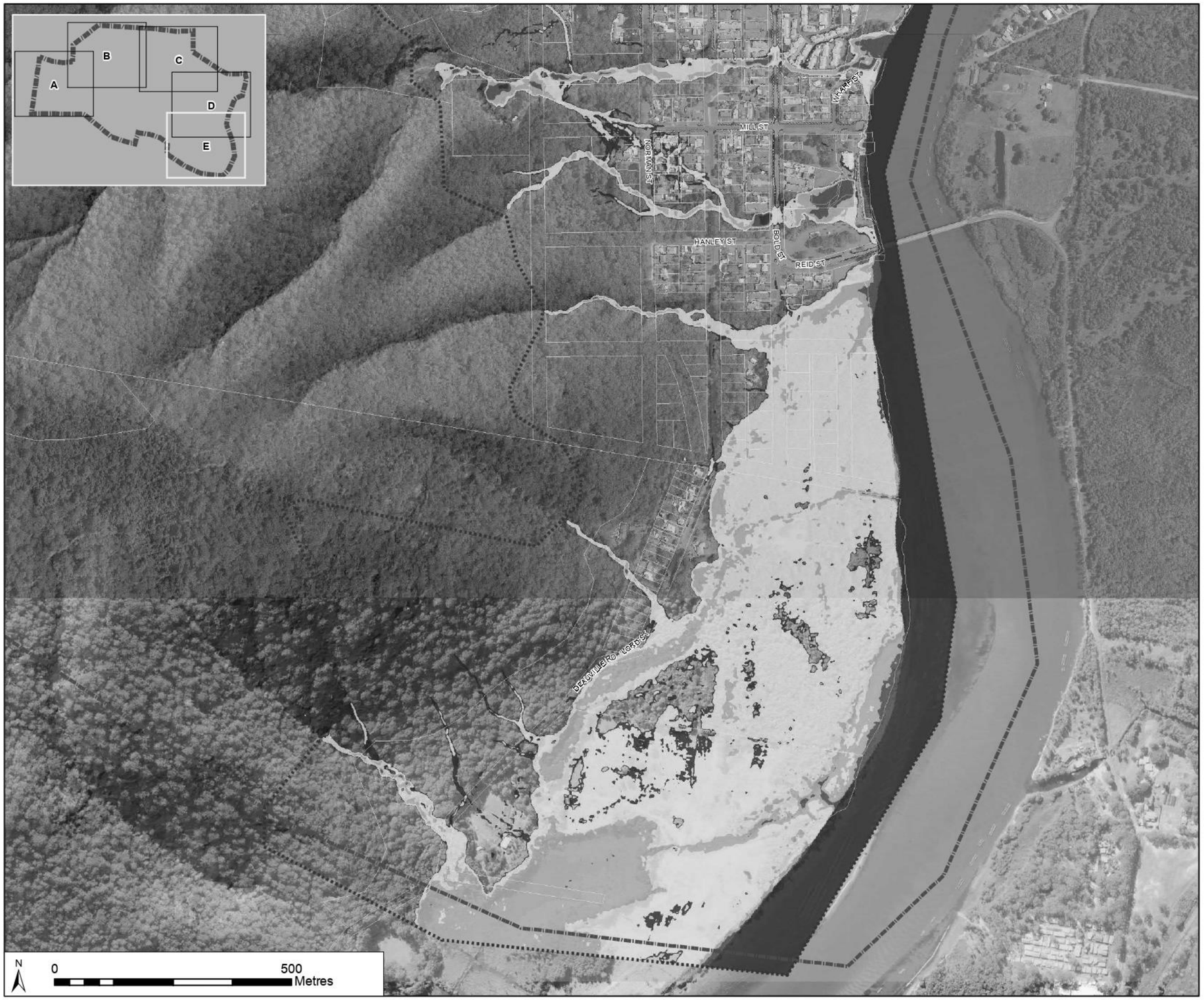
GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	0.2EY Design Flood Peak Flood Depths
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-1(D)
DATE 28/11/2018	



Legend

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area
- Limit of Mapping

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and Lakes System Flood Study (2013) for riverine flooding mapping.

GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	0.2EY Design Flood Peak Flood Depths
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-1(E)
DATE 28/11/2018	

Legend

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area
- Limit of Mapping

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and LakesSystem Flood Study (2013) for riverine flooding mapping.

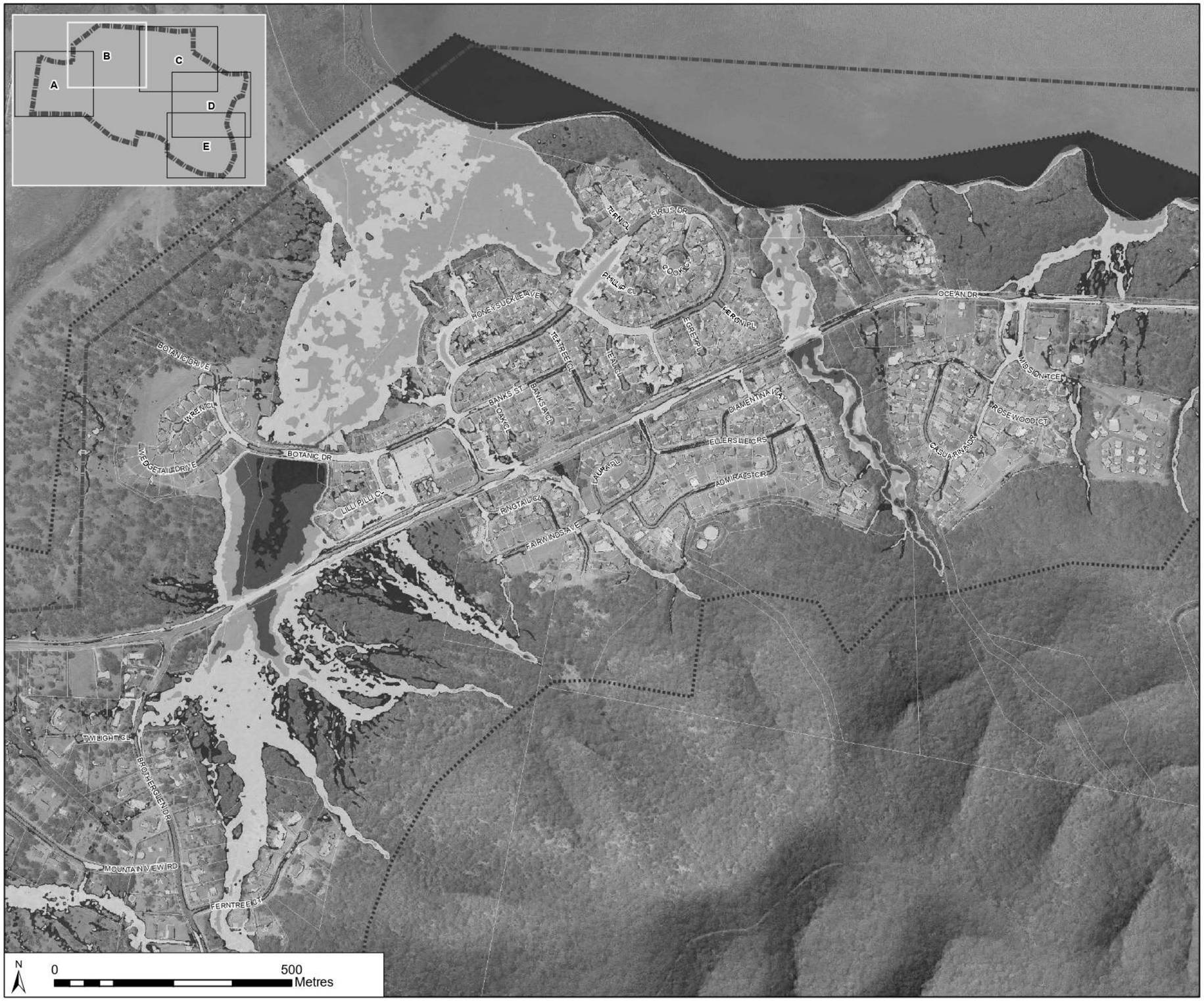
GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	5% AEP Design Flood Peak Flood Depths
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-2(A)
DATE 3/03/2020	



Legend

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area
- Limit of Mapping

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and LakesSystem Flood Study (2013) for riverine flooding mapping.

GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	5% AEP Design Flood Peak Flood Depths
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-2(B)
DATE 3/03/2020	

Legend

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area
- Limit of Mapping

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and LakesSystem Flood Study (2013) for riverine flooding mapping.

GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	5% AEP Design Flood Peak Flood Depths
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-2(C)
DATE 3/03/2020	

Legend

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area
- Limit of Mapping

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and LakesSystem Flood Study (2013) for riverine flooding mapping.

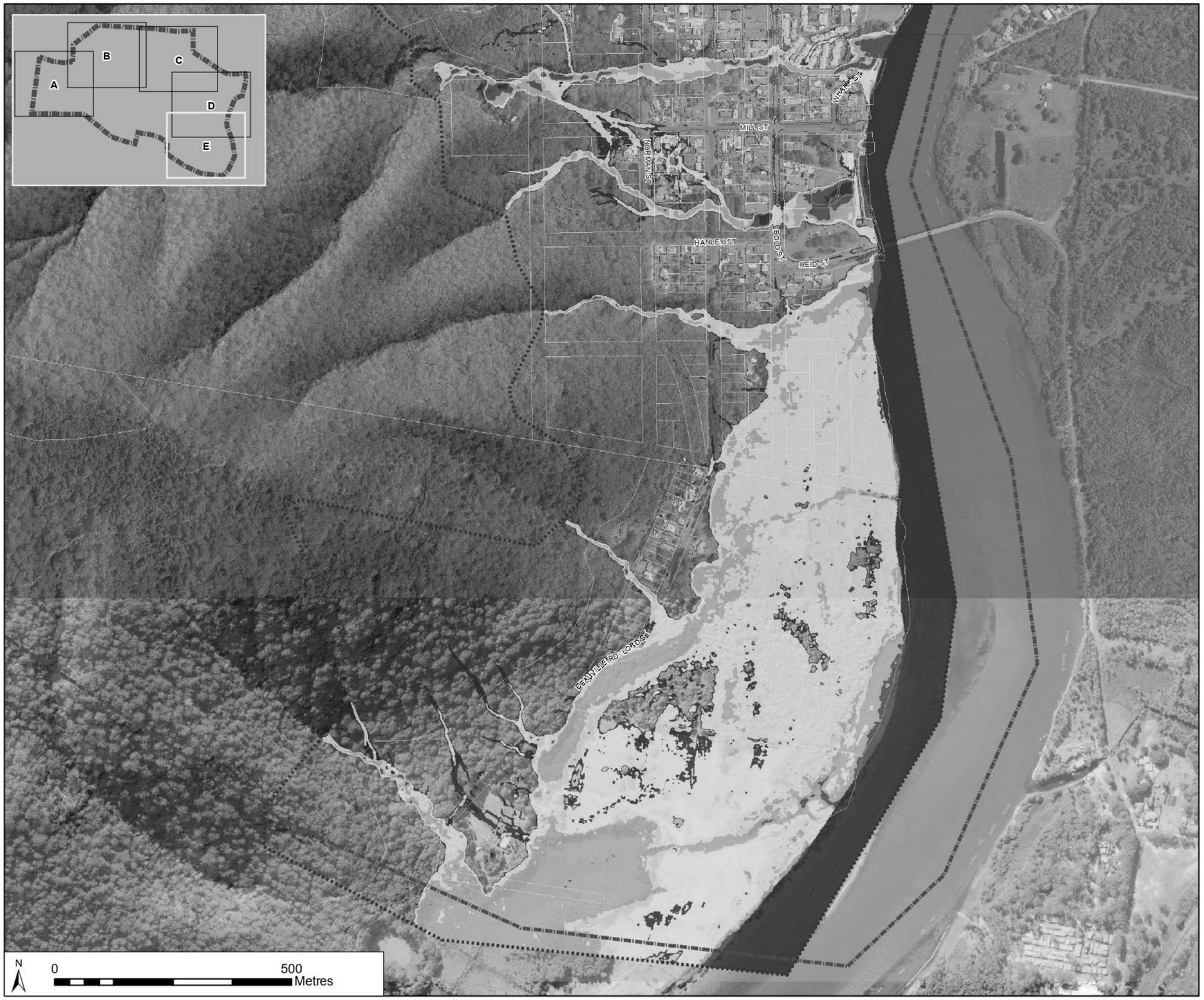
GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	5% AEP Design Flood Peak Flood Depths
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-2(D)
DATE 3/03/2020	



Legend

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area
- Limit of Mapping

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and LakesSystem Flood Study (2013) for riverine flooding mapping.

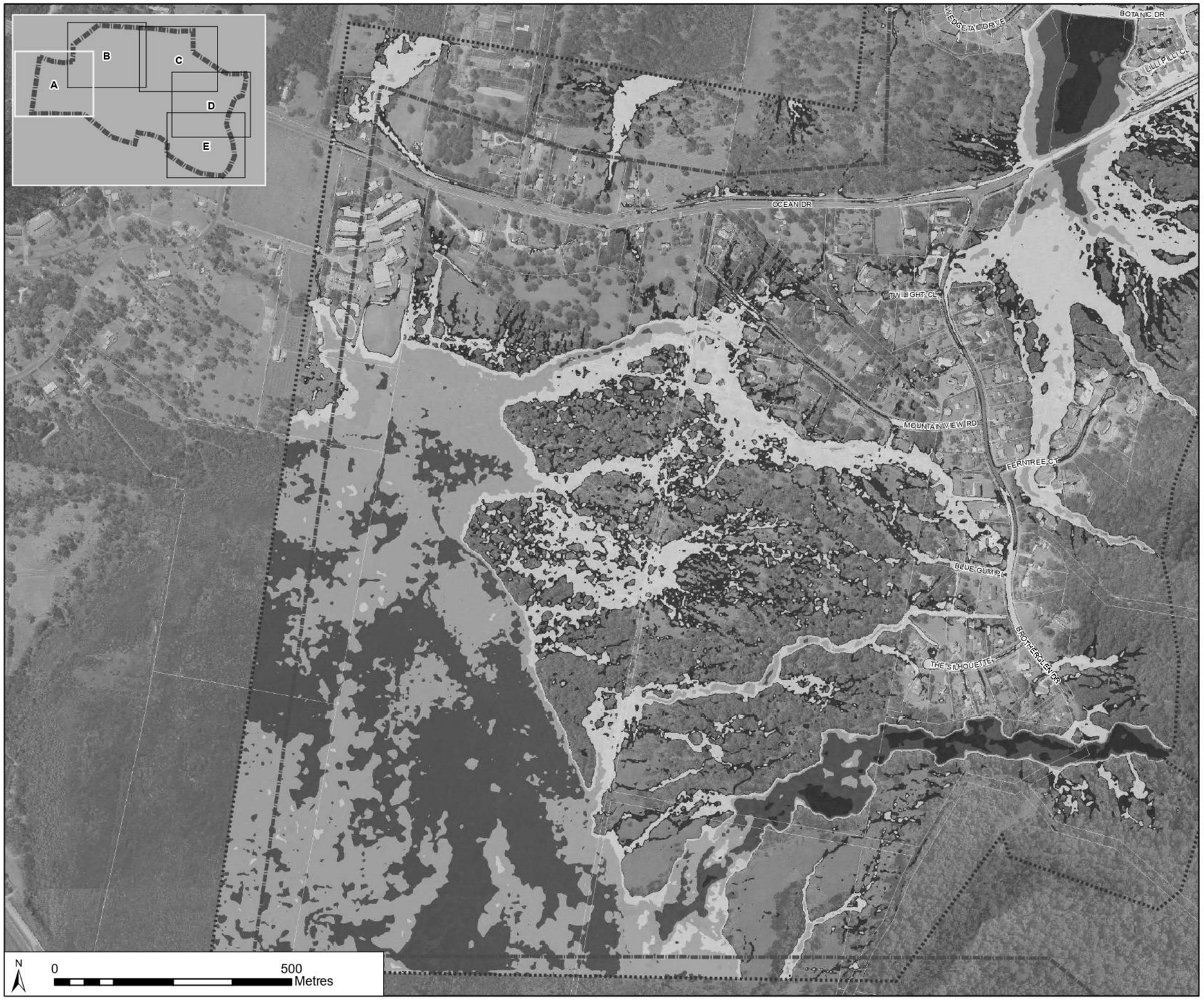
GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	5% AEP Design Flood Peak Flood Depths
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-2(E)
DATE 3/03/2020	



Legend

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area
- Limit of Mapping

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and LakesSystem Flood Study (2013) for riverine flooding mapping.

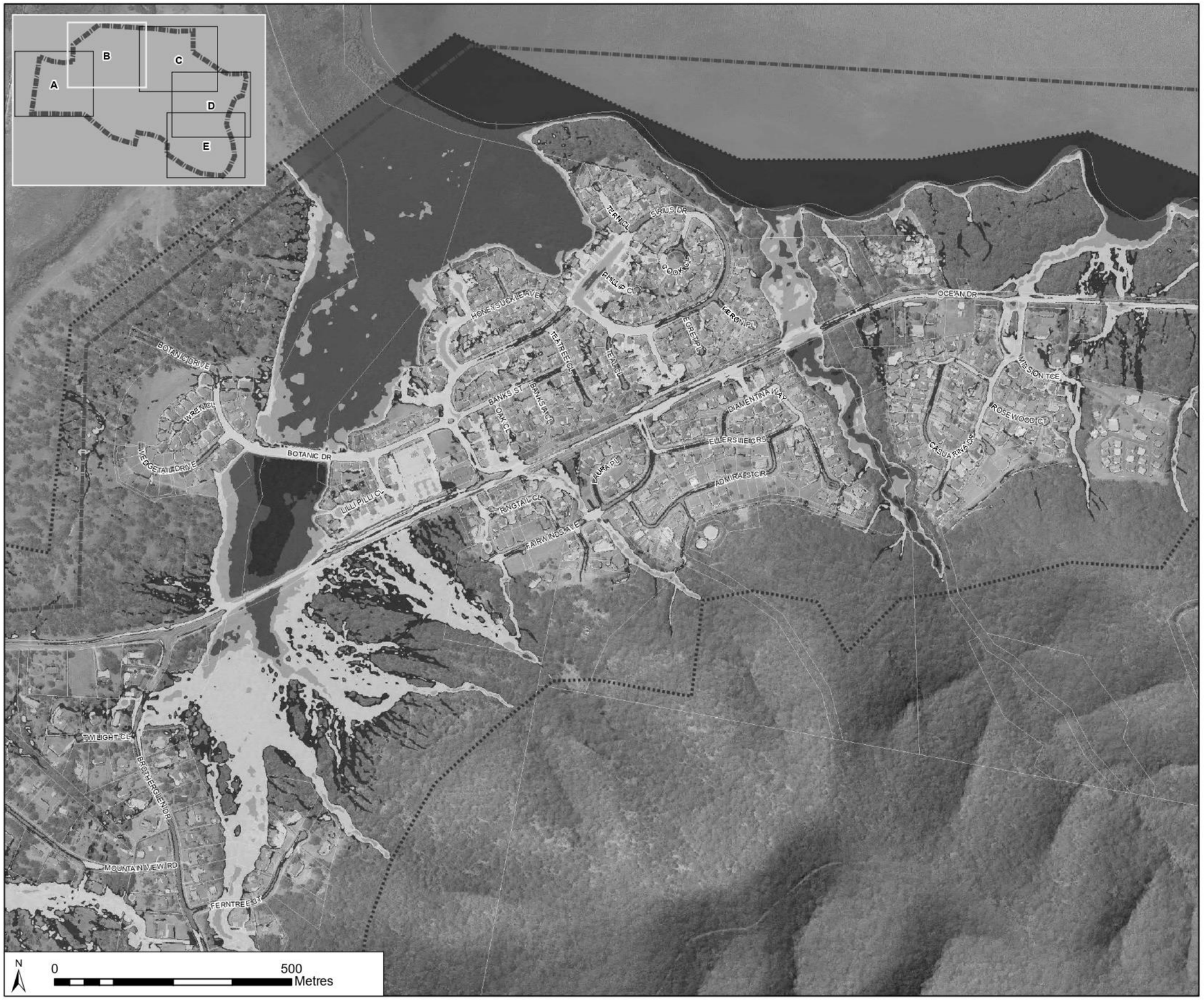
GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	1% AEP Design Flood Peak Flood Depths
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-3(A)
DATE 3/03/2020	



Legend

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area
- Limit of Mapping

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and LakesSystem Flood Study (2013) for riverine flooding mapping.

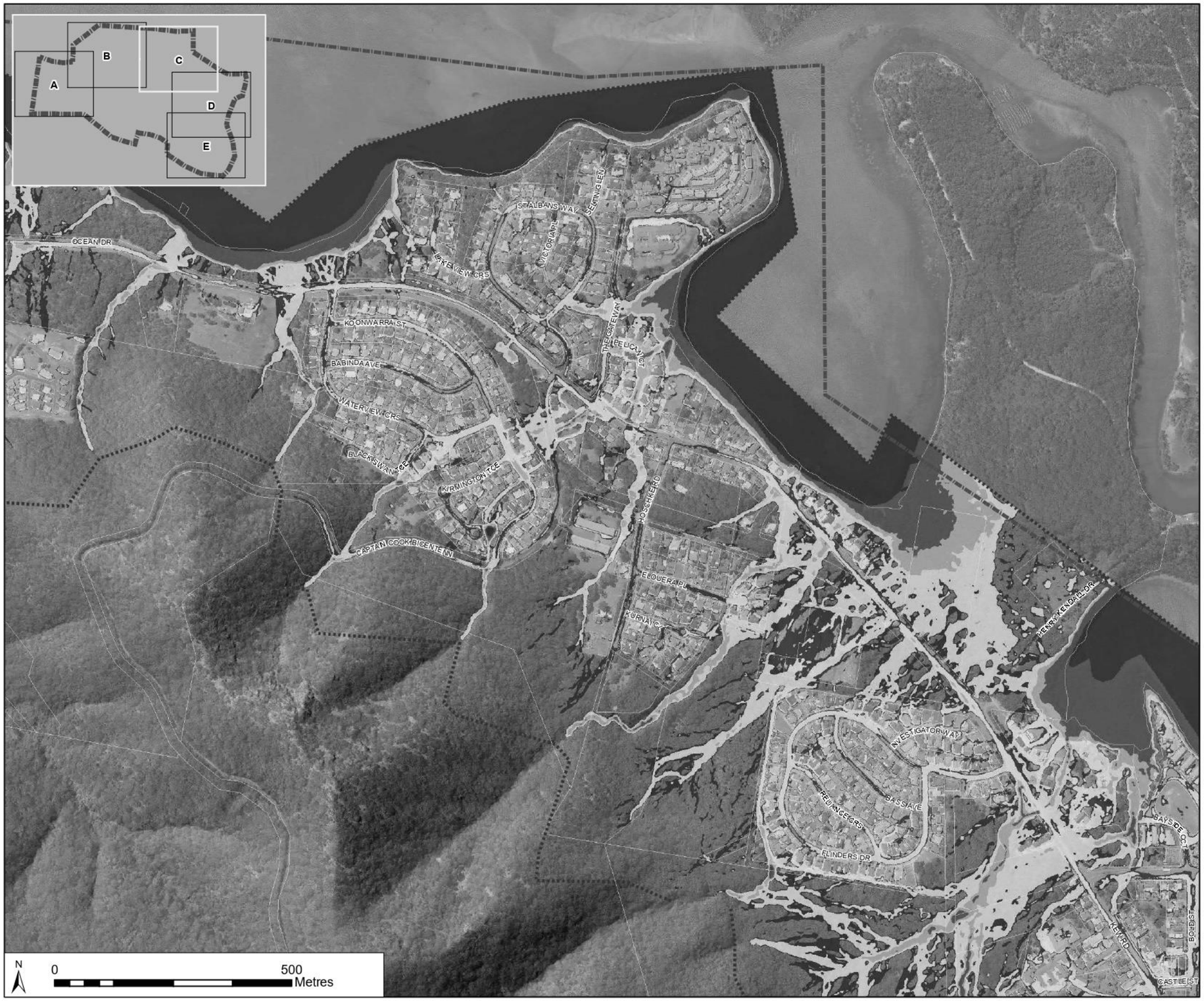
GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	1% AEP Design Flood Peak Flood Depths
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-3(B)
DATE 3/03/2020	



Legend

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area
- Limit of Mapping

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and LakesSystem Flood Study (2013) for riverine flooding mapping.

GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	1% AEP Design Flood Peak Flood Depths
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-3(C)
DATE 3/03/2020	

Legend

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area
- Limit of Mapping

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and LakesSystem Flood Study (2013) for riverine flooding mapping.

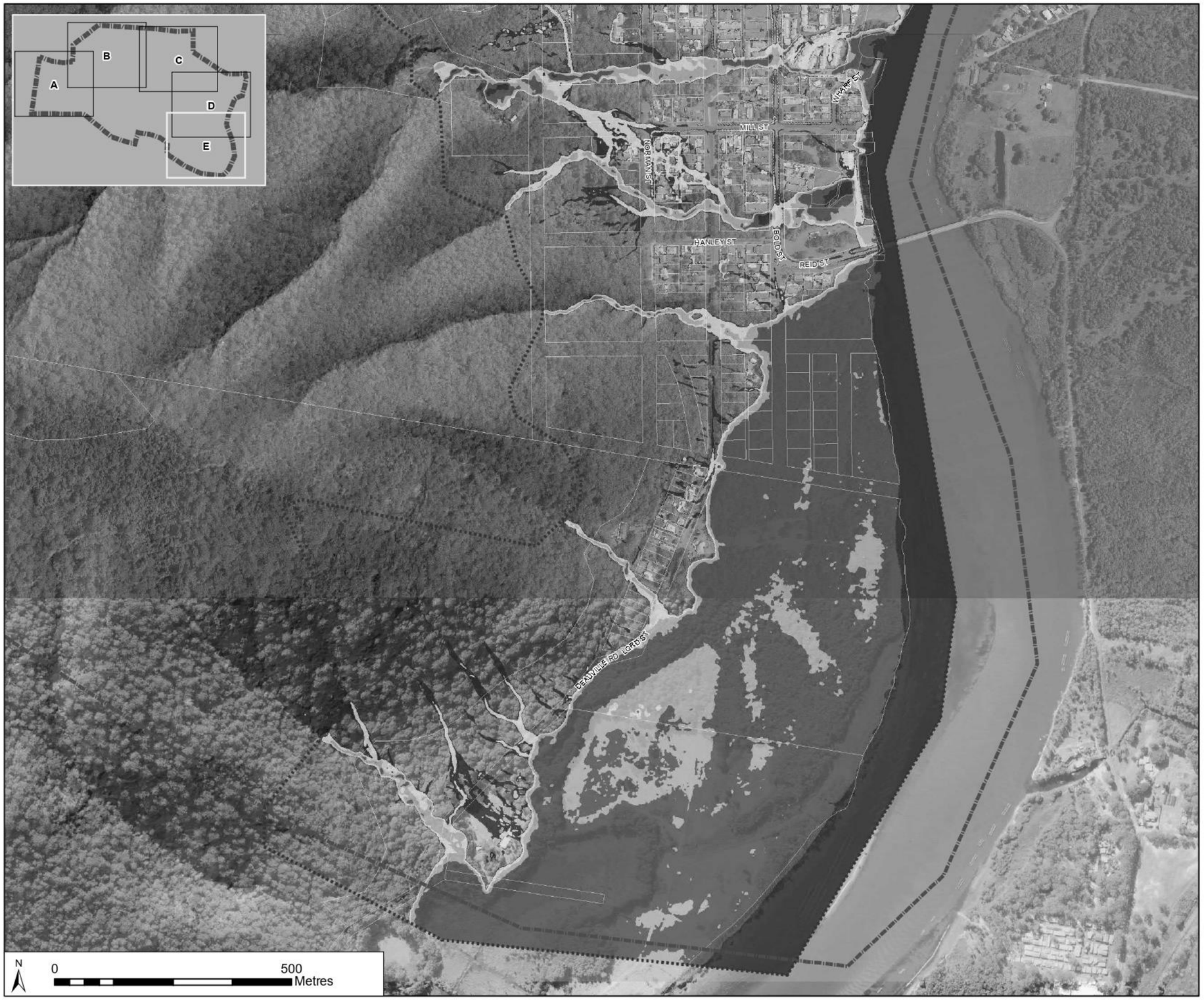
GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	1% AEP Design Flood Peak Flood Depths
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-3(D)
DATE 3/03/2020	



Legend

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area
- Limit of Mapping

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and LakesSystem Flood Study (2013) for riverine flooding mapping.

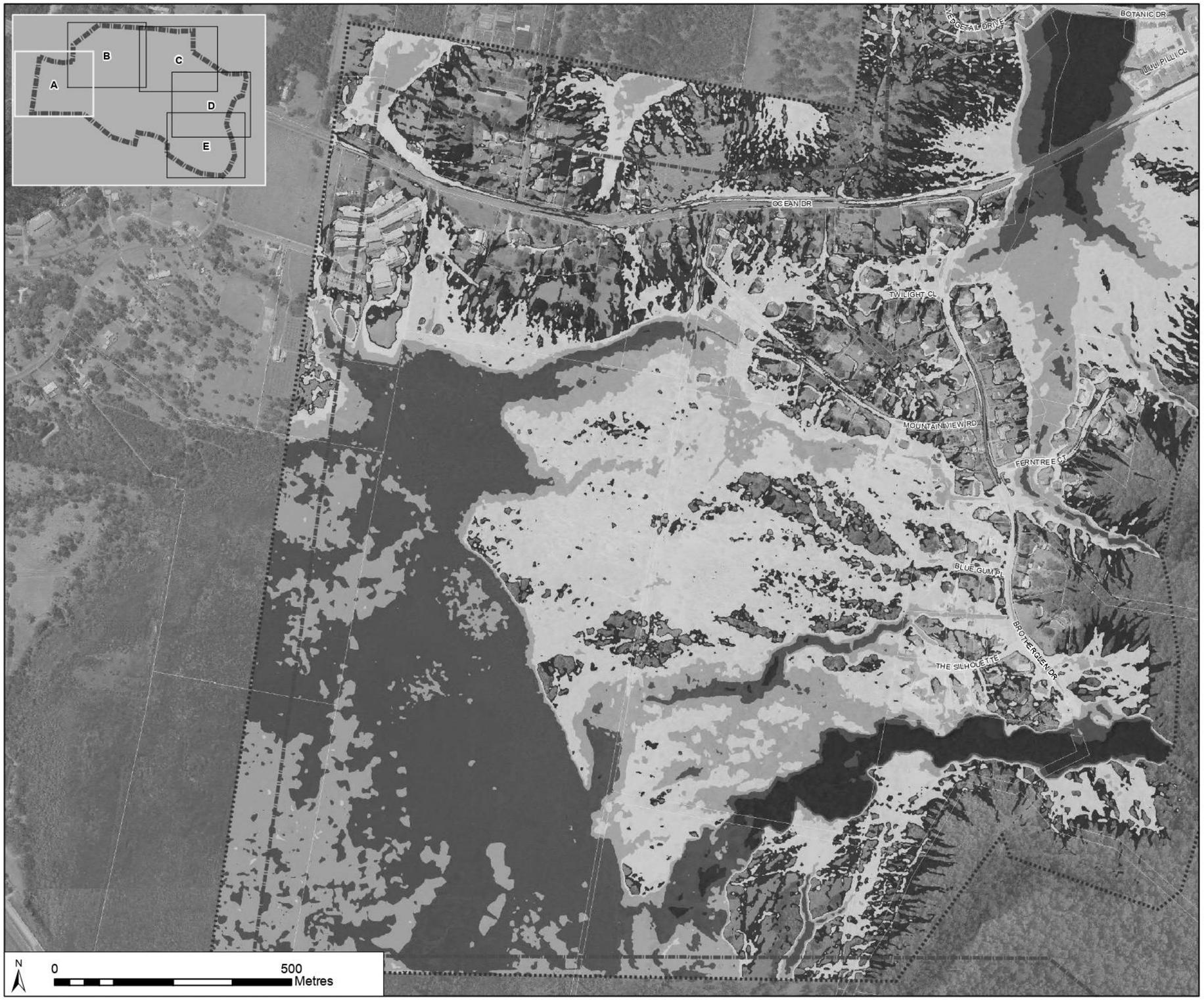
GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	1% AEP Design Flood Peak Flood Depths
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-3(E)
DATE 3/03/2020	



Legend

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area
- Limit of Mapping

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and Lakes System Flood Study (2013) for riverine flooding mapping.

GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	Probable Maximum Flood Peak Flood Depths
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-4(A)
DATE 28/11/2018	

Legend

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area
- Limit of Mapping

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and Lakes System Flood Study (2013) for riverine flooding mapping.

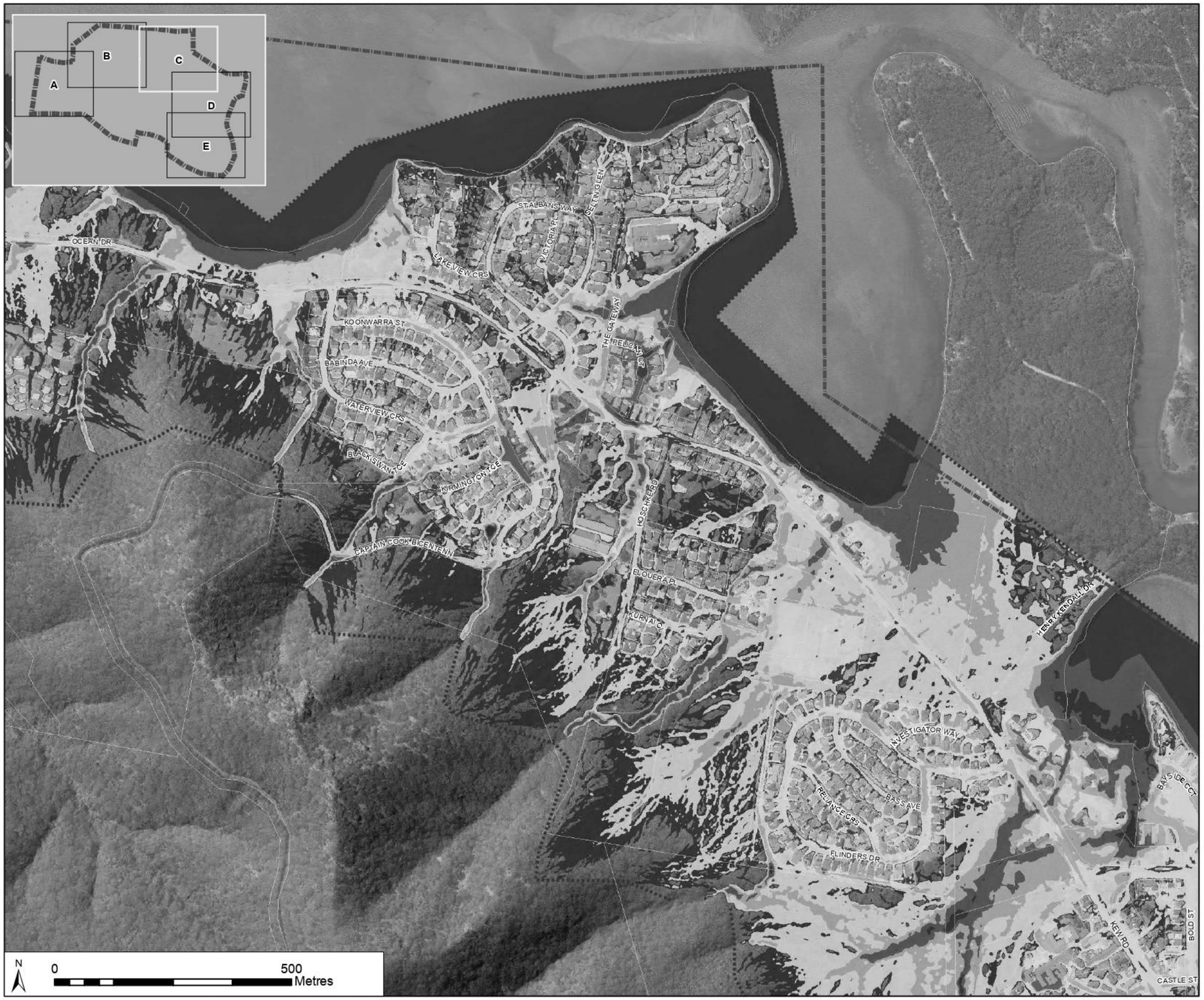
GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	Probable Maximum Flood Peak Flood Depths
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-4(B)
DATE 28/11/2018	



Legend

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area
- Limit of Mapping

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and Lakes System Flood Study (2013) for riverine flooding mapping.

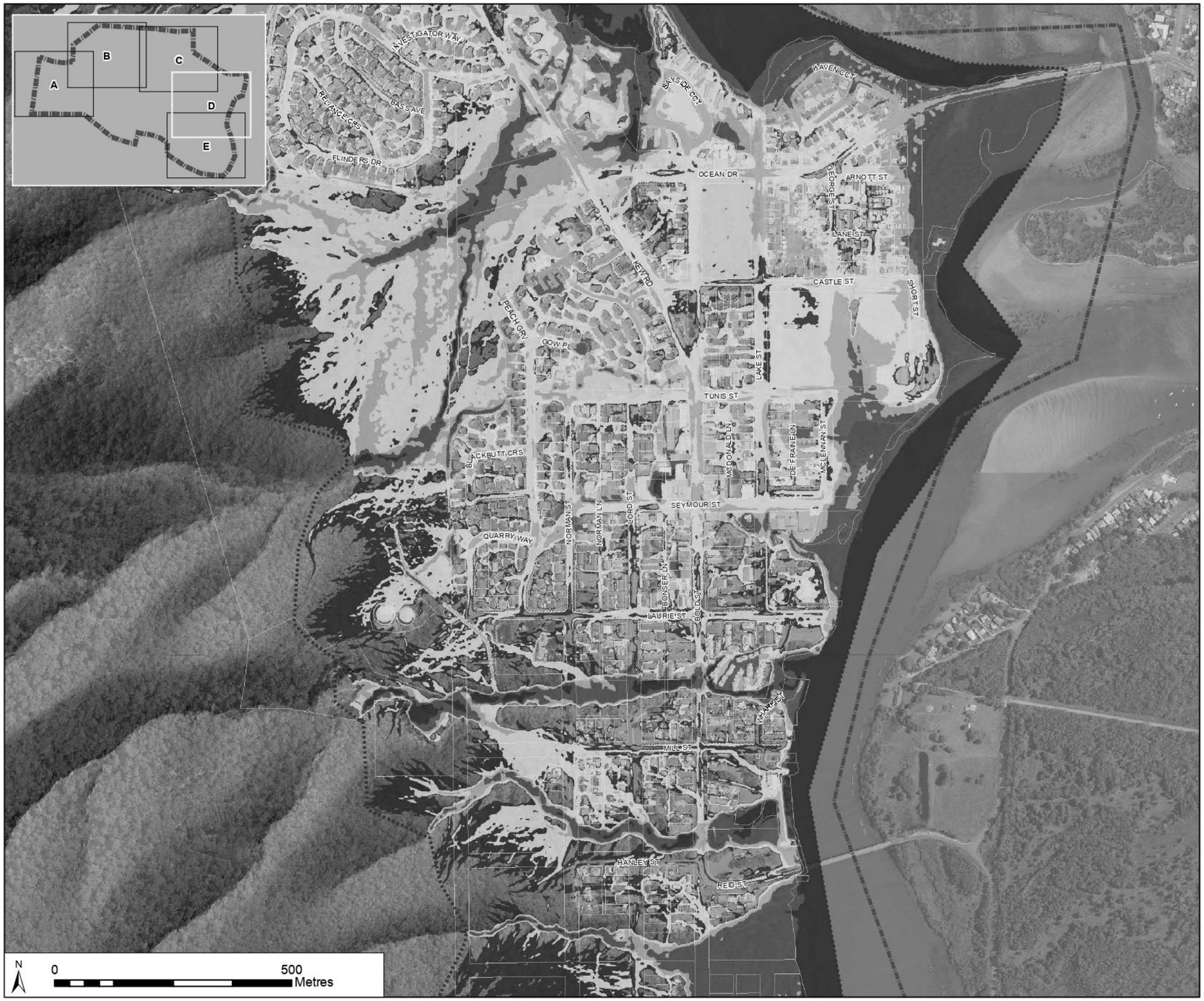
GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	Probable Maximum Flood Peak Flood Depths
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-4(C)
DATE 28/11/2018	



Legend

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area
- Limit of Mapping

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and Lakes System Flood Study (2013) for riverine flooding mapping.

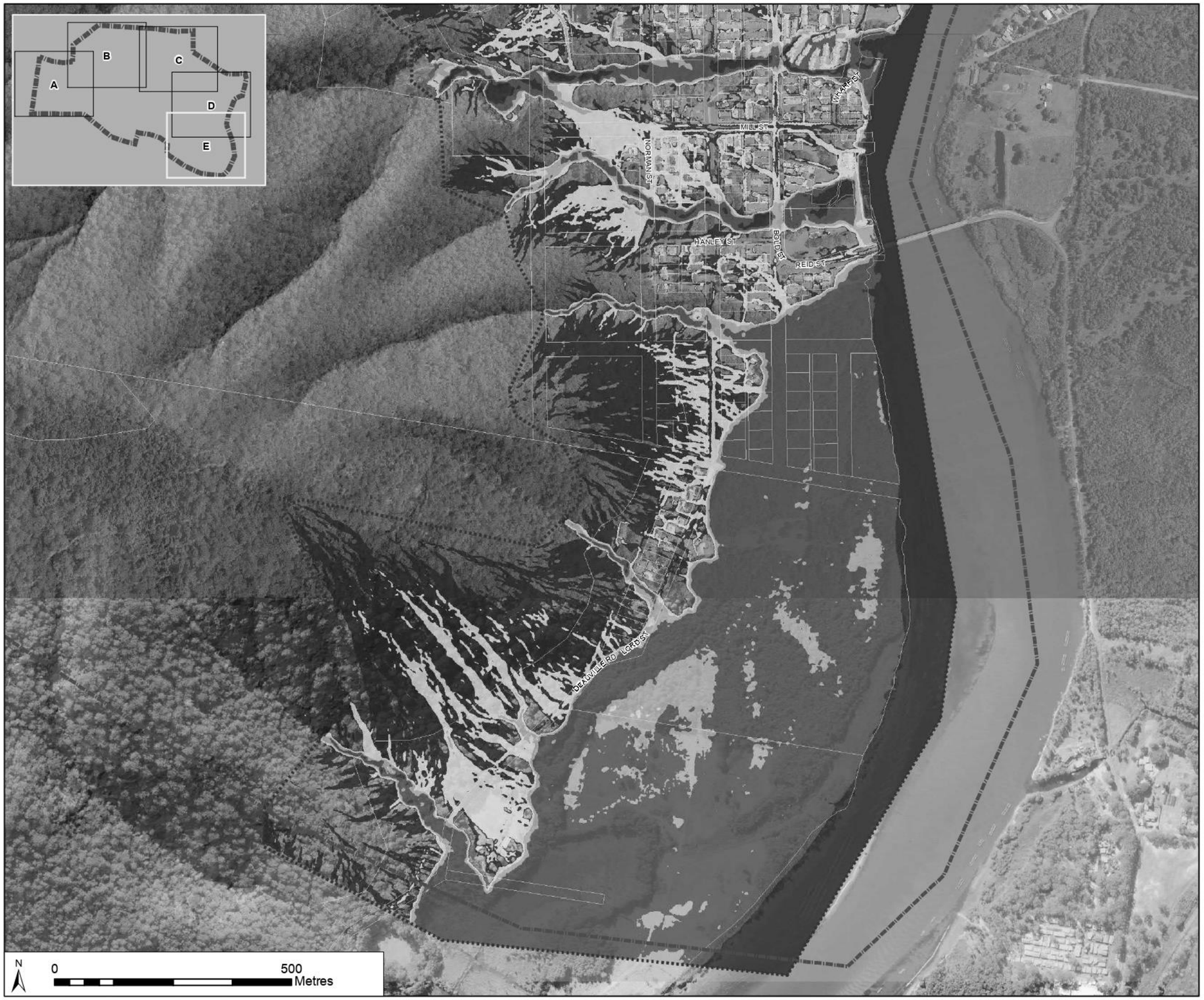
GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	Probable Maximum Flood Peak Flood Depths
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-4(D)
DATE 28/11/2018	



Legend

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area
- Limit of Mapping

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and Lakes System Flood Study (2013) for riverine flooding mapping.

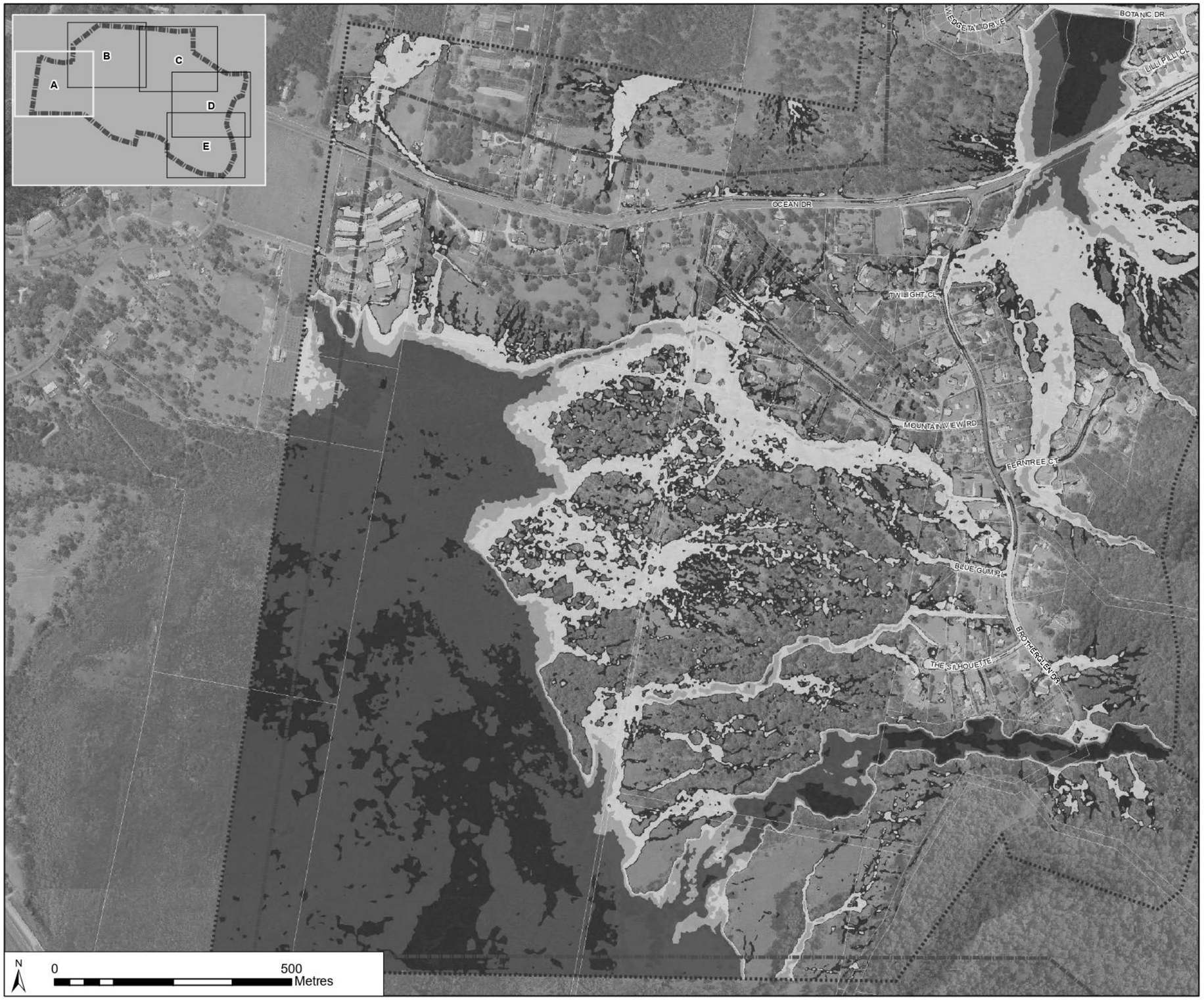
GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	Probable Maximum Flood Peak Flood Depths
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-4(E)
DATE 28/11/2018	



Legend

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area
- Limit of Mapping

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and LakesSystem Flood Study (2013) for riverine flooding mapping.

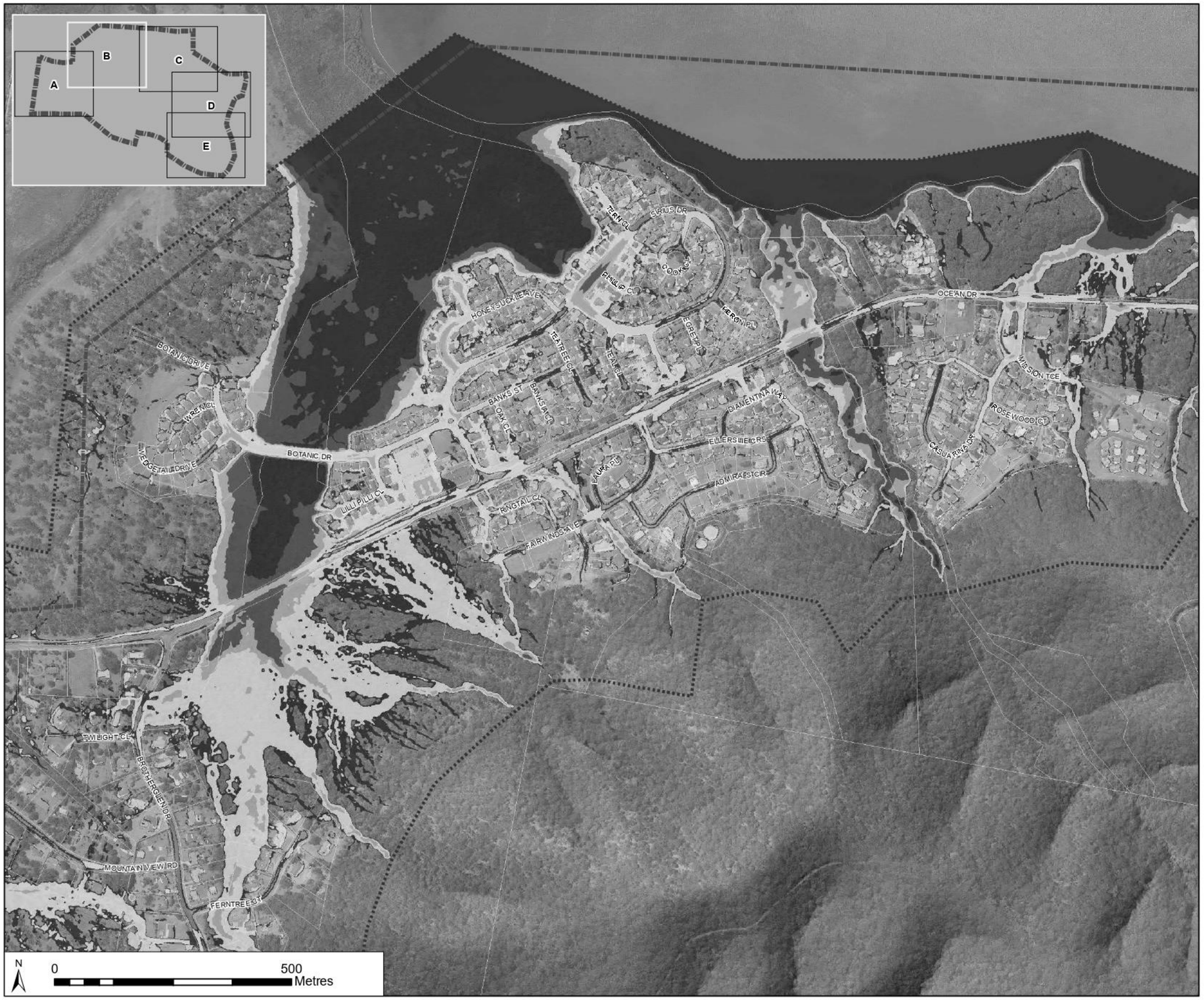
GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	1% AEP Design Flood Climate Change Scenario Peak Flood Depths
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-5(A)
DATE 3/03/2020	



Legend

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area
- Limit of Mapping

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and LakesSystem Flood Study (2013) for riverine flooding mapping.

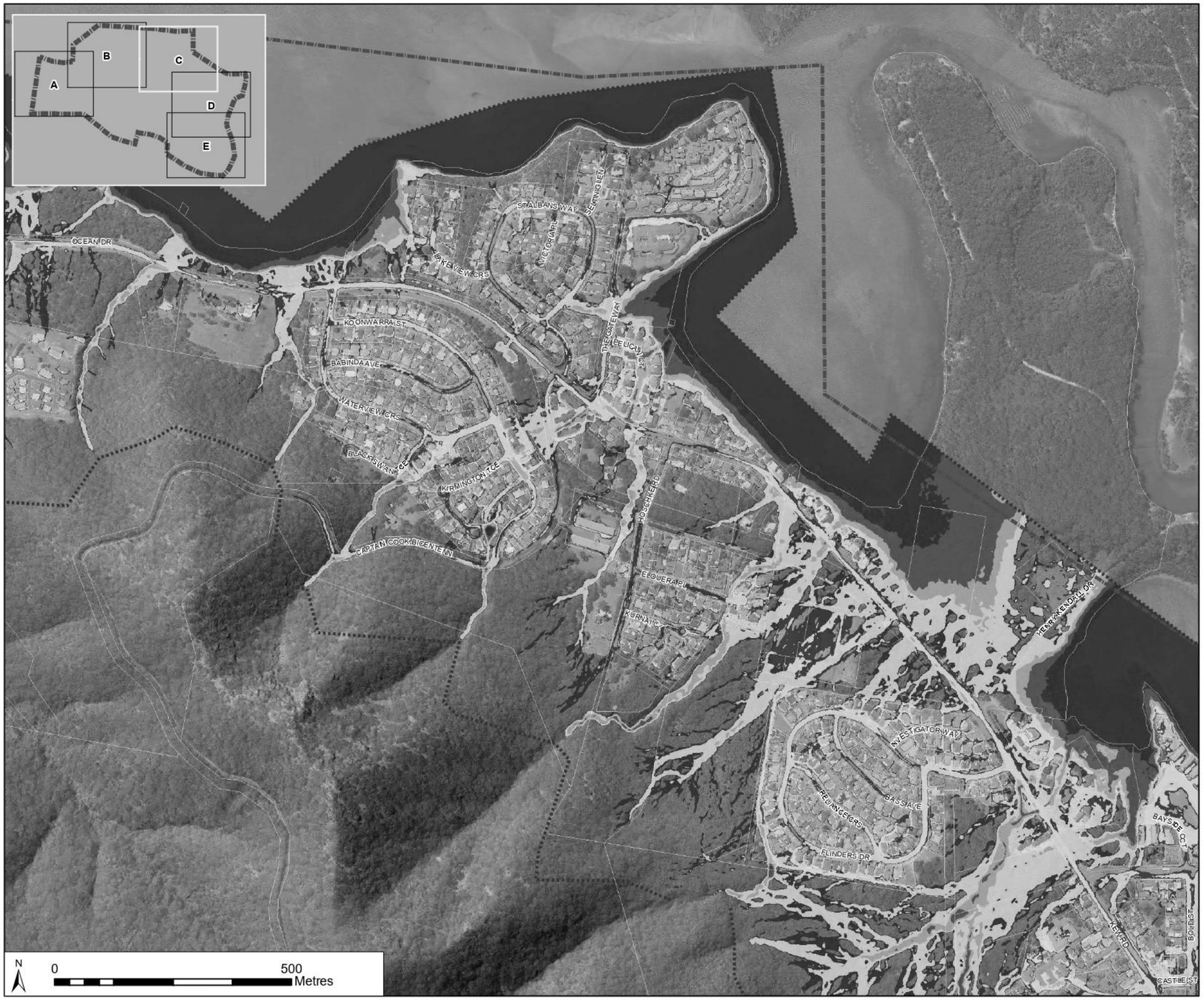
GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	1% AEP Design Flood Climate Change Scenario Peak Flood Depths
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-5(B)
DATE 3/03/2020	



Legend

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area
- Limit of Mapping

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and LakesSystem Flood Study (2013) for riverine flooding mapping.

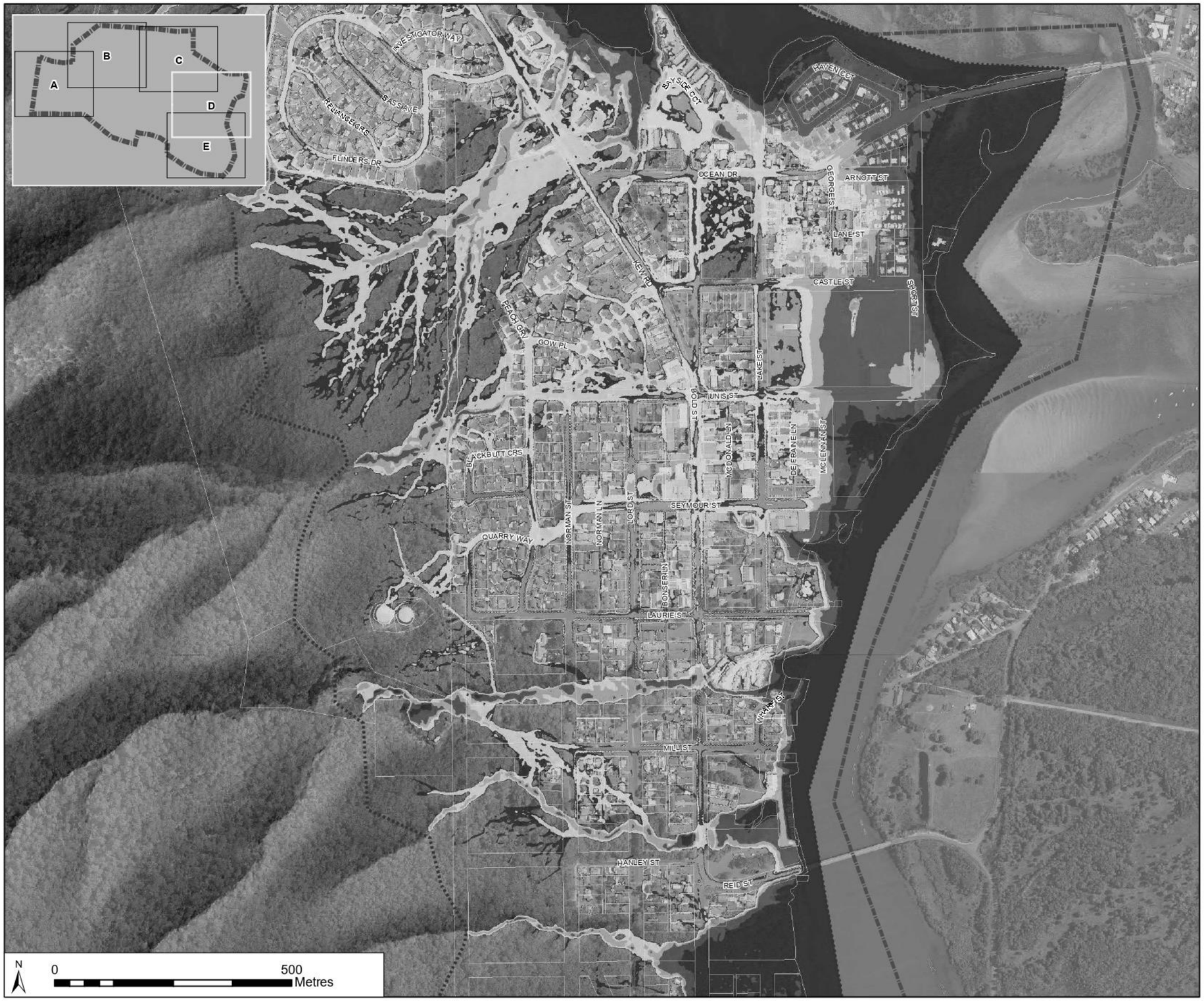
GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	1% AEP Design Flood Climate Change Scenario Peak Flood Depths
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-5(C)
DATE 3/03/2020	



Legend

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area
- Limit of Mapping

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and LakesSystem Flood Study (2013) for riverine flooding mapping.

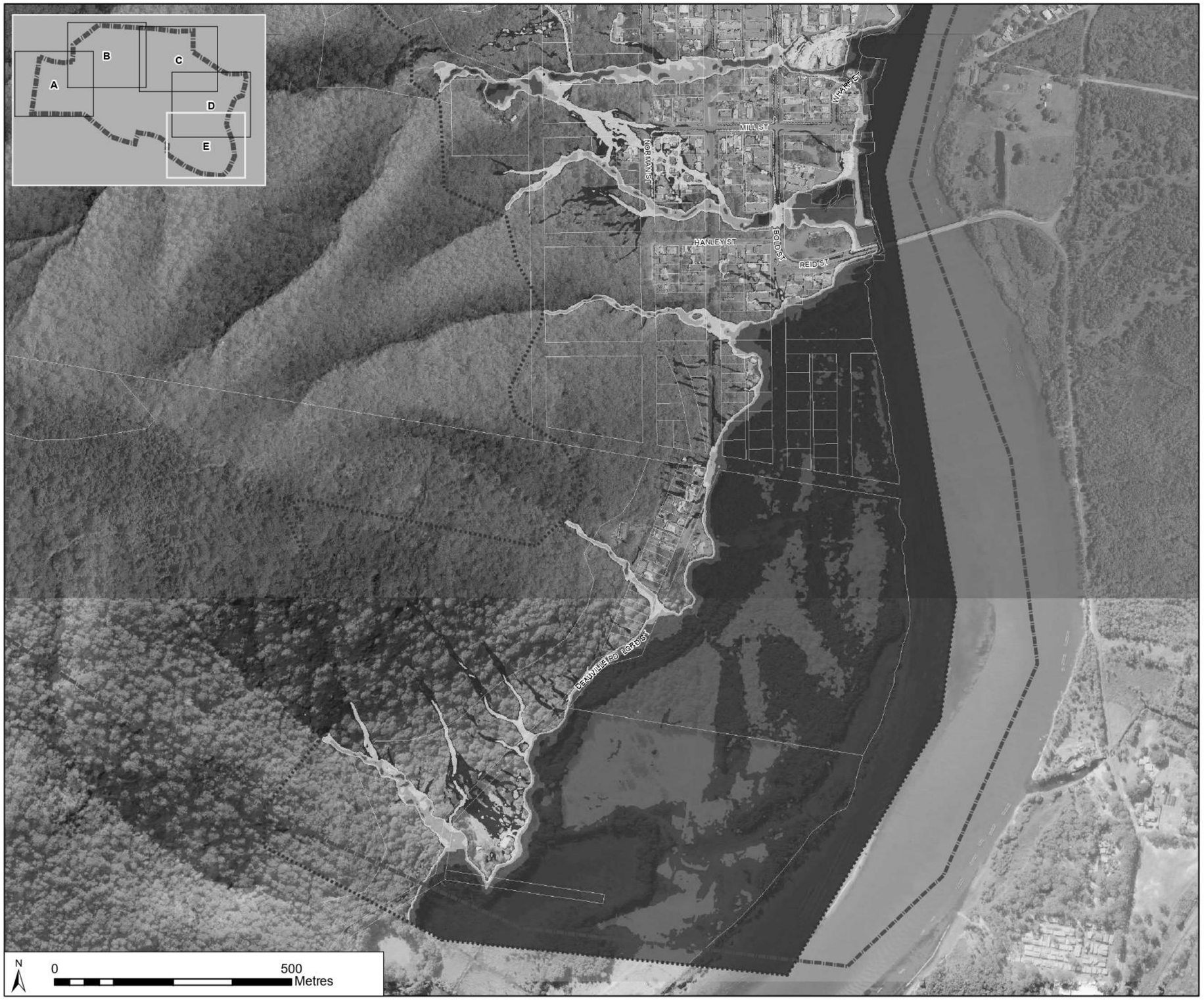
GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	1% AEP Design Flood Climate Change Scenario Peak Flood Depths
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-5(D)
DATE 3/03/2020	



Legend

Peak Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- Study Area
- Limit of Mapping

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and LakesSystem Flood Study (2013) for riverine flooding mapping.

GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	1% AEP Design Flood Climate Change Scenario Peak Flood Depths
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-5(E)
DATE 3/03/2020	

Legend

Flood Hazard Category

- H1 - Generally safe for vehicles, people and buildings.
- H2 - Unsafe for small vehicles.
- H3 - Unsafe for all vehicles, children and the elderly.
- H4 - Unsafe for all people and all vehicles.
- H5 - Unsafe for all people and all vehicles. Buildings require special engineering design and construction.
- H6 - Unsafe for Vehicles and people. All building types considered vulnerable to failure.
- Study Area
- Limit of Mapping

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and Lakes System Flood Study (2013) for riverine flooding mapping.

GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	1% AEP Design Flood Flood Hazard Categories
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-6(A)
DATE 3/03/2020	

Legend

Flood Hazard Category

- H1 - Generally safe for vehicles, people and buildings.
- H2 - Unsafe for small vehicles.
- H3 - Unsafe for all vehicles, children and the elderly.
- H4 - Unsafe for all people and all vehicles.
- H5 - Unsafe for all people and all vehicles. Buildings require special engineering design and construction.
- H6 - Unsafe for Vehicles and people. All building types considered vulnerable to failure.
- Study Area
- Limit of Mapping

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and Lakes System Flood Study (2013) for riverine flooding mapping.

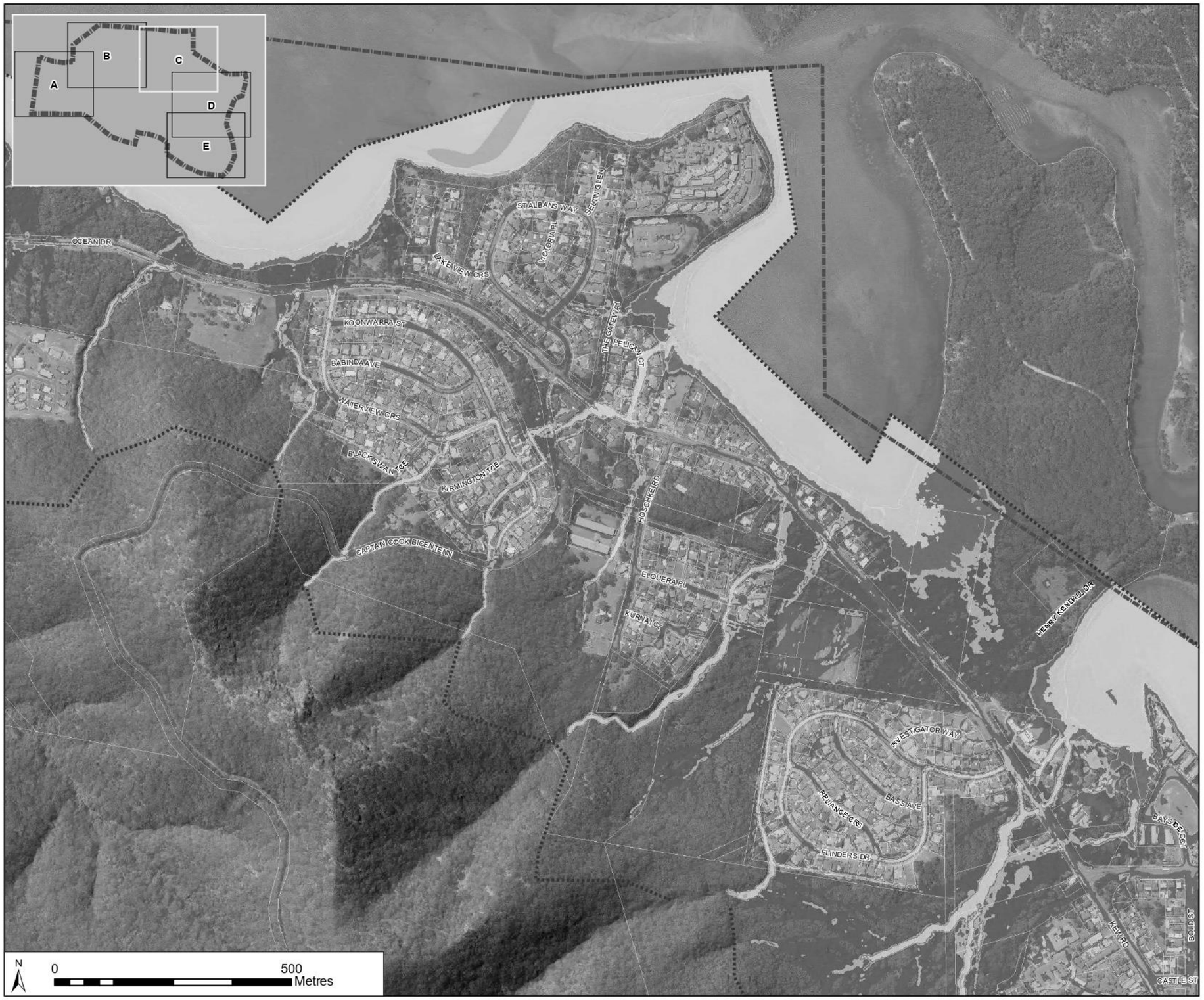
GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	1% AEP Design Flood Flood Hazard Categories
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-6(B)
DATE 3/03/2020	



Legend

Flood Hazard Category

- H1 - Generally safe for vehicles, people and buildings.
- H2 - Unsafe for small vehicles.
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- H4 - Unsafe for all people and all vehicles.
- H5 - Unsafe for all people and all vehicles. Buildings require special engineering design and construction.
- H6 - Unsafe for Vehicles and people. All building types considered vulnerable to failure.
- Study Area
- Limit of Mapping

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and Lakes System Flood Study (2013) for riverine flooding mapping.

GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	1% AEP Design Flood Flood Hazard Categories
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-6(C)
DATE 3/03/2020	

Legend

Flood Hazard Category

- H1 - Generally safe for vehicles, people and buildings.
- H2 - Unsafe for small vehicles.
- H3 - Unsafe for all vehicles, children and the elderly.
- H4 - Unsafe for all people and all vehicles.
- H5 - Unsafe for all people and all vehicles. Buildings require special engineering design and construction.
- H6 - Unsafe for Vehicles and people. All building types considered vulnerable to failure.
- Study Area
- Limit of Mapping

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GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

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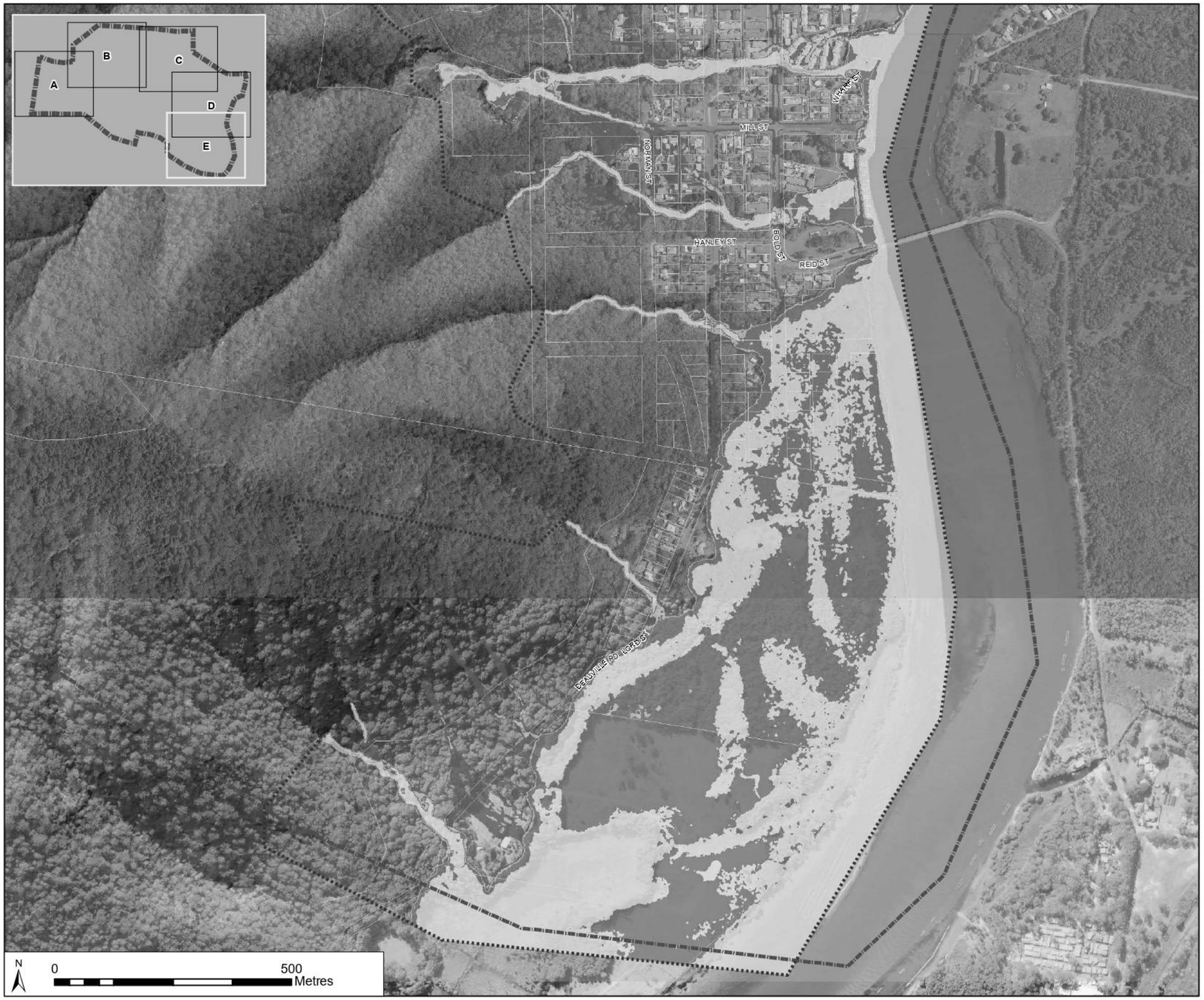
JACOBS

TITLE	1% AEP Design Flood Flood Hazard Categories
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-6(D)
DATE 3/03/2020	



Legend

Flood Hazard Category

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- H5 - Unsafe for all people and all vehicles. Buildings require special engineering design and construction.
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- Study Area
- Limit of Mapping

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GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

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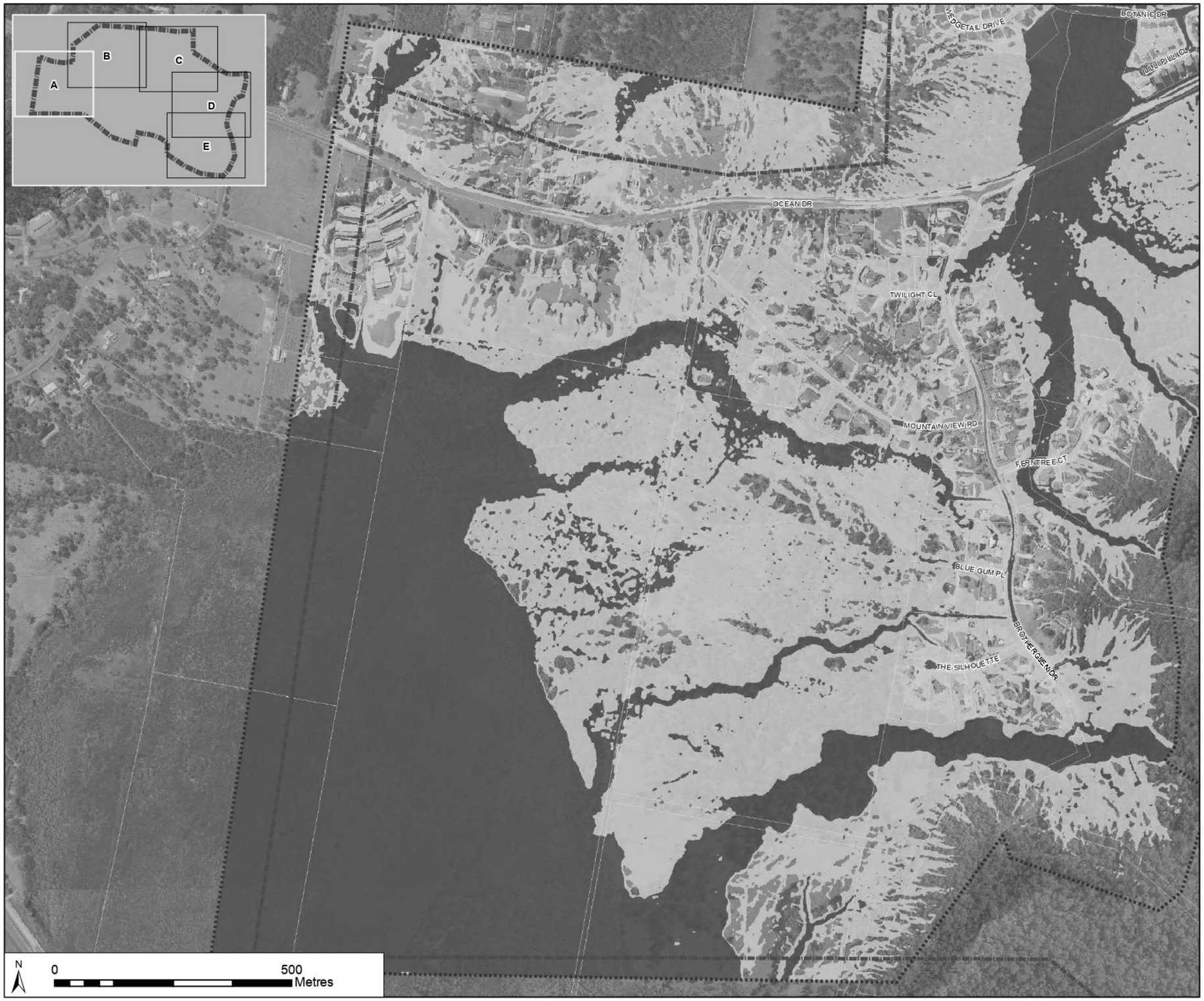
JACOBS

TITLE	1% AEP Design Flood Flood Hazard Categories
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-6(E)
DATE 3/03/2020	



Legend

Hydraulic Categories

- Floodway
- Flood Storage
- Flood Fringe
- Watercourse
- Limit of Mapping
- Study Area

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and Lakes System Flood Study (2013) for riverine flooding mapping.

GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

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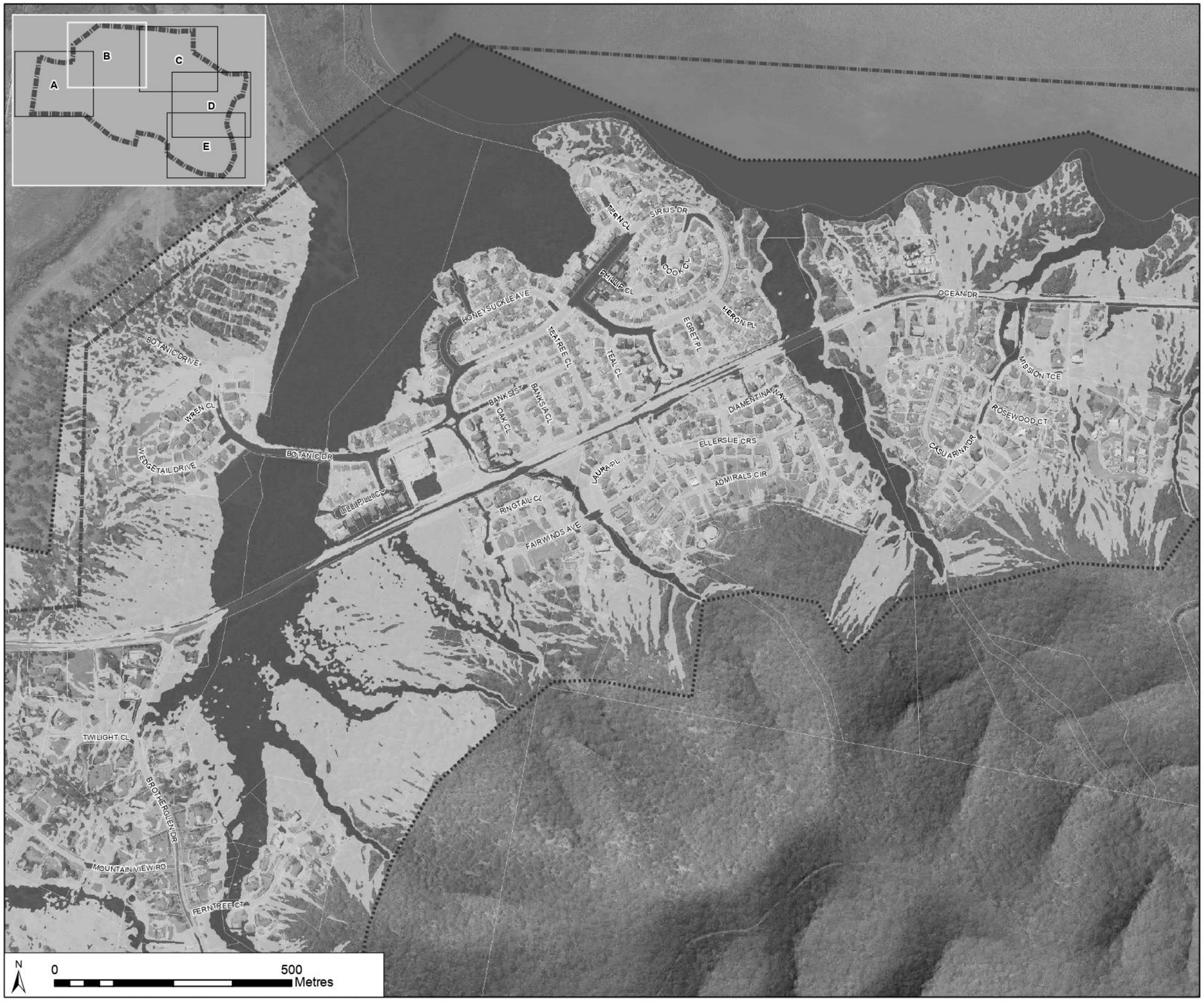
JACOBS

TITLE	1% AEP Design Flood Hydraulic Categories
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-7(A)
DATE 5/12/2018	



Legend

Hydraulic Categories

- Floodway
- Flood Storage
- Flood Fringe
- Watercourse
- Limit of Mapping
- Study Area

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and Lakes System Flood Study (2013) for riverine flooding mapping.

GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

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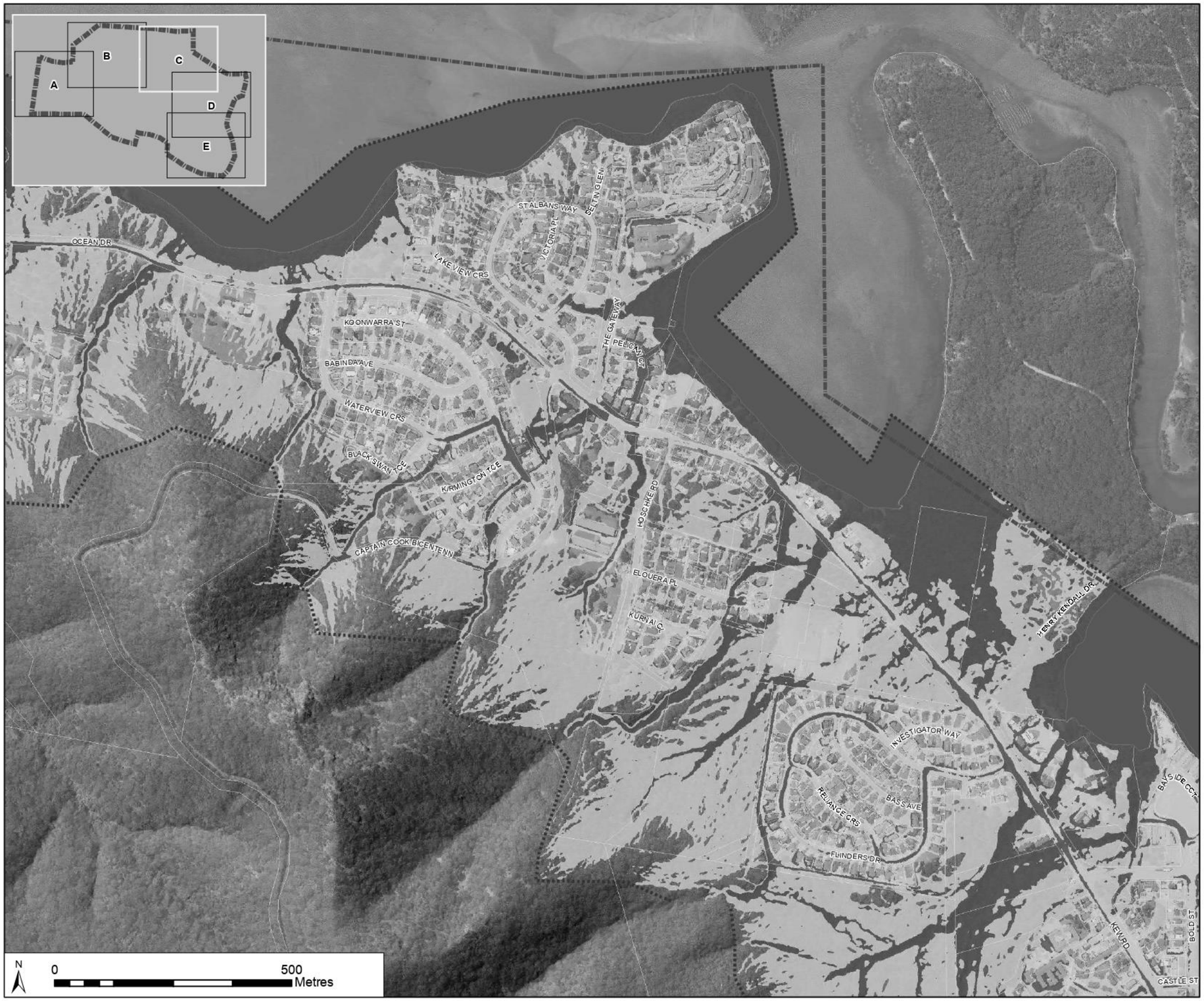
JACOBS

TITLE	1% AEP Design Flood Hydraulic Categories
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-7(B)
DATE 5/12/2018	



Legend

Hydraulic Categories

- Floodway
- Flood Storage
- Flood Fringe
- Watercourse
- Limit of Mapping
- Study Area

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and Lakes System Flood Study (2013) for riverine flooding mapping.

GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

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JACOBS

TITLE	1% AEP Design Flood Hydraulic Categories
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-7(C)
DATE 5/12/2018	

Legend

Hydraulic Categories

- Floodway
- Flood Storage
- Flood Fringe
- Watercourse
- Limit of Mapping
- Study Area

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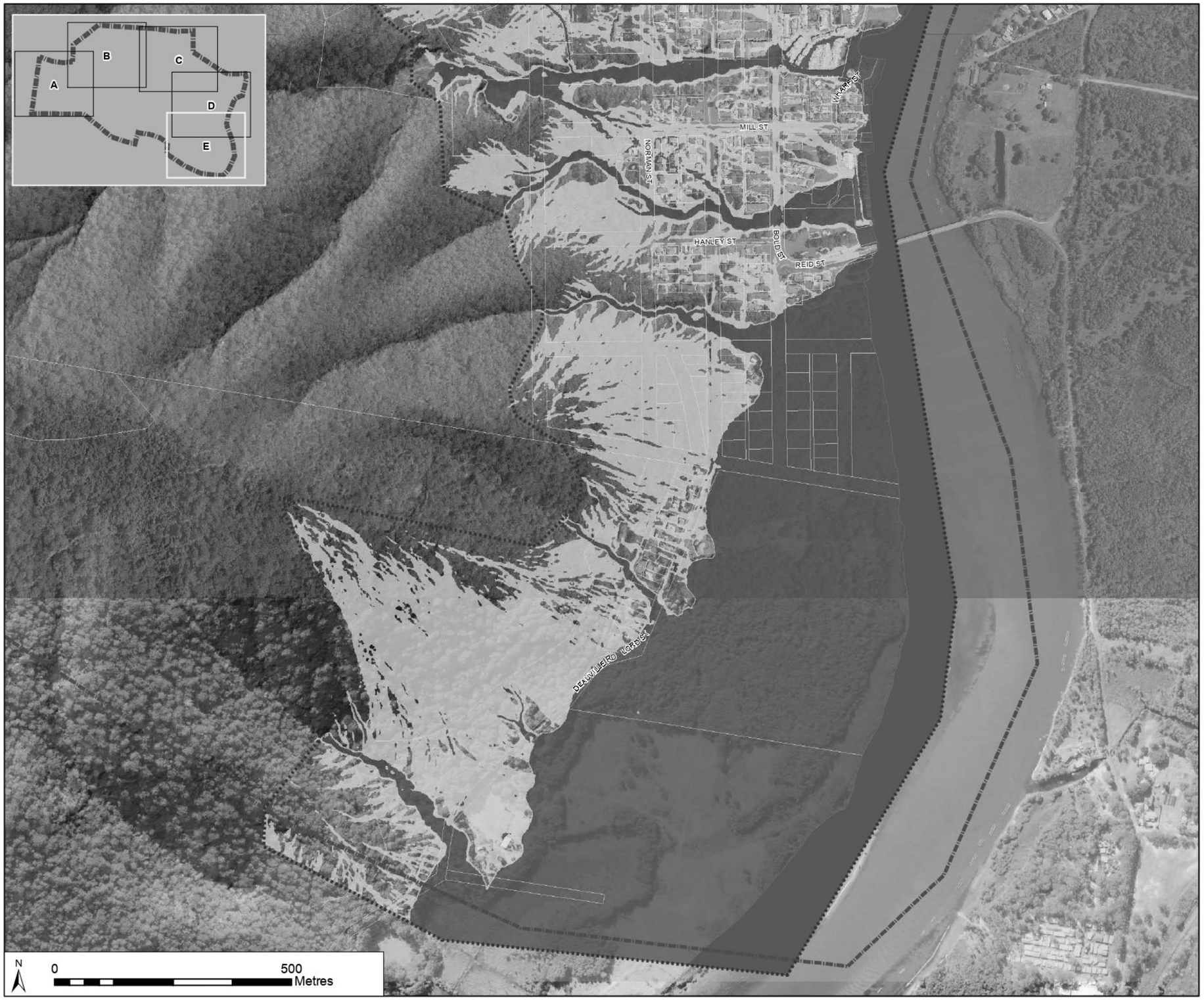
GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	1% AEP Design Flood Hydraulic Categories
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-7(D)
DATE 5/12/2018	



Legend

Hydraulic Categories

- Floodway
- Flood Storage
- Flood Fringe
- Watercourse
- Limit of Mapping
- Study Area

NOTE: The mapping shown here is for North Brother local catchment flooding only. Refer to the Camden Haven and Lakes System Flood Study (2013) for riverine flooding mapping.

GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

LIMITATIONS: This mapping is based on data and assumptions identified in the North Brother Local Catchments Flood Study prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy ofinformation contained in this map.

JACOBS

TITLE	1% AEP Design Flood Hydraulic Categories
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-7(E)
DATE 5/12/2018	

Legend

Flood Hazard Category

- H1 - Generally safe for vehicles, people and buildings.
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- Limit of Mapping

NOTES:
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2. The climate change scenario comprises a 10% increase in the 1% AEP rainfall and a 0.9m sea level rise.

GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

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JACOBS

TITLE	1% AEP Design Flood Climate Change Scenario Flood Hazard Categories
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-8(A)
DATE 3/03/2020	

Legend

Flood Hazard Category

- H1 - Generally safe for vehicles, people and buildings.
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- Study Area
- Limit of Mapping

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GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

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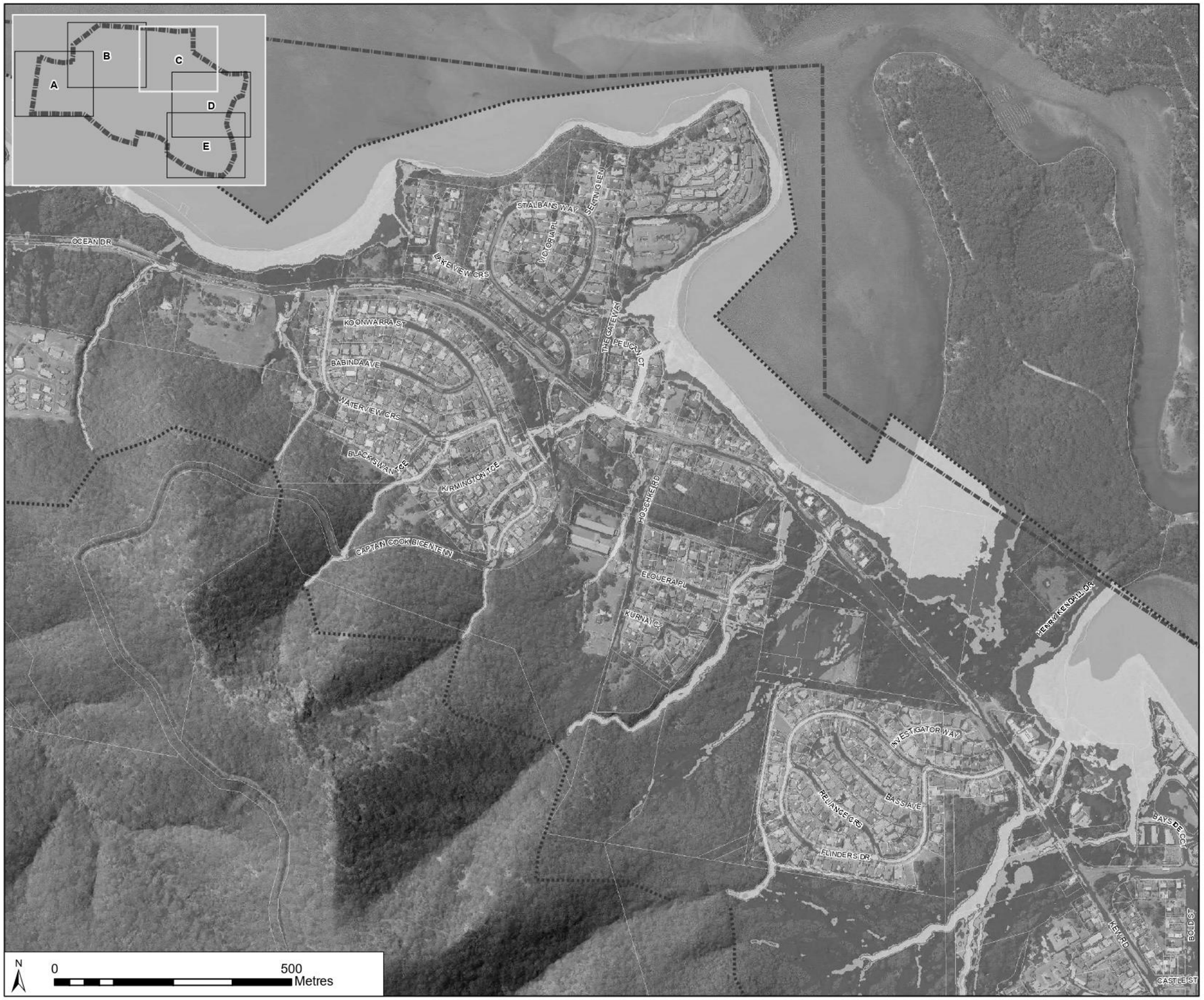
JACOBS

TITLE	1% AEP Design Flood Climate Change Scenario Flood Hazard Categories
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-8(B)
DATE 3/03/2020	



Legend

Flood Hazard Category

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Scale: A3

Data Sources: LPI, OEH, Council

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JACOBS

TITLE	1% AEP Design Flood Climate Change Scenario Flood Hazard Categories
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-8(C)
DATE 3/03/2020	

Legend

Flood Hazard Category

- H1 - Generally safe for vehicles, people and buildings.
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Scale: A3

Data Sources: LPI, OEH, Council

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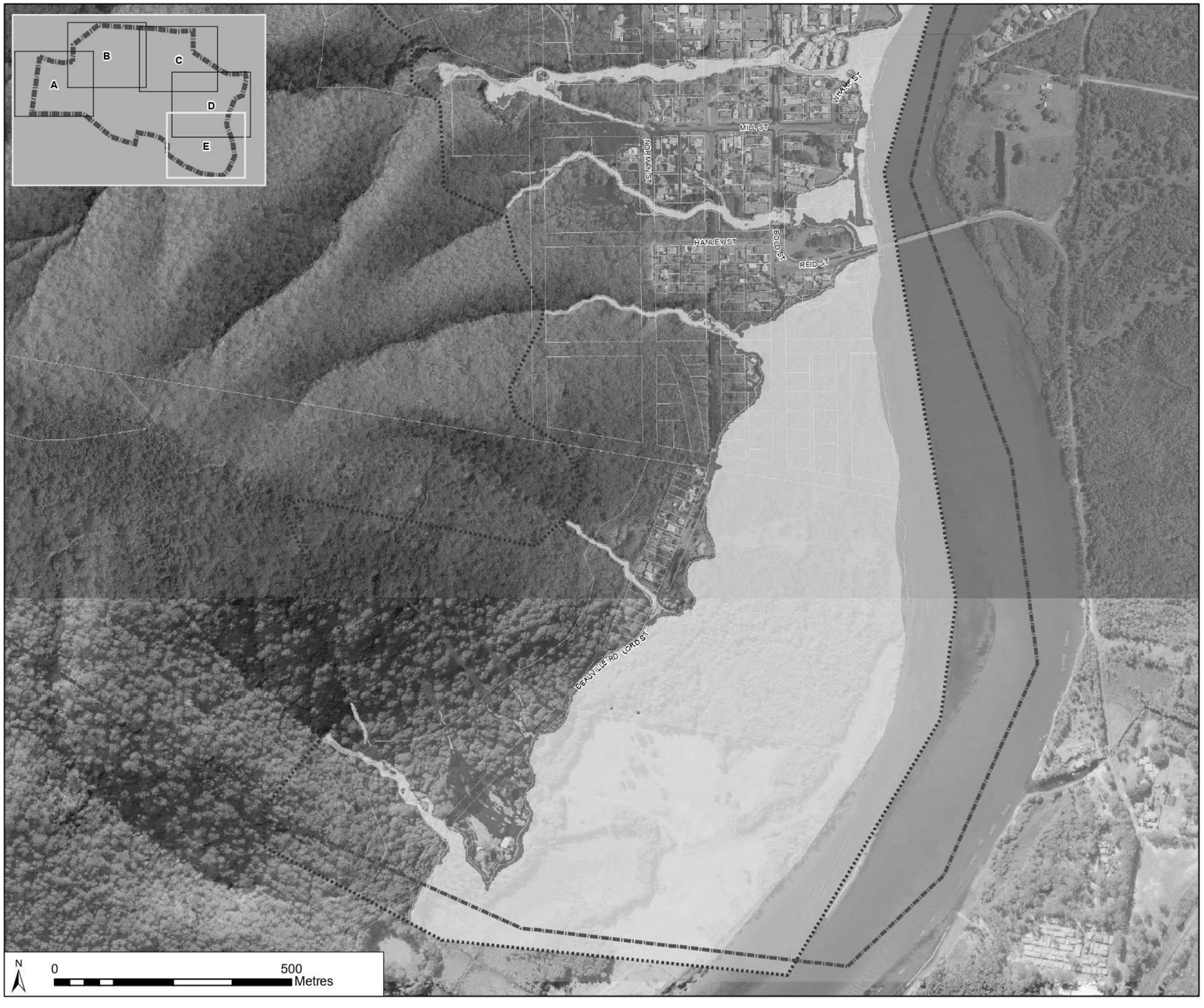
JACOBS

TITLE	1% AEP Design Flood Climate Change Scenario Flood Hazard Categories
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-8(D)
DATE 3/03/2020	



Legend

Flood Hazard Category

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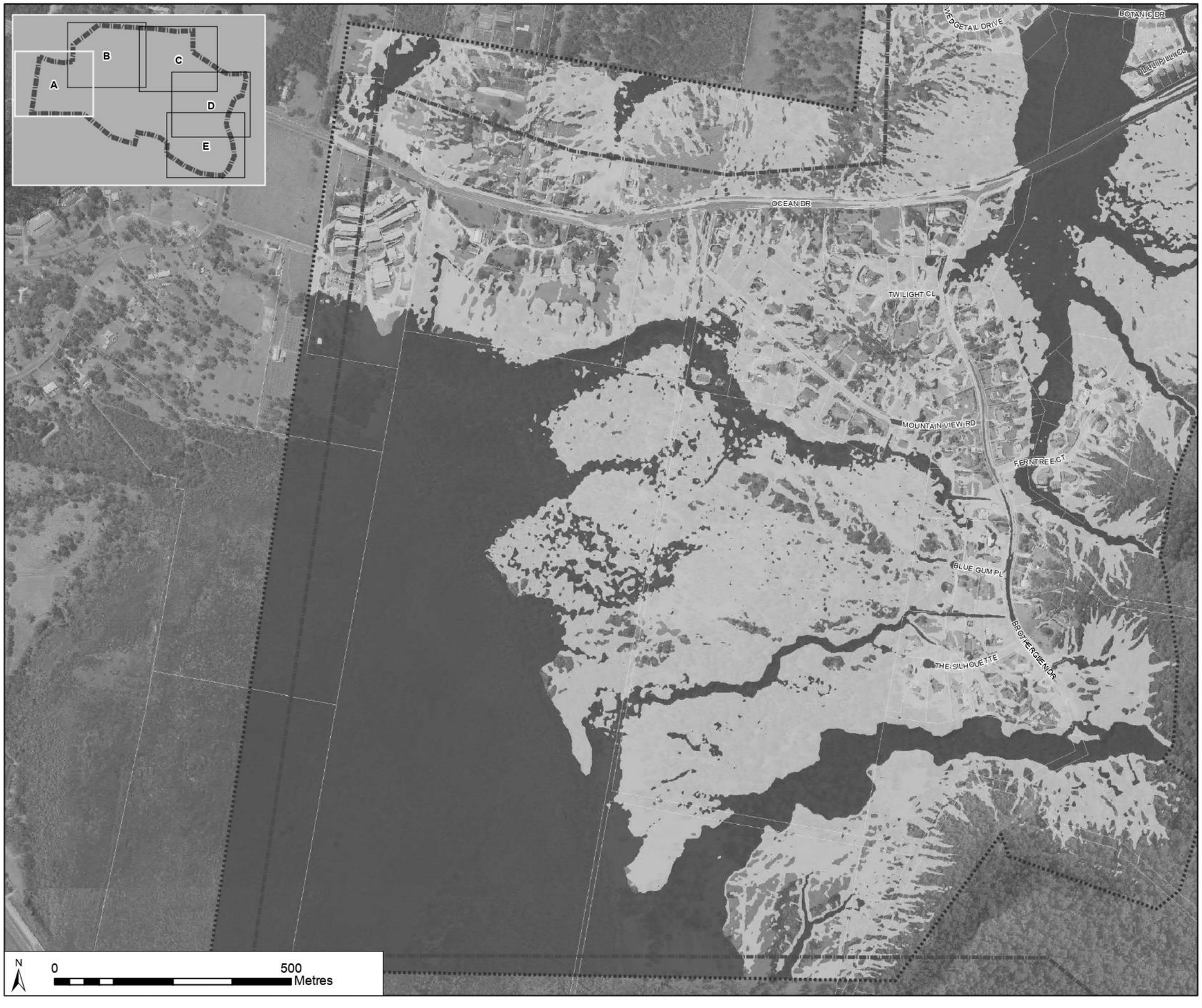
JACOBS

TITLE	1% AEP Design Flood Climate Change Scenario Flood Hazard Categories
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-8(E)
DATE 3/03/2020	



Legend

Hydraulic Categories

- Floodway
- Flood Storage
- Flood Fringe
- Watercourse
- Study Area
- Limit of Mapping

NOTES:
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Scale: A3

Data Sources: LPI, OEH, Council

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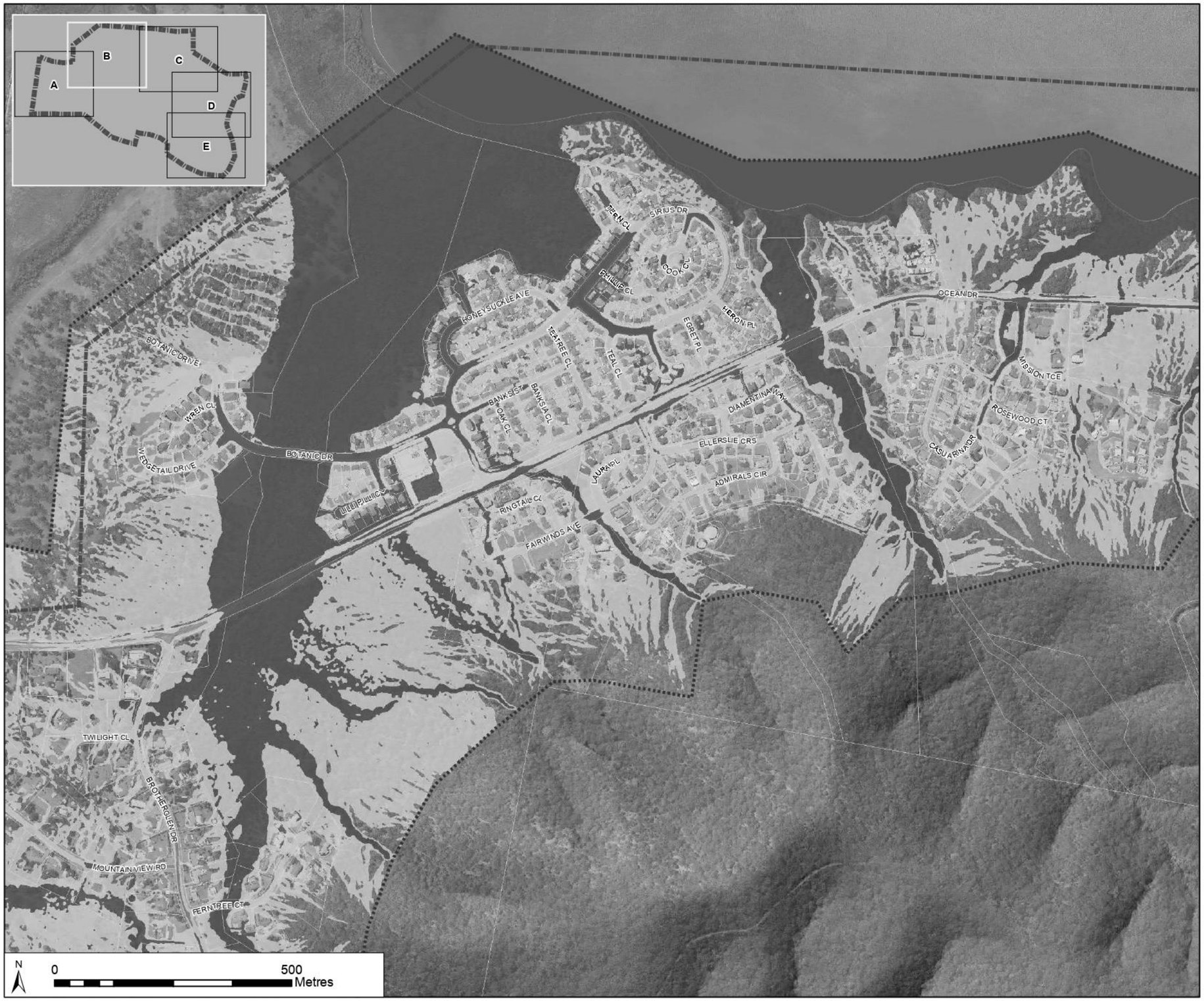
JACOBS

TITLE	1% AEP Design Flood Climate Change Scenario Hydraulic Categories
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-9(A)
DATE 5/12/2018	



Legend

Hydraulic Categories

- Floodway
- Flood Storage
- Flood Fringe
- Watercourse
- Study Area
- Limit of Mapping

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Scale: A3

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JACOBS

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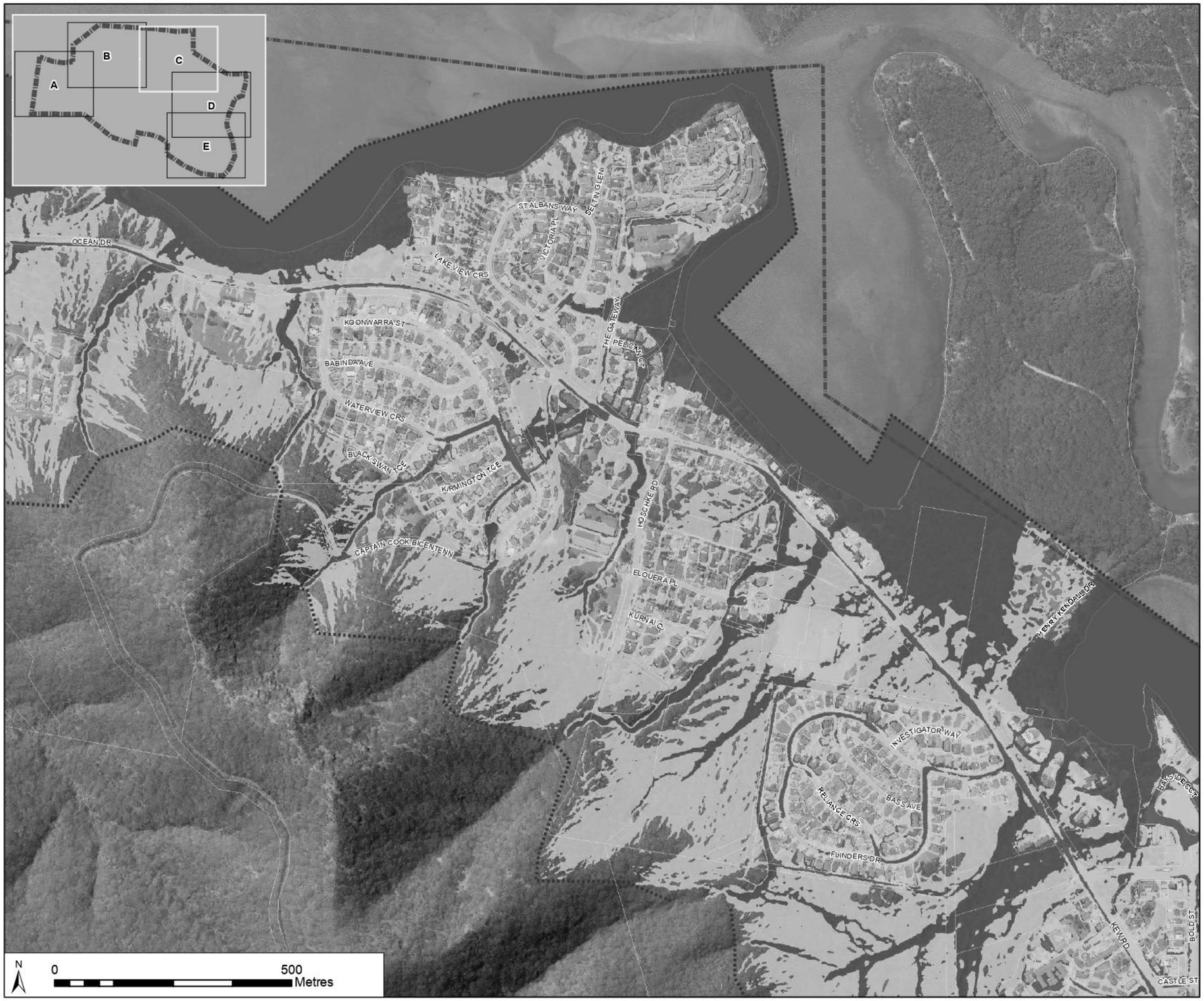
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-9(B)
DATE 5/12/2018	



Legend

Hydraulic Categories

- Floodway
- Flood Storage
- Flood Fringe
- Watercourse
- Study Area
- Limit of Mapping

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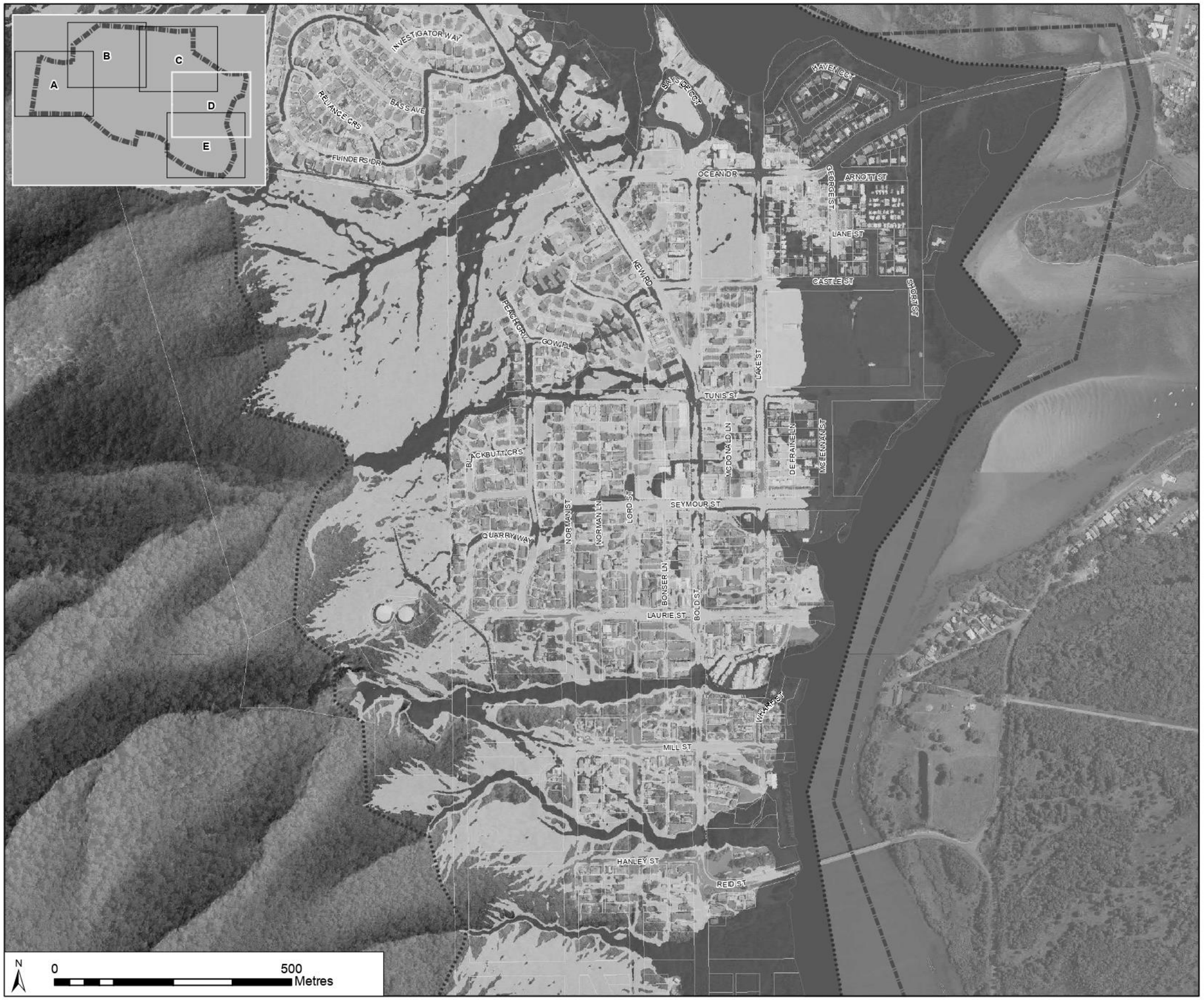
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-9(C)
DATE 5/12/2018	



Legend

Hydraulic Categories

- Floodway
- Flood Storage
- Flood Fringe
- Watercourse
- Study Area
- Limit of Mapping

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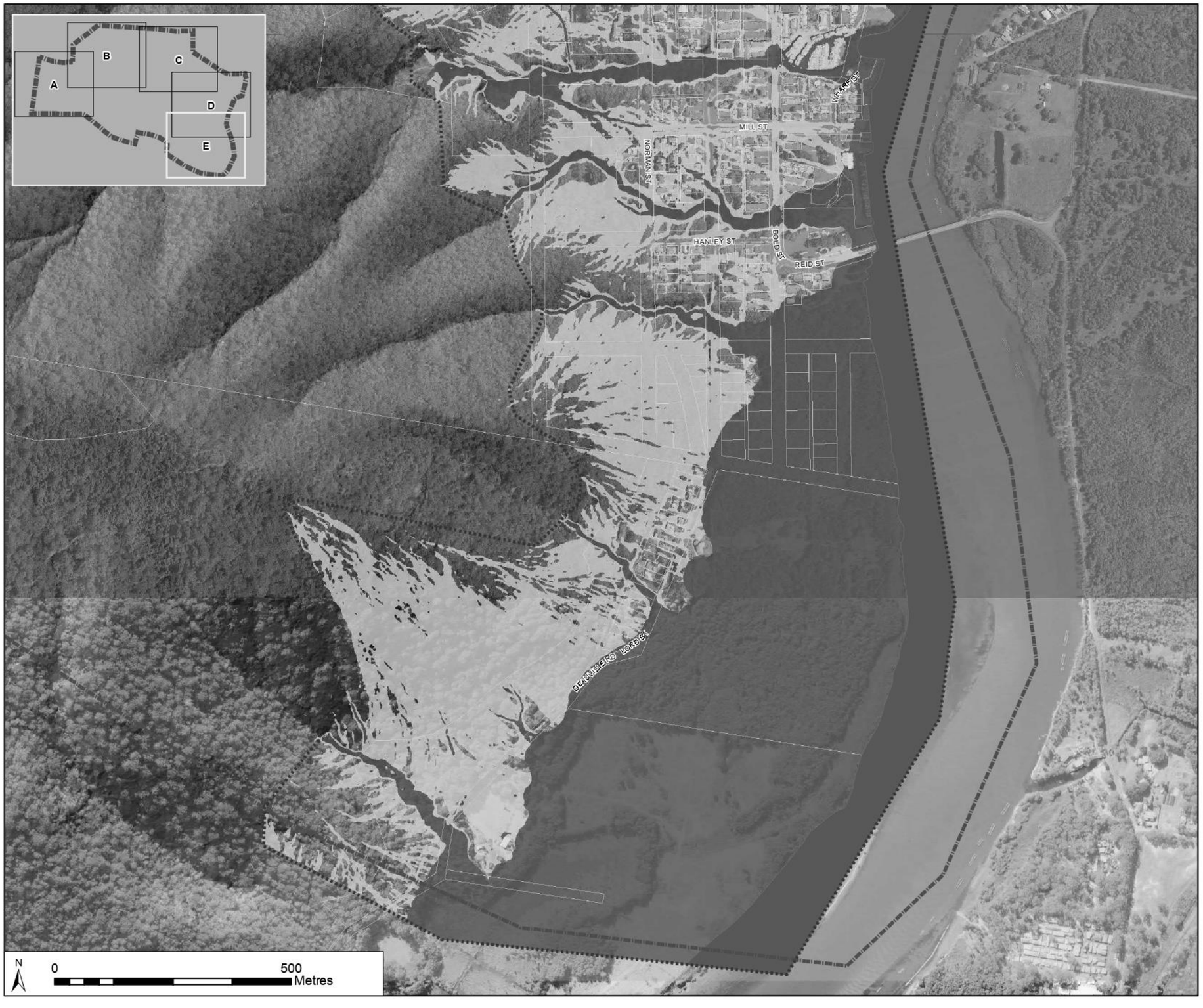
JACOBS

TITLE	1% AEP Design Flood Climate Change Scenario Hydraulic Categories
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-9(D)
DATE 5/12/2018	



Legend

Hydraulic Categories

- Floodway
- Flood Storage
- Flood Fringe
- Watercourse
- Study Area
- Limit of Mapping

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GDA 1994 MGA Zone 56
Scale: A3

Data Sources: LPI, OEH, Council

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JACOBS

TITLE	1% AEP Design Flood Climate Change Scenario Hydraulic Categories
PROJECT	North Brother Local Catchments Flood Study
PROJECT # IA157500	MAP A-9(E)
DATE 5/12/2018	

North Brother Local Catchments Flood Study - Results of Exhibition of Draft Options Assessment Report

Community Submissions

Table 1 - Summary of submissions

Issue - Location of high priority works		
CRM 12041 / 2020	Wayne Fuller	*Have Your Say* Online Submission - yes/no responses to predefined questions included in summary text. Additional comments as below: Does not agree with locations selected for high priority mitigation works. Alternate locations are: • Repair and maintain The Boulevard and Camden head Road. • Provide footpaths between Laurieton and the Beach.
	Response/ Comment:	This project seeks to identify potential works and measures to mitigate the flood risks associated with Local Catchment Flash Flooding from the North Brother Mountain. The works requested relate to Councils separate road rehabilitation and footpath program.
Issue - Location of high priority works		
CRM 12041 / 2020	George Pagacs	*Have Your Say* Online Submission - yes/no responses to predefined questions included in summary text. Additional comments as below: Does not agree with locations selected for high priority mitigation works. Bushfire protection is a higher priority.
	Response/ Comment:	This project seeks to identify potential works and measures to mitigate the flood risks associated with Local Catchment Flash Flooding from the North Brother Mountain. Implementation of any mitigation measures adopted at the Floodplain Risk Management Plan phase will be assessed for funding priority against all other Council priorities for such as bushfire protection works, through a future Operational Plan budgetary process.
Issue - Maintenance of existing diversion drain		
CRM 12039 / 2020	Robert G Scott	*Have Your Say* Online Submission - yes/no responses to predefined questions included in summary text. Additional comments as below: Maintenance of the diversion drain located beneath the Laurieton Reservoir is seen as a higher priority than the identified works. Mr Scott advises that this drain is over grown and in need have significant maintenance to restore the channel to its designed task of diverting water away from Quarry Way properties.

Table 1 - Summary of submissions		
	Response/ Comment:	This drain has been subsequently inspected and it is agreed that the drain is overgrown and in need of maintenance. However the subject drain is located with National Parks land is not under the care and control of Council. Further, National Parks obtains no benefit from maintaining this drain, as it is located at the downstream end of the National Park. Maintenance of this drain (and other diversion drains not located in Council land) will be considered in the preparation of the upcoming Floodplain Risk Management Study and Plan process. Suggest that plan give consideration to developing a maintenance plan for these drains in partnership with National Parks Authority.
Issue - Maintenance of existing open drain		
CRM 12037 / 2020	Ian Butlin	*Have Your Say* Online Submission - yes/no responses to predefined questions included in HYS summary text. Additional comments as below: a) Request to maintain the existing open drain along Ocean Drive adjacent to Lilli Pilli Close. This drain has not been cleaned since last flood event 2013. b) Support for Council to implement flood mitigation works in the catchment. Further development in flood prone areas is not supported.
	Response/ Comment:	a) Subject open drain has been risk assessed and maintenance works currently being programmed via a separate CRM. b) This project will ultimately result in the adoption of a range of structural and non-structural measures which will result in the outcomes noted.
Issue - Maintenance of existing open drain and vegetation		
CRM 12106 / 2020	Michael Ducat	Existing trees along Tunis Street and located in the stormwater drain constrict flows and continually drop limbs on adjoining homes
	Response/ Comment:	Tunis Street has been identified as one of the locations for prioritised remedial works, with an augmented piped drainage system identified as a preliminary solution. Such works would replace the need for the current open drains in this location. Whilst no related to the current project, a separate request has been forwarded to Council's Parks Team to assess the safety of the existing trees at this location.
Issue - Maintenance of existing open drains upstream of Ocean Drive		
CRM 11744 / 2020	Robert Ellicott	Submission provides recommendations regarding various locations to undertake open drain maintenance works upstream of Ocean Drive in the vicinity of Captain Cook Bicentennial Drive

Table 1 - Summary of submissions

	Response/ Comment:	A site meeting was held with Mr Ellicott and the subject open drains were inspected. Whilst these maintenance works are not the subject of this study, a separate maintenance request has been created to clear palm fronds and debris from the drains in the locations described by the customer and as inspected on site.
Issue - Maintenance of existing open drains upstream of Ocean Drive		
CRM 12310 / 2020	Christine Kurteff	*Hard copy survey submission* - yes/no responses to predefined questions included in summary table. Additional comments as below: Resident is landowner of one of the two properties identified for voluntary land acquisition (Pelican Ct) and has indicated that she is not willing to participate in a Voluntary Purchase if required. Furthermore, and prior to the commencement of the exhibition period, a site meeting was conducted with Mrs Kurteff to discuss the study and identified potential impacts to her property. Mrs Kurteff also verbally informed Council at that stage that she would not support an acquisition of her property.
	Response/ Comment:	As a Voluntary Acquisition was suggested within the Draft Options Report and the landowner is not agreeable, an alternate solution requiring no land acquisition at this location will be investigated during the preparation of the Floodplain Risk Management Study and Plan.
Issue - Request for general open drain maintenance		
CRM 12308 / 2020	Frances Forman	*Hard copy survey submission* - yes/no responses to predefined questions included in summary text. Additional comments as below: Large amount of leaf litter located within the open drains, which can block and cause flooding in heavy rain. Request for general maintenance.
	Response/ Comment:	Site inspection of the open drains upstream of and in proximity to the resident's property was undertaken on 30 July 2020, with no significant debris buildup located. The area will continue to be monitored as part of ongoing routine inspections, with future maintenance programmed as required.
Issue - Ocean Drive and Brotherglen overland flooding		
CRM 12369 / 2020	Michelle Taylor	*Hard copy survey submission* - yes/no responses to predefined questions included in summary text. Additionally, Ocean Drive near Brotherglen Drive has been identified by this submission as an additional location for stormwater mitigation measures on the basis that the resident has driven through floodwater at this location on numerous occurrences.
	Response/ Comment:	The Flood Study phase of this project has identified that this location is subject to overland flooding as suggested, however

Table 1 - Summary of submissions		
		the risks associated with flooding at this location have been determined to be lower than those that have been identified for structural flood mitigation measures at this stage. See Flood Hazard mapping for details. Whilst it would be great to design concept solutions for each location where there is a risk of flooding identified, the current Floodplain Risk Management Study and Plan process aims to identify, assess and prioritise works at a small number of high risk locations only at this stage. This is on the basis that the costs associated with remedying all flood risks to the catchment in the short term would be unaffordable. Hence, to streamline the Floodplain Risk Management Study and Plan Process, we are attempting to prioritise the highest risk locations only. Once future works have been completed to address the current high prioritised, an updated Floodplain Risk management Study would be prepared to re-prioritise and assess the next ranked priorities for further consideration and assessment.
Issue - Emergency access/escape route		
CRM 12492 / 2020	Lorna Schumack	Verbal submission collected via phone call on 24 July 2020 - Resident suggested that a separate bridge/culvert crossing be considered across the drain located to the south of the Theatre in Laurieton. The location of this bridge could be to the rear of the Community Health building and would function to provide an alternate access to Dunbogan if Bold Street were cut off by flooding at the gully. Also suggested the addition of a roundabout at Bold and Mill Streets, Laurieton to improve traffic flow.
	Response/ Comment:	Emergency access/escape have not been considered to date, however escape/access routes such as the one proposed will be considered and assessed during the preparation of the Floodplain Risk Management Study and Plan. Suggestion regarding the placement of a roundabout is outside the scope of this project and has been referred to Councils' Transport Planning Team for a separate response.
Issue - Emergency access/escape route		
CRM 12585 / 2020	Daphne Eggins	Hard copy submission - yes/no responses to predefined questions included in summary text. Submission also asks a number of questions as noted below: 1. Why does the water in the north end of Lake Street not go around to the river? The corner goes uphill. 2. Where does the water from the creek between the service station and shop on Bold Street come out? 3. Why does the manhole on the corner of Lake and Tunis Streets lift and flood out during heavy rain? 4. Why cannot all the water from the top of Tunis Street be piped to the river?

Table 1 - Summary of submissions		
		5. The drain should not have been put in the block where it is in Lake Street. 6. Why do we have to put up with all the water coming across the road? 7. Footpath adjacent to Mrs Eggins' property was lifted as part of an adjoining development and she was advised that it would also be lifted adjacent to adjoining properties at that time. This never occurred and the adjoining property with a lower level footpath is now flooded.
	Response/ Comment:	Responses to the queries raised are as below: 1. Topography of the Lake and Tunis Street intersection directs overland flows from the upper catchment from Tunis Street into Lake Street, This has been confirmed by the modelling undertaken at the Flood Study Phase. This is a result of historic road and subdivision design practices employed in the early design of the Laurieton Township. Current standards would likely result in a very different layout. 2. This surface runoff is captured in a piped drainage network just upstream of Kew Road. The piped drainage than conveys flows into Tunis Street and eastwards to the Camden Haven River. Mapping of Council's piped stormwater drainage network can be viewed online here: https://www.pmhc.nsw.gov.au/Building-Planning/Industry-Resources/Online-mapping-of-underground-services 3. This lid is understood to be a stormwater pit lid at this location. The pit lid would lift as a result of the pressure of the large volumes of stormwater flowing within this undersized stormwater drainage system - i.e. the system is undersized and stormwater is surcharging from this under pressure. 4. As noted above, the existing stormwater system within Tunis Street is significantly undersized and does not have capacity to convey flows generated by the upstream catchment without surcharge/overflow. This was identified and confirmed by the North Brother Local Catchments Flood study and has subsequently been prioritised as one of the 4 highest risk locations in the catchment. The concept of collecting all runoff from the top of Tunis Street is essentially what has been identified in Structural Mitigation Option 6D within the Draft Options Report and will be further modelled and assessed as part of the upcoming Floodplain Risk Management Study and Planning process. 5. Agreed - current development standards would not have resulted in the stormwater system and overland flowpaths within Lake Street looking as they do today. This is unfortunately a historic development issue, with the works designed and constructed prior to current standards and levels of understanding of the flowpaths originating from the upstream North Brother Mountain.

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		6. In identifying the Tunis Street flowpaths as one of the highest risk priority locations for structural mitigation works, Council is working towards remediating the problems currently experienced at this location. Unfortunately, these works are likely very high cost, however by identifying the scope of the issue and designing mitigation measures via the State Governments Floodplain Risk Management Process as we are doing, Council will be eligible to apply for grant funding to assist with the costs associated with constructing the flood mitigation measures identified by the Floodplain Risk Management Plan prepared at the conclusion of this project. 7. Modelling has indicated that the large volumes of stormwater overflows arriving at this location cannot be simply redirected by works to raise a footpath. A significant pit and pipe system upgrade is required - such as that identified in Option 6Dof the Draft Options Report.
Issue - Mitigation of measures impacting Laurieton United Service Club		
CRM 12498 / 2020	Greg Armstrong - Submission on behalf of LUSC	Submitter cannot find information in the report detailing where the study considers or addresses the existing stormwater drainage and flooding problems impacting the Laurieton United Services Club. Submission queries Council's prior written advice to the Club that any works to extend the pipeline traversing the property and / or create an easement on that property may be considered as part of any future development application by the Club. Requests that Jacobs review the flooding experienced by the natural waterway within the Club land and suggest mitigation options.
	Response/ Comment:	The Flood Study phase of the project identified and defined the scope and extent of flooding within the study area. A copy of the Flood Study can be viewed online here: https://www.pmhc.nsw.gov.au/Services/Environment/Waterways-and-coastlines/Floodplain-management/North-Brother-Local-Catchments The Draft Options Report defines the risk assessment process that has been undertaken to date to arrive at the current four high priority locations for flood mitigation works and the conceptual options identified to address flooding within the catchment by non-structural means. No works have been identified or proposed to address the flooding problems experienced by the club at this time as a result of the study and investigations to date identifying other higher priority locations. This is not to say that the club does not have any issues, rather that there are other locations in the study area that pose a greater risk to life and property. Council's prior advice to the club that any works to extend the existing stormwater pipelines through the club site would be

Table 1 - Summary of submissions		
		assessed as part of a future development application by the club for expansion works still stands. This is on the basis that the pipelines traversing the LUSC property were constructed over an existing creek/gully by LUSC at time of initial development to enable the orderly development of that site. There would be no public benefit (only private) to Council extending these pipelines further than existing. Furthermore, the requirement to create an easement over the existing pipelines was a development requirement of the initial works by the Club which remains outstanding. The North brother Local Catchments Flood Study (link above) already defines the extent of flooding experienced by the flowpath through the LUSC site. No further analysis is required at this stage. Note that the subject creek is a tidal component of the Camden Haven estuary and is also substantially flood affected by riverine flooding from the Camden Haven River. Details of the Camden Haven River flood extents can be found within the Camden Haven River Flood Study here: https://www.pmhc.nsw.gov.au/Services/Environment/Waterways-and-coastlines/Floodplain-management/Camden-Haven-floodplain
Issue - Suitability of development applications in flood prone areas		
CRM 12789 / 2020	Faith Bell	*Have Your Say* Online Submission - yes/no responses to predefined questions included in summary text. Additional comments as below: • Notes that Pelican Ct is a natural watercourse form the North Brother Mountain and feels that the areas should not have been developed. • Noted that drainage system upstream of Tallowood Place operates very well • Council should cease accepting building applications in flood prone areas at the base of the mountain until detailed flood studies have been finalised
	Response/ Comment:	Pelican Ct does function as the natural overland flowpath from a number of upstream natural gullies on the lower slopes of the North Brother Mountain and appears to have been a natural gully/stream prior to its development in the early 1990's. The area poses a high flood hazard and has been identified as one of four high priority locations for structural mitigation works. In relation to future building applications, whilst there are currently no planning controls in place around overland flooding from the North Brother Mountain, the Draft Options Report lists a number of high level non-structural measures, including planning controls which will be developed further in the upcoming Floodplain Risk Management Study and Planning Phase of the project.
Issue - Changes to LEP and Flood Policy & Option 8B and alternatives		

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CRM 12919 / 2020	Andrew McCoubrie	Very detailed submission has been prepared addressing two separate issues: 1. Changes to LEP and Flood Policy Submission concerned that significant changes to the LEP and Flood Policy would result in far-reaching consequences to the affected property owners and to the greater Camden Haven area including increased insurance premiums, reduced property values, increased development restrictions and increased development costs. Submission queries why the Draft Options report does not discuss the proposed changes in detail, nor why any of the potential impacts are discussed? Mr McCoubrie believes that a majority of residents and those who received notification of the Draft Options Report would not comprehend the potential impacts of this policy recommendation. By not including any discussion of the potential consequences of LEP and Flood Policy changes, the community response may be misrepresented and any future actions by Council based upon this draft survey could be misguided and wasteful. Submission defines five impacts that are perceived to result from changes to the LEP and Flood Policy: i. The impacts and losses of increased insurance costs. Submission advises that Property and Business insurance will become harder to obtain and premiums will increase if properties are mapped as flood effected. Examples provided of property in North Haven and Dunbogan. ii. The loss of property value caused by updating Section 10.7 certificates. Submission queries the impact of 10.7 certificate informing a property purchaser of a high flood risk on sale values and process. iii. Development restrictions on potential uses of affected properties. Submission defines requirements of the current flood policy in regard to controls for building in Floodways' or Flood Storage Areas' and some of the impacts that those restrictions may have on a landowner - limited development potential, raised floor levels, higher costs etc. in addition to the related impacts of such development on adjoining properties such as view losses and privacy. Mr McCoubrie's property is substantially impacted by overland flooding as identified by the North Brother Flood Study and the

Table 1 - Summary of submissions

		submission raises concern that LEP provisions will sterilise his land, devaluing the property. iv. Development costs Submission notes that modifying the LEP would potentially trigger additional planning requirements on any potential development (building extensions, replacing your home, new developments etc.) such as: • A property owner will most likely be required to undertake some form of "Flood Impact Assessment", which can add $000's to development costs • Flood impacted properties are typically required to undertake specialised construction measures, based on specialist design and survey as required to meet the flood zoning requirements. This adds further cost. • Most property developments (rebuilds, extensions etc.) would be required to meet "Site Access and Flood Evacuation Requirements" which require that driveways be raised to 1:20 flood levels and evacuation routes be clearly defined. • Developments on flood prone land may take longer to assess and approve - costing more time to the landowner. • General loss of property value by flood zoning. Property values will substantially lessen as a result of adopting flood prone land mapping in relation to flood impacts associated with Flooding from the North Brother Mountain 2. Option 8B and alternatives Submission notes that Option 8B directly impacts their property and queries whether the option is beneficial at all on the basis that it only reduces flood levels by 100mm in the context of flood waters in excess of 1000m deep? It is acknowledged that the option will result in a small improvement in risk to life, however other options are suggested: • Installation of a piped drainage system in lieu of the existing open drain traversing the property (sketch attached to submission) • Installation of a new trunk main along Seymour Street would bypass the open drain through the subject site and (sketch attached to submission).

Table 1 - Summary of submissions		
	Response/ Comment:	Given the detailed submission, the response has been broken into two sections as below and corresponding to the submission: 1. Item 1 It is acknowledged that changes to the LEP and flood policy as raised in the Draft Options Report have the potential to impact insurance costs, property values, development requirements and development costs as suggested, however at this stage no proposed changes to the Flood Policy or LEP have been developed and as such any impacts are hypothetical. The aim of the Draft Options Report was to gauge community support for the development of such controls, identify issues to be addressed via their development (such as the issues raised in this submission), and in the absence of the actual controls, inform the community that Council and our consultants, Jacobs, are planning to develop them as part of the upcoming Floodplain Risk Management Study and Plan. The flood study phase of this project has already defined and quantified the extent of flooding experienced within the study area and the associated risks. These risks are real and current. As shown in the structural options section of the Draft Options Report, significant works are required to mitigate and / or lower the identified risks in the top four highest risk locations. Furthermore, if adopted via the Floodplain Risk Management Plan phase, funding to construct those concepts in the four high priority locations is likely to be high in quantity and is yet to be secured. If the scope of works required at those four priority locations was extrapolated to the initial list of 16 high risk areas, the construction costs to the community would be astronomical. Hence, in the absence of unlimited budgets and time, some level of non-structural measures are required to be implemented across the catchment as a means of managing the risks to the community as a result of overland flooding from the catchment. Given the differences with respect to flow depths, durations and velocities when compared to riverine flooding, specific changes and additions to the Flood Policy will need to be developed to enable the actual risks associated with overland local catchment flooding to be managed. These will be developed initially by Jacobs in consultation with Council technical staff and the Coast, Estuary and Floodplain Sub Committee, prior to seeking community feedback via public exhibition. Likewise, the standard flood controls applicable to development as defined in the LEP will not be a good fit to local catchment overland flooding as the scale and risks are vastly different. As noted above, it is acknowledged that changes to the LEP and flood policy as raised in the Draft Options Report have the potential to impact insurance costs, property values, development requirements and development costs as

Table 1 - Summary of submissions		
		suggested, however we plan to work with the Coast estuary and Floodplain Sub Committee and wider Community to ensure that the tools developed are a good fit for the catchment and community. 2. Item 2 The initial risk assessment undertaken by Jacobs identified the subject property as a critical flood problem location, rated as a high priority, however alternate options such as the extension of a piped drainage system along the length of Seymour Street were discounted during the development of the Draft Options Report on the basis of the high cost involved and limited benefit to the wider community (predominant benefits to one property). When assessed against other works and locations, the cost to benefit ratio of larger scale works at this location is considered to be not favourable. That said, option 1 as suggested appears to be a suitable solution to address the existing overland flowpath through the site and may be more appropriately addressed via negotiation with Council in conjunction with a future development proposed for the site.
Issue - Request to be notified of Draft Options Report being reported to Council		
CRM 12894 / 2020	Penny Small	Resident wishes to be notified of this report being reported to Council
	Response/ Comment:	All persons who lodged a submission will be notified of the report being presented to Council when the Council meeting agenda is published.
Issue - Comments on preferences regarding Options 9A and 9B - works through School Property		
CRM 13127 / 2020	Jim Treeves - St Josephs Primary School Laurieton	Following site meeting with Jim Treeves (Parish Business Manager) regarding Options 9A and 9B, the School indicated the following preferences concerning the proposed works: • Option 9B is preferable • Works should be designed to retain existing lake on site and maintain surface flows to feed the lake in some extent.
	Response/ Comment:	Noted. Further concept investigations at this property will focus on Option 9B only.
Issue - Query regarding locations identified for Structural Mitigation Measures		
CRM 13187 / 2020	Betty Booth	Verbal submission lodged following discussion with resident. Resident enquired if her property was in one of the locations flagged for mitigation measures as she is continuing to experience overland flooding issues.

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	Response/ Comment:	The North Brother Flood Study Draft Options Report is currently targeting the assessed four highest risk locations at present. Mrs Booth's property is not located in one of these areas as it currently stands, nor would be impacted by any of the proposed structural mitigation works. This current exhibition period was seeking feedback from residents on whether they agree with our assessment and options identified prior to further detailed assessment and design. Following completion of the future Floodplain Risk Management Study and Planning phase and implementation of measures at some time in the future, Council will again look to reprioritise the next high priority locations.
Issue - Hard copy survey submission lodged.		
CRM 13318 / 2020	Deborah Murray	*Hard copy survey submission* - yes/no responses to predefined questions included in summary text. Additional comments provided on submission related to a Traffic Signage query, and have been referred to the Transport Planning team for separate action
	Response/ Comment:	Thank you for your submission. Query regarding traffic signage has been referred to the Transport Planning team for separate action and response.
Issue - Table drain and Open Drain issues at Ocean Drive Westhaven		
CRM 13307 / 2020	John Wood	*Have Your Say* Online Submission - yes/no responses to predefined questions included in summary text. Additional comments as below: • Submission describes a local drainage issue impacting the frontage of the resident's property and describes the history of the issue in detail. • Table drain is currently undersized and causes stormwater to back up into the property, inundating a lower floor level. • This issue is exacerbated by runoff form an upstream property and the poor condition of an open drain located within an adjoining property to the west. • Also queries whether the concept options identified considered an Ocean Drive bypass road realignment that was initially identified in the 1980s.
	Response/ Comment:	The issue raised is primarily a local drainage issue as opposed to a consequence of a North Brother flood event in that the problem stems from an inadequately sized table drain / pipeline within the frontage of the property and maintenance of an adjoining open drain. Inspections of the open drainage assets at this location have been scheduled to be undertaken during the week commencing 14 September 2020 to determine the need for maintenance

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		and/or upgrade. A separate response will be provided following assessment and prioritisation of any identified works. With regard to the consideration of a future road bypass of Westhaven area, the current structural mitigation options are conceptual only and do not currently consider any road realignment changes. Review of the compatibility of concept designs with future works plans will be confirmed following further testing of the feasibility of he identified options during the Floodplain Risk Management Study phase.
Issue - Waterlogged ground experienced at Quarry Way		
CRM 13305 / 2020	Christine Lomax	Submission advises that they experience very sodden and waterlogged ground around their property following heavy rain. Resident believes that this is subsurface water seeping from upstream North Brother Mountain and that clearing of the drainage diversion channels upstream will alleviate this issue.
	Response/ Comment:	The issue described is very common amongst properties located at the base of North Brother Mountain. Our experience in the locality indicates that the subsurface geology of the Mountain is very porous and is subject to very large and fast moving subsurface groundwater flows during and in the days following heavy and / or prolonged rainfall. From a Council perspective, there are many locations where subsurface stormwater pipelines and other conduits convey large groundwater flows for many days or weeks following significant rainfall, often leading to premature failure of these critical council assets. Our experience is that maintenance and sealing of open drains around the base of the Mountain can reduce the incidence of concentrated groundwater ingress to the subsurface profile, however the majority of subsurface water is likely to enter via those natural undrained surfaces up and downslope of formal drains. Other than constructing large cut-off subsurface drains upstream of residential areas this s considered to be a natural feature of the topography/geology of the Mountain.
Issue - Condition of water diversion drain beneath Laurietion Reservoir		
CRM 13254 / 2020	Robert Scott	Submission raises concern regarding the condition of the existing water diversion drain located beneath the Laurieton Reservoir and provided examples of current blockage and flooding that has occurred historically from this drain. Submissions demonstrates that this has been a longstanding issue for the community and recommends that maintenance work is required to clear fallen trees and debris from the drain.

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	Response/ Comment:	This drain has been subsequently inspected and it is agreed that the drain is overgrown and in need of maintenance. However the subject drain is located with National Parks land is not under the care and control of Council. Further, National Parks obtains no benefit from maintaining this drain, as it is located at the downstream end of the National Park. Maintenance of this drain (and other diversion drains not located in Council land) to be considered in the preparation of the upcoming Floodplain Risk Management Study and Plan process. Suggest that plan give consideration to developing a maintenance plan for these drains in partnership with National Parks Authority.
Issue - Consideration of existing works		
	Mark Canterbury	*Have Your Say* Online Submission - yes/no responses to predefined questions included in summary text. Additional comments as below: • Would like report to give consideration to existing drainage works carried out by residents to minimise the flood impacts on their homes
	Response/ Comment:	The Floodplain Risk Management Study and Plan are relatively high level studies and contain information based on best available survey and plans. Prior to the commencement of any detailed designs and following the completion of the Floodplain Risk Management Plan process, these kind of site specific improvements and works will need to be assessed and incorporated into the detailed design phase, prior to construction.
Issue - Description of existing flooding issue		
	Greg Watson on behalf of Camden Haven Anglican Church.	*Have Your Say* Online Submission - yes/no responses to predefined questions included in summary text. Additional comments as below: • Provided details of historic flooding experienced at the Camden Haven Anglican Church. • Church has raised the driveway and verge of their property in an attempt to divert overland flows around the building and works.
	Response/ Comment:	The Flood Study Phase of this project has confirmed the flood risk defined in the submission however when assessed against all other issues / risks in the catchment area, the location has not been assigned as one of the top four priorities for mitigation measures at this stage on the basis that there are higher risk locations.
Issue - Description of existing flooding issue		
	James Black	*Have Your Say* Online Submission - yes/no responses to predefined questions included in summary text.

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		Additional comments as below: • Provided details of historic local flooding issue experienced at Flinders Drive, Laurieton.
	Response/ Comment:	Whilst this area has not been prioritised for Structural Mitigation Measures under the Draft Options Report, the issue described is considered a local drainage issue and may be able to be rectified via some minor modifications to the street verge and existing local drainage. Council's Stormwater Engineers will investigate this solution with the resident separately to the Flood Study Process.
Issue - Kerb and Guttering in Hanley Street		
	Paul Bedwell	*Have Your Say* Online Submission - yes/no responses to predefined questions included in summary text. Additional comments as below: • Guttering needs to be installed along the length of Hanley Street. This would stop the flooding at this location
	Response/ Comment:	Whilst this area has not been prioritised for Structural Mitigation Measures under the Draft Options Report, the issue described is considered a local drainage issue. Council has a register of pending Kerb and Gutter requests and have now added this location to the list for further assessment, prioritisation and consideration of funding as part of the future Operational Plan budgetary planning process.
Issue - Private drainage issue at Rosewood Court, Lakewood		
	Michael Davison	*Have Your Say* Online Submission - yes/no responses to predefined questions included in summary text. Additional comments as below: • Defines existing drainage issues impacting properties at Rosewood Court, Lakewood
	Response/ Comment:	The issues described relate to surface drainage between private properties. Prior to further Council assessment of these private matters, landowners should talk to their neighbours and attempt to address/solve issues civilly. If unsuccessful, residents may contact Council's Compliance team on 6581 8111 for advice.
Issue - Survey submission		
	Susanna van Niekerk	*Have Your Say* Online Submission - yes/no responses to predefined questions included in summary text.
	Response/ Comment:	Thank you for your submission
Issue - Various matters raised		

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	Joy Walker	*Have Your Say* Online Submission - yes/no responses to predefined questions included in summary text.
		Additional comments as below:
		• Defines existing stormwater issues impacting properties in Sirius Dr and Honeysuckle Ave, Lakewood whereby water backs up from the downstream lake, compromising the function of the public stormwater system.
		• Submission notes that maintenance is required to be undertaken prior to significant rainfall to allow stormwater drainage system to function and reduce likelihood of flooding.
		• Drainage works needed urgently to ensure CBD is not impacted by flooding
		• Suggested that St Josephs School and Catholic Church should co-contribute to the cost of works required within the school site.
		• Queries around potential flood mapping
		  ○ Impact on insurance costs
		  ○ Does Council provide this information to insurance companies
		  ○ May impact property values as buyers may not wish to purchase a flood prone property.

	Response/ Comment:	The Flood Study phase of this project has confirmed that the location listed is at risk of overland flooding due to a combination of local catchment overland flows, topography and elevated tailwater levels. Council Maintenance staff do proactively inspect the subdivision to assess the need for urban drainage maintenance, however residents are requested to advise of any specific concerns via contacting the customer service team on 6581 811 to enable a prompt assessment to be undertaken. In regard to the CBD flooding, Option 6 as defined in the Draft Options Report addresses flooding within the northern end of the Laurieton CBD. When viewed in the context of all the flood risks identified by the Flood Study, work to address the other identified risks in the CBD area are not as high of a priority at this stage and may be considered in a future iteration of the Floodplain Risk Management Plan. Concerning the potential for a co-contribution from St Josephs School and the Catholic Church for any works through their properties, the plan at this stage does not consider funding sources, however generally speaking, as the issues experienced stem from upstream public land, it would be anticipated that works will be publically funded (Council and / or Grant Funded). That said, Council would welcome any Co-Contribution offered in future. Lastly, with regard to flood mapping, preliminary flood hazard and flood planning mapping has been prepared, however without

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		corresponding draft LEP provisions and Flood Policy updates, the impact of flood mapping on the community is difficult to define at this stage. The Draft Options Report is very high level at this point in time and simply lists flood mapping as one of many non-structural measured to be investigated as the Floodplain Risk Management Study and Planning process proceeds. Further analysis of the potential impacts will need to be undertaken in consultation with the Coast, Estuary and Floodplain Committee and local community as the non-structural measures are developed in the coming months. With no draft policy or planning changes prepared to date, the Draft Options Report was simply seeking feedback on whether such measures are likely to be supported at this early stage.
Issue -		
	Michael K Carroll	*Have Your Say* Online Submission - yes/no responses to predefined questions included in summary text. Additional comments as below: • Have noticed water pooling in the verge area outside 386 and 388 Ocean Drive after light rain in addition to a location between 282 Ocean Dr and 25 Diamentina Way
	Response/ Comment:	Inspections of the drainage assets at this location have been scheduled to be undertaken during the week commencing 14 September 2020 to determine the need for maintenance and/or upgrade. A separate response will be provided following assessment and prioritisation of any identified works.
Issue -		
	Bernie and Trish Cheetham	*Have Your Say* Online Submission - yes/no responses to predefined questions included in summary text. Additional comments as below: • Feedback provided on the option to Voluntarily Acquire a property in Kirmington Tce. Alternate suggestion provided for consideration. • Gully near 38 Kirmington Tce is overgrown and requires maintenance. • The creation of flood areas and notations on the 10.7 zoning certificates could be counterproductive for property owners as far as property values and ability to get insurance. This point needs careful consideration. • Based on observed water depths across Ocean Drive during flood events, submitted believes that installation of flood level signs is not warranted.

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		• Recommends that consideration be given to face to face meetings in the next phase of the process in attempt to get a better involvement of the stakeholders. • Notes that the size and complexity of the study was daunting and possibly deterred the older residents from being involved.
	Response/ Comment:	The first part of this submission was discussed with the resident during the Zoom meeting on 27 July. In this regard and on the basis that the landowner subject to the proposed Voluntary Acquisition is not agreeable, further options as suggested will be investigated. Concerning the maintenance of the gully between Kirmington Tce and Koonwarra Street, an inspection has been undertaken to confirm its condition and Council technical staff are currently in the process of prioritising and planning maintenance works. With regard to flood notations on 10.7 zoning certificates, provisional flood hazard and flood planning mapping has been prepared, however without corresponding draft LEP provisions and Flood Policy updates, the impact of flood mapping on the community is difficult to define at this stage. Furthermore, the provisional mapping will be revised following drafting of appropriate changes to the Flood Policy and LEP to reflect suitable freeboards, levels and controls applicable to local catchment flooding (as opposed to riverine flooding - which is the focus of the current Flood Policy) The Draft Options Report is very high level at this point in time and simply lists 10.7 zoning certificate notifications as one of many non-structural measured to be investigated as the Floodplain Risk Management Study and Planning process proceeds. Further analysis of the potential impacts will need to be undertaken in consultation with the Coast, Estuary and Floodplain Committee and local community as the non-structural measures are developed in the coming months. It is agreed that face to face meetings/consultation would be beneficial in future stages of this project and acknowledged that the current COVID-19 related meeting restrictions have made mass participation difficult at this point in time. We will monitor State and Federal Government COVID-19 related meeting restrictions and tailor future consultations around available/permissible consultation/meeting methods, with a view to more face to face engagement. With regard to flood signage, the need for flood signage will be defined based on depth and velocity related risks as identified by the Flood Study Phase.

13.02 NOTICE OF MOTION - GOVERNMENT FUNDING FOR MANAGEMENT OF CROWN LAND

RESOLVED: Pinson/Griffiths

That Council:
1. Acknowledge the important and valuable role that environmental volunteer groups, including but not limited to Landcare and Bushcare, play in the management of public lands.
2. Request the Acting General Manager write to both the Local Member for Port Macquarie, Hon Leslie Williams MP and Local Member for Oxley and Minister for Water, Property and Housing, Hon Melinda Pavey MP, seeking their support, on behalf of Council and the Port Macquarie-Hastings volunteer groups, for increased funding to support the management of Crown Land within the Port Macquarie-Hastings Local Government Area that is not managed by or devolved to Council, to assist in ecological restoration, biosecurity obligations and bushfire management.

CARRIED: 7/0
FOR: Alley, Dixon, Griffiths, Hawkins, Intemann, Pinson and Turner
AGAINST: Nil

13.03 NORTH BROTHER LOCAL CATCHMENTS FLOOD STUDY - RESULTS OF EXHIBITION OF DRAFT OPTIONS ASSESSMENT REPORT

Councillor Alley declared a Non-Pecuniary, Significant Interest in this matter and left the room and was out of sight during the Council's consideration, the time being 8:04pm.

Mayor Pinson declared a Pecuniary Interest in this matter and left the room and was out of sight during the Council's consideration, the time being 8:05pm.

The Mayor vacated the Chair and the Deputy Mayor assumed the Chair.

RESOLVED: Intemann/Griffiths

That Council:
1. Acknowledge the submissions made during the exhibition period and thank those landowners for this input into this ongoing project.
2. Advise those landowners who made submissions of the outcome of Council's consideration of this matter,
3. Endorse the North Brother Local Catchments Flood Study Draft Options Assessment Report, and
4. Incorporate the community feedback obtained via the abovementioned exhibition process into the Floodplain Risk Management Study and Plan phase of the project.

CARRIED: 5/0
FOR: Dixon, Griffiths, Hawkins, Intemann and Turner
AGAINST: Nil

Councillor Alley returned to the meeting, the time being 8:07pm.

Mayor Pinson returned to the meeting, the time being 8:07pm.

The Deputy Mayor vacated the Chair and the Mayor resumed the Chair.

13.04 SETTLEMENT SHORES CANALS - MAINTENANCE AND DREDGING

The Mayor tabled and displayed photos of the canals.

RESOLVED: Griffiths/Pinson

That Council:
1. Note the information contained in the Settlement Shores Canal - Maintenance and Dredging report.
2. Include works to replenish the beaches of the Ballina and Newport Canals that are greater than 150mm below the top of the revetment wall in the draft 2021/2022 Operational Plan.
3. Investigate and work with property owners along the Ballina and Newport Canals to determine and implement an effective way to stabilise and replenish beaches to reduce the long term maintenance of the canals as works in the draft 2021/2022 Operational Plan.
4. Note the 2017 Canal Maintenance Plan outlines further works to be completed.
5. Consult with property owners in the Settlement Shores Canal Estate to determine an equitable fee/charge to be added to the draft 2021/2022 Fees and Charges to fund maintenance activities as outlined in the 2017 Canal Maintenance Plan.

CARRIED: 7/0
FOR: Alley, Dixon, Griffiths, Hawkins, Intemann, Pinson and Turner
AGAINST: Nil

13.05 ROADSIDE VEGETATION MANAGEMENT POLICY - OUTCOME OF PUBLIC EXHIBITION

RESOLVED: Griffiths/Hawkins

That Council defer adoption of the Roadside Vegetation Management Policy pending further advice via a briefing from the Acting General Manager and a report presented to the November 2020 Council meeting.

CARRIED: 7/0
FOR: Alley, Dixon, Griffiths, Hawkins, Intemann, Pinson and Turner
AGAINST: Nil

PORT MACQUARIE
HASTINGS
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WHAT IS THE PROPOSED REVETMENT WALL?

The Lake Cathie Illaroo Road Revetment Wall project consists of the construction of a 440m rock wall from Bundella Avenue, along Illaroo Road to Jonathon Dickson Reserve.

The revetment wall will provide protection to 41 properties over the next 50 years from the impacts of large storm events and coastal erosion due to sea level rise. It has been designed to include linking footpaths, seating, lighting, beach access stairs and a beach access ramp. It will also provide formalised parking spaces within Bundella Avenue and the installation of new kerb and gutter along Illaroo Road.

Figure 1: Illaroo Road Rock Revetment Wall Detailed Design, Aurecon 2015

HOW DID WE GET HERE?

We have been working through the Lake Cathie Coastal Zone Management Plan (CZMP) over the past 14 years. This was prompted by historical State Government investigations and community concern around sustained coastal erosion and impacts to infrastructure and amenities. This included damage to stormwater infrastructure and beach access points and an erosion escarpment that threatened to undermine the southern end of Illaroo Road. The development of the CZMP identified a revetment wall as a preferred option to deal with this ongoing issue.

To help you understand how we got to where we are now, we have compiled a snapshot timeline of events.

2008 - 2009

In 2008 we completed the Lake Cathie Coastal Hazard Study, documenting a detailed coastal hazard assessment of the beach at Lake Cathie. It describes the coastal processes affecting the beach at Lake Cathie and the impact of these processes on the areas of the beach where property is at risk. The report quantifies the observed long-term beach changes at Lake Cathie, as well as estimating the beach recession that may be caused by sea-level rise as a result of climate change. The risk to property is defined in terms of the present day risk, a 50 year planning period and a 100 year planning period *[See Figure 2 below]*.

Figure 2: SMEC Coastal Hazard Lines (Green = Immediate threat, Purple = 2055 threat, Orange = 2100 threat)

Following the 2008 Hazard Study, a Management Study was undertaken which was broken down into Stage 1 and Stage 2.

Stage 1 Management Study was completed by SMEC in 2009 and focused on seeking feedback from the community about their values and views on how Lake Cathie coastline was used. This allowed 13 potential management options to be put forward for assessment. After a period of public exhibition and consultation, the options to manage the coastal erosion were 'short listed' to four.

2012 - 2013

Stage 2 Management Study was completed by SMEC during 2012 and 2013 to examine the 'short listed' options put forward in Stage 1. The focus of Stage 2 was to seek feedback from the community on their preferred single option to manage the coastal erosion threat, and who their preferred sourcing option was to fund any coastal erosion protection works. There was strong public support to build a revetment wall with sand nourishment, and for State and Federal Government to fund the revetment wall project. Ultimately, at the 20 November 2013 Ordinary Council Meeting, it was resolved to proceed with a rock revetment wall with beach nourishments.

2014 - 2016

After adopting the preferred community option for coastal erosion protection, Council formally requested Certification of the CZMP by the NSW State Government (a legislated requirement). The then Minister for the Environment, Rob Stokes, wrote to us stating Certification would not be forthcoming without a number of actions to be undertaken;

a) Updated costs of the revetment wall.

b) A Cost Benefit Analysis (CBA) be undertaken.

c) Consider reviewing the management of stormwater to minimise the direct outflow of stormwater onto the beach.

In recognition that Council had already undertaken extensive work and community consultation in preparing the CZMP, the Minister directed the NSW Office of Environment and Heritage (OEH) to engage a consulting firm to prepare the CBA on our behalf (known as the Balmoral Group CBA). The CBA needed to assess; a) the costs and benefits of the identified 13 potential options for managing the identified threat posed by coastal processes to the Lake Cathie community, and b) to understand the social and economic impacts of each option in terms of local tourism, housing, jobs, population, supporting industries and the long-term viability of Lake Cathie as a community.

We then revised the CZMP to incorporate the results of this CBA which Council adopted in April 2016 and Ministerial Certification was requested again. Ministerial Certification of the Lake Cathie CZMP 2016 was provided by the then Minister for Planning, Rob Stokes, in November 2016 and the CZMP was Gazetted on 27 January 2017.

2017 - 2020

The finalisation of the Certification came with a list of required actions to implement. The most significant action required was to develop a workable funding model based on a distributional analysis that accords with the provisions of the new NSW Government Coastal Management Manual.

Council engaged Marsden Jacob Associates (MJA) to prepare a funding model, based on the new NSW Government Coastal Management Manual, which would rely on the results of the 2015 Balmoral Group CBA. However, upon review of the Balmoral modelling, MJA advised us that the CBA produced by Balmoral Group on behalf of the OEH in 2015 could not be used due to issues with the modelling used. The main issues being, the CBA was based on a wall covering a longer geographical area than we proposed to NSW State Government in our CZMP and that the wall design life was limited to only 20 years, however the CZMP states the revetment wall has a design life exceeding 20 years, so the residual value should have been factored into the analysis.

Accordingly, a new CBA was then prepared by MJA, along with the Funding Model requested by Minister for Planning, Rob Stokes.

The findings of the CBA and Funding Model, were presented to Ordinary Council Meeting in August 2020 and it was resolved to undertake extensive community engagement on the Illaroo Road Revetment Wall.

2021

We are engaging with the properties directly benefitting from the construction of the revetment wall, along with the surrounding Lake Cathie community, to discuss the findings of the CBA and the Funding Model – and to see if the properties directly benefitting from the construction of the revetment wall have the capacity or willingness to fund the revetment wall that will mitigate the coastal erosion issue.

WHAT IS A FUNDING MODEL?

A funding model is a financial model created to determine a variety of reliable and sustainable funding sources that enables the product or service to be implemented. The funding model conclusion is narrowed down to only one or two funding sources based on the findings from a CBA report.

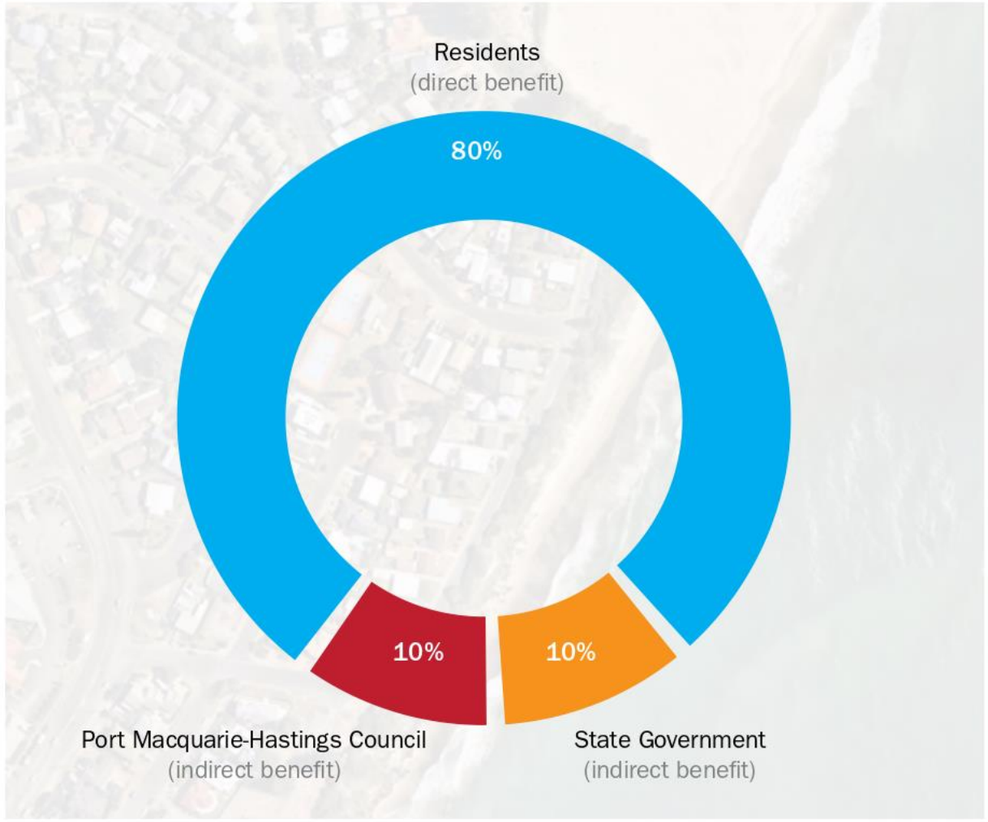

Figure 3: Suggested funding model for Illaroo Road Revetment Wall

WHAT IS A CBA?

Cost–benefit analysis (CBA) is a form of economic appraisal that can be used to estimate changes to the economic wellbeing of local and wider communities. A CBA is used to estimate and compare the costs and benefits of implementing a proposed project or management activity with the costs and benefits of a 'base case', which represents a continuation of current conditions under which the proposed project is not implemented.

In the analysis we modelled:

- Base Case = Business as usual
- Option Case = Revetment wall and beach nourishment to mitigate storm impacts

WHAT HAPPENS NOW?

Next, we encourage you to follow the three steps listed below. We want to reiterate no decision will be made without your input. Following these three steps, together we will work towards an outcome for this project.

Step 1 - Read the CBA & Funding Model reports, available online at haveyoursay.pmhc.nsw.gov.au/illaroo-road

Step 2 - Attend all the meetings made available to you by registering online at pmhc.nsw.gov.au/illaroo-road

Step 3 - Provide formal feedback in writing. To find out how, visit haveyoursay.pmhc.nsw.gov.au/illaroo-road

WHAT HAPPENS NEXT?

Once all the feedback has been received, this information will then be presented in an Ordinary Council Meeting, for the next course of action to be decided.


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Phone: 6559 9958
CUSTOMER SERVICE CENTRES
Open 8.30am - 4.30pm, Monday to Friday
CUSTOMER SERVICE CALL CENTRE
Operates 8.00am - 5.00pm, Monday to Friday
AFTER HOURS EMERGENCY CALLS
Phone 6583 2225

Illaroo Road Revetment Wall

Cost Benefit Analysis & Funding Model

Fact sheet

FREQUENTLY ASKED QUESTIONS

For directly affected property owners

Important Information about the Lake Cathie Revetment Wall for directly affected property owners

Why are we talking with you?

Your property has been identified as benefiting from the construction of the revetment wall.

How would you benefit from the revetment wall?

Your property will be located behind the wall so it will be protected from coastal erosion over the next 50 years.

What would the revetment wall do?

It would provide a solid structure that will be engineered to withstand impacts from the ocean during storm events and from the threat of rising sea levels. It would protect your property and other assets located behind the wall including roads, water and sewer networks, power and telecommunications assets etc.

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PORT MACQUARIE HASTINGS COUNCIL

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How was my property identified as being behind the wall?

The revetment wall was designed in 2015 and will extend from Jonathan Dickson Reserve to Bundella Avenue. The wall is 440m in length and is designed to protect assets located behind the wall.

Coastal erosion modelling over the next 50 years has been undertaken. The potential coastal erosion impact zone either applies to the entirety of some properties and portions of others.

All properties that are My property is not mapped My property is not mapped landward (ie west) of the revetment wall have been identified as being behind the wall. Only those properties that were subject to protection within the next 50 years have been included. Properties located further west have not been included.

How much will the revetment wall cost?

The capital cost of the revetment wall was estimated to be $8.1M in 2015.

The revetment wall capital cost and maintenance cost is now estimated to be $10.8M in 2019. This figure has been used for the calculation of costs in the Cost Benefit Analysis (CBA) and Funding Model.

What is a Cost Benefit Analysis and Funding Model, and why has this work been done?

The CBA assesses the costs and benefits of the revetment wall against a base case, or status quo scenario. The status quo scenario is what we presently see at Lake Cathie beach, i.e. no wall and therefore no protection from coastal erosion.

This work has been done to address the funding requirements of the Coastal Management Act & Coastal Management Manual (2016). Before Council can apply for grant funding, or the NSW Government can provide their funding contribution for the revetment wall, a CBA & Funding Model must be completed. The CBA is used to determine whether a project proceeds, based on the cost vs the benefits. The funding model is used to determine who pays what, based on the apportionment of benefits.

Why have costs only been calculated over 50 years?

Economic analysis can only be carried out over a maximum of 50 years. It is not feasible to accurately predict economic conditions beyond this time so it is not included in the current cost estimates. The total cost over the life of the revetment wall, as per the economic analysis (i.e. 50 years) including maintenance and periodic beach nourishment is $10M. The revetment wall has also been designed for a 50-year lifespan. Whilst the revetment wall will likely last considerably longer than this, it can only be guaranteed for 50 years. Ongoing maintenance and operational aspects will need to be considered in future years.

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Why is the revetment wall so expensive?

Initially, the rock revetment wall was estimated to cost around $4M. However environmental impacts and social impacts (such as beach access and amenity values) are key considerations of the NSW Government Coastal Management Guidelines and coastal protection legislation. As such, the wall design now includes access stairs, access ramp, footpaths, seating, lighting, car parking, new kerb and gutter, etc.

Aside from this, the beach is relatively inaccessible and dynamic so construction of the wall will be a difficult exercise. The headland at Illaroo Road is around 7 metres above the beach so the revetment wall will be a significant structure and involve the placement of a large amount of hard, durable quarried rock, which is located a considerable distance away from the project site.

My property does not directly front the beach, why have I been identified?

The benefits from the revetment wall have been applied over a 50-year timeframe. Properties closest to the coast will have an immediate benefit (i.e. from a 1:100 year storm) whereas properties further from the coast will have a longer term benefit (over 50 years) from storms and rising sea levels. Overall, 41 properties have been identified as benefitting from the wall over the 50-year timeframe.

Who pays what?

Each individual property has been assigned its own benefit so each property has its own payment amount. Council and NSW State Government have also been assigned a contribution amount. The amount differs between properties based on factors such as:

- Distance of the property from the ocean,
- Distance of the improvements (dwelling footprint) from the ocean,
- Amount of frontage to the revetment wall,

The amount of benefit has also been calculated in two different ways, as per the NSW Government funding model guidelines. This means that there are two different contribution amounts that can be applied, depending on which methodology is applied. A 'benefit shares' approach and a 'metres of frontage' approach have been used in the funding model. The difference between the approaches can vary considerably so the cost for each property can too.

How could the cost be levied?

If property owners have the capacity and willingness to pay their share of the revetment wall construction, the payment can be made as an up-front one-off payment. may wish to pay for their share of the revetment wall construction up front.

We could also use various methods to fund the works. The Funding Model recommends that the cost will be applied is via a Special Rate Variation (SRV) which could be applied over your existing property rating. Council would need to

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apply to the NSW Independent Pricing and Regulatory Tribunal (IPART) for the SRV. We can only apply a SRV when it has support from the community and that capacity and willingness to pay the additional rates has been demonstrated. This may be a two-step process depending on the outcome of this engagement. For example, if the 41 directly impacted properties agree to pay for the revetment wall, the SRV will be applied to these properties. If the broader community agrees to pay for the wall, the SRV will be applied to all rateable properties within the Local Government Area (LGA).

Alternatively, another potential option is to impose an encumbrance on the title of the property meaning that if the property changed hands, some or all of the costs of the revetment wall attributable to that property would be levied when the property ownership was transferred.

Why isn't State and Federal Government paying for the wall?

Federal, State and Local Government funding can potentially be used. Grant money can be made available and Council budgets can be apportioned. For Council, the project needs to be priorities against the competing interests of the LGA. The amount of funding available from Council is limited and projects such as the revetment wall are very expensive.

Government funding can only be utilised when grant program guidelines are followed and eligibility criteria are met. For example, the most appropriate grant funding stream available to us to funding the construction of the revetment wall is the Coastal Management Grant Program. However, there are various rules that apply under this grant program which caps the amount of grant money that Council and the State Government are required to contribute. Council would not be awarded grant funding if it has not followed the eligibility criteria of this grant program. This general rule applies to all other grant programs too.

The Council resolution from 2013 requires the State and Federal Government to fully fund the revetment wall. Why aren't they?

The revetment wall is the key action item from the Lake Cathie Coastal Zone Management Plan (CZMP). For actions over $1M, a Cost Benefit Analysis (CBA) and Funding Model must be undertaken. The CBA & Funding Model have been produced following State Government guidelines. The process has identified 41 properties as having direct benefits from the construction of the revetment wall. The funding model guidelines that have been followed, have identified that direct beneficiaries of the wall should pay.

So how much is the Government paying?

Under the Funding Model the State Government cost is $918,000 and the Council cost is $918,000. No Federal Government grant funding is available as the project does not align with any currently available Federal grant funding schemes. We may be able to apply for State and Federal Government grant funding schemes however

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given the project alignment is low with all identified grant funding programs, the success of these applications is very likely to be limited.

The Flynns Beach Seawall was built using State Government and Council money – why is the approach different for the Illaroo Road Revetment Wall?

Stage 1 of the Flynns Beach Seawall project was undertaken to protect public assets including the surf club and open space reserve. The $1.5M construction cost for an 80m seawall involved a 50/50 funding split between Council and the NSW Government. This was within the Coastal Management Program grant funding rules that applied at the time the grant funding application was made in 2015. The grant funding rules have since been changed by the NSW government meaning the future stages of the Flynns Beach project cannot proceed until Council has completed a Coastal Management Program (CMP) and undertaken a Cost Benefit Analysis and Funding Model, the same as the Illaroo Road revetment wall project.

Why is Council consulting with us now?

At this time Council is aiming to establish whether property owners have 'capacity and willingness' to pay for the revetment wall. Before Council proceeds any further, we need to talk with property owners to determine whether they want to, and/or have the ability to pay for the revetment wall.

Council resolved to proceed with community consultation of the CBA & Funding Model at the meeting held on 12 August 2020.

The feedback received from this consultation exercise will inform Council's decision regarding how it may proceed with the revetment wall project and how it may be funded at this time, noting that a decision of Council was made at the August 2020 Ordinary Council Meeting to ensure that all actions from the Lake Cathie CZMP will be carried over to the new Coastal Management Program (CMP) for Lake Cathie.

15.03 LAKE CATHIE - ILLAROO ROAD REVETMENT WALL COST BENEFIT ANALYSIS & FUNDING MODEL
RESOLVED: Intemann/Hawkins
That Council:
1. Note the information provided in this report.
2. Incorporate the Lake Cathie Coastal Zone Management Plan (CZMP) actions into the new Lake Cathie Bonny Hills Coastal Management Program (CMP).
3. Undertake direct engagement and consultation with impacted properties to explain the Revetment Wall options and cost implications and to assess the capacity and their willingness to pay for a Revetment Wall.
4. Following completion of direct engagement and consultation with impacted properties, receive a further report from the Director, Development and Environment detailing the outcomes of this engagement and future recommended steps in this project including details of the proposed community consultation/engagement for the broader community.
CARRIED: 7/0
FOR: Alley, Dixon, Griffiths, Hawkins, Intemann, Pinson and Turner
AGAINST: Nil

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But the community has already told Council that Government should pay for the wall, this was made clear in 2012.

We are very much aware that there was limited support for property owners to fund the revetment wall as this was the overriding sentiment of the feedback received during the public exhibition phase of the Stage 2 Costal Management Options Study. This was reflected in the 20 November 2013 Council resolution. However, throughout the CZMP process we have been mindful of the fact that funding contributions from a variety of sources, including property owners or ratepayers may be required. This has been a consistent requirement of the NSW Government Coastal Management guidelines that have applied to the project since 2007.

So why did Council resolve to have the NSW & Federal Government fund the revetment wall if they weren't going to fund it?

Council's 2013 resolution reflected public sentiment on who should fund the revetment wall. Council's resolution was valid and genuinely reflected considerable public support from the public during the consultation phase of the Stage 2 Coastline Management Study.

However, CZMPs must be 'certified' by the NSW Government before funding can be made available for any action items. When the CZMP was certified by the NSW Minister for Planning, Rob Stokes in 2016, it was noted that the next step was to undertake further investigation into funding options. The certification letter confirmed that Council must follow the principles of the new Coastal Management Manual. Council has prepared a funding model that accords with the principles of this manual, and is where we are now consulting with the community on the results of this work.

The revetment wall will protect Council's road, why are we paying to protect Council's asset?

The Cost Benefit Analysis (CBA) confirmed that Council would indirectly benefit from the construction of the revetment wall as it would protect the road (and other Council assets) from damage due to coastal erosion, so Council should pay 60% of the cost.

However, the NSW Government Funding Model guidelines, IPART funding hierarchy (which must be followed for any Special Rate Variation) and the Coastal Management Program grant funding guidelines all require us to follow the 'Beneficiary Pays' principal. This means that as Council is not a 'direct' beneficiary and the property owners are a 'direct' beneficiary, the indirect beneficiary costs get transferred to the direct beneficiaries. As such, the 60% benefit attributed to Council is transferred to property owners, so their 40% benefit (and therefore cost) increases to 100%.

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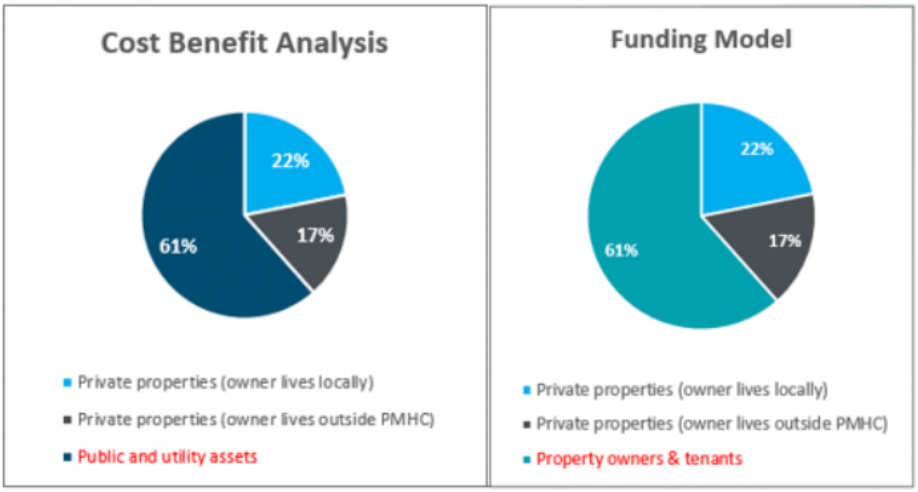
It is noted that Council and State Government have been apportioned 20% of the costs (10% state/10% local split). This has been applied to account for modelling and calculation errors or missed benefits in the CBA & funding model process.



What is an indirect beneficiary?

An indirect beneficiary is someone (in this case, Council) who gets a benefit (via the protection of the road) from the construction of the revetment wall. The indirect benefit of the road can be attributed to Council via retained rates, retained road connectivity, avoided clean-up costs (for example if a large storm damaged the road) and the like.

What is a direct beneficiary?

A direct beneficiary is someone who benefits from the construction of the revetment wall. As the properties protected by the wall will retain their direct access to services (road, power, water, sewer, etc) then they are identified as directly benefitting from the wall.

Why aren't residents being asked to pay for the Illaroo Road Stormwater Upgrade?

This project does not exceed $1M so the NSW Government grant funding guidelines permit Council to apply for 50% grant funding under the Coastal Management Program without the need to undertake a CBA or Funding Model. Council has provided its 50% contribution which presently totals approximately $440,000. Funding for this type of infrastructure is much more common for Council to deliver from its general rate base. It is also a much smaller sum than the revetment wall construction and maintenance costs.

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What happens if the road is damaged by coastal erosion, doesn't Council need to fix the road?

Council has numerous roads that are impacted by riverbank erosion or have failed due to land slips. Council will assess the impact of any erosion event should it occur and undertakes repairs where possible. In some instances, road repairs have not been feasible, so road closures, partial closures and long term diversions have been imposed on roads within the region in the recent past.

Why haven't I seen a complete copy of the CBA or Funding Model report?

Both reports contain sensitive information and have not been released to the general public. The reports contain information about individual property ratings, and the monetary value attributed to each individual property for the construction and maintenance of the revetment wall.

What happens now?

We are seeking feedback from all 41 property owners. Responses received during this period will be reported back to Council for its consideration. No decision has been made regarding the funding for the construction of the revetment wall. The 2013 resolution of Council that the NSW & Federal Government should fund the wall still stands.

What are the possible future scenarios for us?

The options available to property owners are that they agree with the findings of the Funding Model and agree to pay the costs that have been assigned to each property. Alternatively, if property owners do not agree with the findings of the finding model then Council may consult with the Lake Cathie and the broader Port Macquarie-Hastings community to assess their willingness to pay for the revetment wall. Only once we have undertaken this consultation phase can we go back to the State Government to report our findings.

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Further Information

A number of community and 1 on 1 meetings to engage with Council staff have been arranged for you during February and March. For the latest information and to RSVP visit pmhc.nsw.gov.au/illaroo-road

Funding for the proposed revetment wall is not finalised.

Council must engage with directly impacted residents and the community and considered the views and information gathered.

Community engagement is an important part of the proposed revetment wall

Council is committed to community engagement and making decisions based on the interests and concerns of the community.

Council must follow the NSW Government process for the implementation of CZMP

Council is following the process outlined by the NSW Government in its implementation of the CZMP. Council must consider the new funding arrangements implemented by the Coastal Reforms that were implemented by the NSW Government in 2018.

Illaroo Road Revetment Wall

Cost Benefit Analysis & Funding Model

FREQUENTLY ASKED QUESTIONS

for residents of Lake Cathie and surrounds

Fact sheet

Important Information about the Lake Cathie Revetment Wall for residents of Lake Cathie and surrounds.

What is the Illaroo Road Revetment Wall project?

The Illaroo Road Revetment Wall is the key action item from the Lake Cathie Coastal Zone Management Plan.

Where did the Revetment Wall project come from?

The Illaroo Road Revetment Wall comes from the Lake Cathie Coastal Zone Management Plan that was initiated in 2007 and was adopted by Council in 2013.

When did Council decide to proceed with the Revetment Wall project?

Council decided to proceed with the Revetment Wall in 2013, based on feedback from submissions received during the Stage 2 - Coastline Management Study that was undertaken in 2012.

Why has the Revetment Wall been proposed?

The revetment wall was identified as the primary action item that will protect private and public assets from the threat of coastal erosion from storms or long-term sea level changes.

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What would the Revetment Wall protect?

The revetment wall would protect 41 properties and the assets that service them from the impacts of coastal erosion due to storm events and climate change. The properties and their assets are largely bounded by Illaroo Road, Bundella Avenue, Kywong Street, Kalang Street and Chepana Street.

I thought more properties were impacted by the revetment wall?

A number of properties are located within the Coastal Erosion map under the Port Macquarie-Hastings Local Environmental Plan (LEP) 2011. This map shows the properties that are potentially subject to coastal erosion in a 100-year timeframe. Some properties were identified during the coastal hazard study phase which was undertaken in 2008-2009 and updated in later years to account for climate change impacts. There are a number of Lake Cathie properties that are not likely to be impacted by coastal erosion for some time, the revetment wall was not extended southward to provide protection to Jonathan Dickson Reserve. As a result, whilst some properties are within the Lake Cathie Coastal Zone Management Plan area, these properties will not be impacted by the revetment wall project.

What other options could be used to protect properties and the road?

During the 2012 Stage 2 Coastline Management Study, 13 options were assessed. These include:

1. Vertical Seawall (400 m)
2. Revetment Wall (400 m)
3. Vertical Seawall (entire beach to Middle Rock)
4. Revetment Wall (entire beach to Middle Rock)
5. Artificial Reef
6. Groyne (rock)
7. Groyne (geotubes)
8. Beach nourishment
9. Beach nourishment plus groyne
10. Beach nourishment plus groyne and revetment (400 m)
11. Beach nourishment plus revetment (400m).
12. Planned Retreat with voluntary purchase.
13. Reactive Management Response.

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Would the revetment wall keep Lake Cathie open to the ocean?

No, the revetment wall is only designed to provide protection to assets located behind the wall from coastal erosion events. The revetment wall is not intended to have any impact on the natural opening and closing cycle of the Lake Cathie/Lake Innes ICOLL system.

Would the revetment wall stop the sand from closing the Lake from the Ocean?

No, sand will still drift along the coastline and will accumulate in the mouth of the Lake. It is intended that the revetment wall will not have any impact on the accumulation of sand from the lake mouth and the lake will continue to open and close on an intermittent and irregular cycle.

What impact would the revetment wall have on the beach?

Any solid structure located within the surf zone of a beach will cause localised lowering of the beach. When waves hit a solid structure their energy is reflected by the object they hit (in this case a rock wall), this causes erosion directly in front of and around the wall meaning that the beach will be less useable than if the wall was not in place. This will have an impact on the amenity of the beach at Lake Cathie.

Why is Council discussing funding now, shouldn't it have been finalised before now?

Council has discussed funding options and methodologies throughout the project from its inception in 2007. During the consultation phase of the Stage 2 - Coastline Management Study in 2012, there was large support from the community for state and federal governments to pay for the revetment wall. The 2013 resolution of Council when Council adopted the CZMP reflected this public sentiment.

However, there are rules and guidelines about how funding for projects such as this should occur. Council must follow this process if it wishes to access contributions from other levels of government.

It is noted that the NSW Government introduced new legislation and new guidelines on how projects within CZMP's and CMP's can be funded. Whilst the CZMP was adopted before the new guidelines were endorsed, they now apply to this project.

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Will construction of the Revetment Wall commence following this community engagement period?

Council must wait for feedback from directly affected residents before proceeding any further with the revetment wall project. However, Council has made a commitment to the revetment wall by resolving at 12 August 2020 Ordinary Council meeting to roll the actions from the CZMP into the new CMP. Timing of construction of the revetment wall is still unknown at this time.

Further Information

A community meeting to engage with Council staff has been arranged for you on **Tuesday 23 February 2021**. For the latest information and to RSVP, visit pmhc.nsw.gov.au/illaroo-road

Community engagement is an important part of the proposed revetment wall

Council is committed to community engagement and making decisions based on the interests and concerns of the community.

Council must follow the NSW Government process for the implementation of CZMP

Council is following the process outlined by the NSW Government in its implementation of the CZMP. Council must consider the new funding arrangements implemented by the Coastal Reforms that were implemented by the NSW Government in 2018.

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PORT MACQUARIE HASTINGS COUNCIL

8 February 2021 Refers to: SF20/3096

Owners name
Owners address

Dear Mr & Mrs,

Illaroo Road Rock Revetment Wall Proposal

As you may be aware we have been working for a number of years to find a solution to potential coastal erosion issues in Lake Cathie. In 2007 Council and the community commenced work on the Lake Cathie Coastal Zone Management Plan and in 2014, following extensive consultation with our community, a rock revetment wall was identified as the preferred option for Council to investigate further to address coastal erosion.

We are now writing to explain what this could mean for you and invite you to meet with us to discuss the project. Our focus is to work with you as a property owner on this important project so that together we can make the best possible decisions based on your interests and concerns.

Why are we investigating a revetment wall?

Based on coastal hazard studies along Illaroo Road between 2008 - 2012, it was confirmed that the coastline at Lake Cathie was retreating. Council has been working to find a solution to potential coastal erosion issues and the development of a revetment wall in Lake Cathie for a number of years. Consequently, in 2012-13 Council considered a number of potential management solutions including the revetment wall. Ultimately, at the November 2013 Ordinary Council Meeting, Council resolved to proceed with a concept design for a rock revetment wall with beach nourishment. This preferred solution was then presented to the NSW Government, who requested a Cost Benefit Analysis (CBA) be prepared to analyse the viability of the project and a Funding Model to outline the distribution of costs to direct and indirect beneficiaries.

Cost benefit analysis

Construction of the revetment wall, including associated infrastructure such as footpaths, seating, lighting and beach access is estimated to be $10 million. The findings of the CBA and Funding Model, were presented to Ordinary Council Meeting in August 2020. These findings attribute the costs of the wall to be:

- 80% residents (direct benefit)
- 10% Port Macquarie-Hastings Council (indirect benefit)
- 10% State Government (indirect benefit).

Potential costs for your property

Your property has been identified as one of the 41 properties that could receive a direct benefit from the construction of a revetment wall. As a result, your property could incur a cost associated from the construction of the revetment wall. This cost will vary between properties based on location and benefit received.

PORT MACQUARIE OFFICE
17 Burrawan Street, Port Macquarie NSW 2444
t 02 6581 8111 f 02 6581 8123

WAUCHOPE OFFICE
49 High Street, Wauchope NSW 2446
t 02 6589 6500

LAURIETON OFFICE
9 Laurie Street, Laurieton NSW 2443
t 02 6559 9958

Refers to: SF20/3096

Should you have the willingness and capacity to pay, the total costs to your property INSERT STREET ADDRESS, based on the recommendations of the CBA and Funding Model would be as follows:

Based Benefit Shares *

Upfront Payment
INSERT AMOUNT

Based on Metres Frontage *

Upfront Payment
INSERT AMOUNT

** To understand how the cost to your property was determined please refer to the **Funding Model report** available on our website.*

Please note the Funding Model has determined costs on a per lot basis. Should your property be located on a strata lot, this amount may be shared between properties.

Questions?

There are a number of ways to find out more and to register your views to help Council make a decision on the way forward. Please rest assured that your personal property details and information have not been released to the public. If you attend a public meeting, individual property information such as potential apportioned costs by address will not be discussed for privacy reasons. At this stage no decision has been made by Council on how the revetment wall will be funded or if and when it would proceed.

Directly Impacted Property Owners Meeting

Date:	Thursday 18 February 2021 - 6.00pm-7.30pm
Location:	Lake Cathie Bowling Club, Seaview Function Room
RSVP Essential:	Visit pmhc.nsw.gov.au/illaroo-road or call 6581 8111
COVID:	Only 2 people per household please. Due to COVID restrictions, you must be pre-registered to attend the meeting

Community Meeting

Date:	Tuesday 23 February 2021 - 5.30pm-6.30pm
Location:	Lake Cathie Bowling Club, Seaview Function Room
RSVP essential:	Visit pmhc.nsw.gov.au/illaroo-road or call 6581 8111
COVID:	Numbers are limited. Preference will be given to indirectly impacted property owners/residents in surrounding streets and key stakeholders. Due to COVID restrictions, you must be pre-registered to attend the meeting We have invited a range of key community stakeholders to attend the Community Meeting such as the local Progress Association, media, State and Federal Members and representatives of Council's Coast, Estuary and Floodplain Advisory Sub Committee.

1:1 Meetings with Directly Impacted Property Owners

Refers to: SF20/3096

You can book a one-on-one meeting to discuss the potential impacts for your property specifically. Go to our booking page at pmhc.nsw.gov.au/illaroo-road or call 6581 8111.

Can't make any of the meetings? Please contact our team via engagement@pmhc.nsw.gov.au and we will work on another option to suit you.

Next Steps

- Review the documentation provided with this letter and available online at haveyoursay.pmhc.nsw.gov.au/illaroo-road
- Register to attend a meeting - Visit pmhc.nsw.gov.au/illaroo-road or call 6581 8111
- Book a 1:1 meeting if you have questions specific to your property visit pmhc.nsw.gov.au/illaroo-road or call 6581 8111
- Consider seeking professional advice according to your needs
- Provide your feedback to us in writing by **Monday 12 April 2021**.

We understand this is a complex issue that could have a significant impact on you. Please keep in mind that at this stage we are only presenting to you the findings of the report, and that no decision has been made. We are committed to working with you to find solutions together.

A package of information is included with this letter:

- Illaroo Road Revetment Wall Project Overview
- Frequently Asked Questions
- Feedback form.

The Marsden Jacob Associates Cost Benefit Analysis and Funding Model Report is accessible on our website and printed copies will be available at the meetings.

Please take the time to read and consider all the information, seek professional advice or contact us with your questions and concerns.

Yours sincerely

Melissa Watkins
Director Development & Environment

FORM: Illaroo Road Revetment Wall

pmhc.nsw.gov.au

PORT MACQUARIE-HASTINGS COUNCIL

February 2021

As you may be aware we have been working for a number of years to find a solution to potential coastal erosion issues in Lake Cathie. In 2007 Council and the community commenced work on the Lake Cathie Coastal Zone Management Plan and in 2014, following extensive consultation with our community, a rock revetment wall was identified as the preferred option for Council to investigate further to address coastal erosion.

Your property has been identified as one of the 41 properties that could receive a direct benefit from the construction of a revetment wall. As a result, your property could incur a cost associated from the construction of the revetment wall.

Council is now seeking your feedback regarding your willingness and capacity to pay the amount stated in the attached letter dated 8 February 2021.

It is essential that we obtain your feedback by Monday 12 April 2021 to enable Council to make an informed decision.

PROPERTY OWNERS DETAILS	
Name	INSERT NAME
Street Address	INSERT LOT AND DP AND STREET ADDRESS

As per the results of the funding model as outlined in your letter, what is your preference for providing funding for the revetment wall?

Based Benefit Shares	**Based on Metres Frontage**
☐ Yes, upfront payment	☐ Yes, upfront payment
☐ Yes, consider payment plan	☐ Yes, consider payment plan
☐ No	☐ No

Signature	Date

Please return the completed form to any PMHC Council Office, or post to:

Attn: General Manager
Re: Illlaroo Road Revetment Wall Project
Port Macquarie-Hastings Council
PO Box 84
Port Macquarie NSW 2444

or email to: **council@pmhc.nsw.gov.au**

PORT MACQUARIE-HASTINGS COUNCIL

If you have any further comments, please add them here:

PORT MACQUARIE
HASTINGS
COUNCIL

WHAT IS THE PROPOSED REVETMENT WALL?

The Lake Cathie Illaroo Road Revetment Wall project consists of the construction of a 440m rock wall from Bundella Avenue, along Illaroo Road to Jonathon Dickson Reserve.

The revetment wall will provide protection to 41 properties over the next 50 years from the impacts of large storm events and coastal erosion due to sea level rise. It has been designed to include linking footpaths, seating, lighting, beach access stairs and a beach access ramp. It will also provide formalised parking spaces within Bundella Avenue and the installation of new kerb and gutter along Illaroo Road.

Figure 1: Illaroo Road Rock Revetment Wall Detailed Design, Aurecon 2015

HOW DID WE GET HERE?

We have been working through the Lake Cathie Coastal Zone Management Plan (CZMP) over the past 14 years. This was prompted by historical State Government investigations and community concern around sustained coastal erosion and impacts to infrastructure and amenities. This included damage to stormwater infrastructure and beach access points and an erosion escarpment that threatened to undermine the southern end of Illaroo Road. The development of the CZMP identified a revetment wall as a preferred option to deal with this ongoing issue.

To help you understand how we got to where we are now, we have compiled a snapshot timeline of events.

2008 - 2009

In 2008 we completed the Lake Cathie Coastal Hazard Study, documenting a detailed coastal hazard assessment of the beach at Lake Cathie. It describes the coastal processes affecting the beach at Lake Cathie and the impact of these processes on the areas of the beach where property is at risk. The report quantifies the observed long-term beach changes at Lake Cathie, as well as estimating the beach recession that may be caused by sea-level rise as a result of climate change. The risk to property is defined in terms of the present day risk, a 50 year planning period and a 100 year planning period *[See Figure 2 below]*.

Figure 2: SMEC Coastal Hazard Lines (Green = Immediate threat, Purple = 2055 threat, Orange = 2100 threat)

Following the 2008 Hazard Study, a Management Study was undertaken which was broken down into Stage 1 and Stage 2.

Stage 1 Management Study was completed by SMEC in 2009 and focused on seeking feedback from the community about their values and views on how Lake Cathie coastline was used. This allowed 13 potential management options to be put forward for assessment. After a period of public exhibition and consultation, the options to manage the coastal erosion were 'short listed' to four.

2012 - 2013

Stage 2 Management Study was completed by SMEC during 2012 and 2013 to examine the 'short listed' options put forward in Stage 1. The focus of Stage 2 was to seek feedback from the community on their preferred single option to manage the coastal erosion threat, and who their preferred sourcing option was to fund any coastal erosion protection works. There was strong public support to build a revetment wall with sand nourishment, and for State and Federal Government to fund the revetment wall project. Ultimately, at the 20 November 2013 Ordinary Council Meeting, it was resolved to proceed with a rock revetment wall with beach nourishments.

2014 - 2016

After adopting the preferred community option for coastal erosion protection, Council formally requested Certification of the CZMP by the NSW State Government (a legislated requirement). The then Minister for the Environment, Rob Stokes, wrote to us stating Certification would not be forthcoming without a number of actions to be undertaken;

a) Updated costs of the revetment wall.

b) A Cost Benefit Analysis (CBA) be undertaken.

c) Consider reviewing the management of stormwater to minimise the direct outflow of stormwater onto the beach.

In recognition that Council had already undertaken extensive work and community consultation in preparing the CZMP, the Minister directed the NSW Office of Environment and Heritage (OEH) to engage a consulting firm to prepare the CBA on our behalf (known as the Balmoral Group CBA). The CBA needed to assess; a) the costs and benefits of the identified 13 potential options for managing the identified threat posed by coastal processes to the Lake Cathie community, and b) to understand the social and economic impacts of each option in terms of local tourism, housing, jobs, population, supporting industries and the long-term viability of Lake Cathie as a community.

We then revised the CZMP to incorporate the results of this CBA which Council adopted in April 2016 and Ministerial Certification was requested again. Ministerial Certification of the Lake Cathie CZMP 2016 was provided by the then Minister for Planning, Rob Stokes, in November 2016 and the CZMP was Gazetted on 27 January 2017.

2017 - 2020

The finalisation of the Certification came with a list of required actions to implement. The most significant action required was to develop a workable funding model based on a distributional analysis that accords with the provisions of the new NSW Government Coastal Management Manual.

Council engaged Marsden Jacob Associates (MJA) to prepare a funding model, based on the new NSW Government Coastal Management Manual, which would rely on the results of the 2015 Balmoral Group CBA. However, upon review of the Balmoral modelling, MJA advised us that the CBA produced by Balmoral Group on behalf of the OEH in 2015 could not be used due to issues with the modelling used. The main issues being, the CBA was based on a wall covering a longer geographical area than we proposed to NSW State Government in our CZMP and that the wall design life was limited to only 20 years, however the CZMP states the revetment wall has a design life exceeding 20 years, so the residual value should have been factored into the analysis.

Accordingly, a new CBA was then prepared by MJA, along with the Funding Model requested by Minister for Planning, Rob Stokes.

The findings of the CBA and Funding Model, were presented to Ordinary Council Meeting in August 2020 and it was resolved to undertake extensive community engagement on the Illaroo Road Revetment Wall.

2021

We are engaging with the properties directly benefitting from the construction of the revetment wall, along with the surrounding Lake Cathie community, to discuss the findings of the CBA and the Funding Model – and to see if the properties directly benefitting from the construction of the revetment wall have the capacity or willingness to fund the revetment wall that will mitigate the coastal erosion issue.

WHAT IS A FUNDING MODEL?

A funding model is a financial model created to determine a variety of reliable and sustainable funding sources that enables the product or service to be implemented. The funding model conclusion is narrowed down to only one or two funding sources based on the findings from a CBA report.

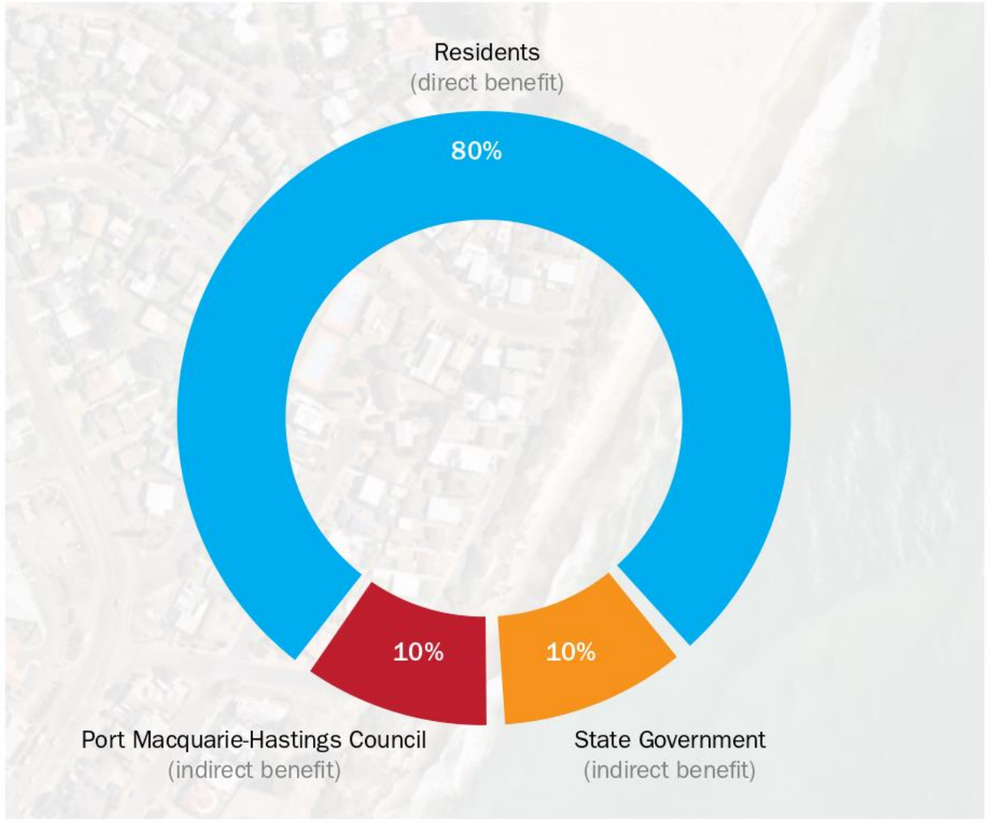

Figure 3: Suggested funding model for Illaroo Road Revetment Wall

WHAT IS A CBA?

Cost–benefit analysis (CBA) is a form of economic appraisal that can be used to estimate changes to the economic wellbeing of local and wider communities. A CBA is used to estimate and compare the costs and benefits of implementing a proposed project or management activity with the costs and benefits of a 'base case', which represents a continuation of current conditions under which the proposed project is not implemented.

In the analysis we modelled:

- Base Case = Business as usual
- Option Case = Revetment wall and beach nourishment to mitigate storm impacts

WHAT HAPPENS NOW?

Next, we encourage you to follow the three steps listed below. We want to reiterate no decision will be made without your input. Following these three steps, together we will work towards an outcome for this project.

Step 1 - Read the CBA & Funding Model reports, available online at haveyoursay.pmhc.nsw.gov.au/illaroo-road

Step 2 - Attend all the meetings made available to you by registering online at pmhc.nsw.gov.au/illaroo-road

Step 3 - Provide formal feedback in writing. To find out how, visit haveyoursay.pmhc.nsw.gov.au/illaroo-road

WHAT HAPPENS NEXT?

Once all the feedback has been received, this information will then be presented in an Ordinary Council Meeting, for the next course of action to be decided.


PORT MACQUARIE
HASTINGS
COUNCIL
pmhc.nsw.gov.au
PORT MACQUARIE OFFICE
17 Burrawan Street,
Port Macquarie NSW 2444
Phone: 6581 8111
Post: PO Box 84 Port Macquarie NSW 2444
Email: council@pmhc.nsw.gov.au
ABN: 112 369 016 01
WAUCHOPE OFFICE
49 High Street,
Wauchope NSW 2446
Phone: 6589 6500
LAURIETON OFFICE
9 Laurie Street,
Laurieton NSW 2443
Phone: 6559 9958
CUSTOMER SERVICE CENTRES
Open 8.30am - 4.30pm, Monday to Friday
CUSTOMER SERVICE CALL CENTRE
Operates 8.00am - 5.00pm, Monday to Friday
AFTER HOURS EMERGENCY CALLS
Phone 6583 2225

Illaroo Road Revetment Wall

Cost Benefit Analysis & Funding Model

Fact sheet

FREQUENTLY ASKED QUESTIONS

for residents of Lake Cathie and surrounds

Important Information about the Lake Cathie Revetment Wall for residents of Lake Cathie and surrounds.

What is the Illaroo Road Revetment Wall project?

The Illaroo Road Revetment Wall is the key action item from the Lake Cathie Coastal Zone Management Plan.

Where did the Revetment Wall project come from?

The Illaroo Road Revetment Wall comes from the Lake Cathie Coastal Zone Management Plan that was initiated in 2007 and was adopted by Council in 2013.

When did Council decide to proceed with the Revetment Wall project?

Council decided to proceed with the Revetment Wall in 2013, based on feedback from submissions received during the Stage 2 - Coastline Management Study that was undertaken in 2012.

Why has the Revetment Wall been proposed?

The revetment wall was identified as the primary action item that will protect private and public assets from the threat of coastal erosion from storms or long-term sea level changes.

pmhc.nsw.gov.au/illaroo-road

PORT MACQUARIE HASTINGS COUNCIL

FactSheet

PORT MACQUARIE-HASTINGS COUNCIL

What would the Revetment Wall protect?

The revetment wall would protect 41 properties and the assets that service them from the impacts of coastal erosion due to storm events and climate change. The properties and their assets are largely bounded by Illaroo Road, Bundella Avenue, Kywong Street, Kalang Street and Chepana Street.

I thought more properties were impacted by the revetment wall?

A number of properties are located within the Coastal Erosion map under the Port Macquarie-Hastings Local Environmental Plan (LEP) 2011. This map shows the properties that are potentially subject to coastal erosion in a 100-year timeframe. Some properties were identified during the coastal hazard study phase which was undertaken in 2008-2009 and updated in later years to account for climate change impacts. There are a number of Lake Cathie properties that are not likely to be impacted by coastal erosion for some time, the revetment wall was not extended southward to provide protection to Jonathan Dickson Reserve. As a result, whilst some properties are within the Lake Cathie Coastal Zone Management Plan area, these properties will not be impacted by the revetment wall project.

What other options could be used to protect properties and the road?

During the 2012 Stage 2 Coastline Management Study, 13 options were assessed. These include:

1. Vertical Seawall (400 m)
2. Revetment Wall (400 m)
3. Vertical Seawall (entire beach to Middle Rock)
4. Revetment Wall (entire beach to Middle Rock)
5. Artificial Reef
6. Groyne (rock)
7. Groyne (geotubes)
8. Beach nourishment
9. Beach nourishment plus groyne
10. Beach nourishment plus groyne and revetment (400 m)
11. Beach nourishment plus revetment (400m).
12. Planned Retreat with voluntary purchase.
13. Reactive Management Response.

FactSheet PORT MACQUARIE-HASTINGS COUNCIL

Would the revetment wall keep Lake Cathie open to the ocean?

No, the revetment wall is only designed to provide protection to assets located behind the wall from coastal erosion events. The revetment wall is not intended to have any impact on the natural opening and closing cycle of the Lake Cathie/Lake Innes ICOLL system.

Would the revetment wall stop the sand from closing the Lake from the Ocean?

No, sand will still drift along the coastline and will accumulate in the mouth of the Lake. It is intended that the revetment wall will not have any impact on the accumulation of sand from the lake mouth and the lake will continue to open and close on an intermittent and irregular cycle.

What impact would the revetment wall have on the beach?

Any solid structure located within the surf zone of a beach will cause localised lowering of the beach. When waves hit a solid structure their energy is reflected by the object they hit (in this case a rock wall), this causes erosion directly in front of and around the wall meaning that the beach will be less useable than if the wall was not in place. This will have an impact on the amenity of the beach at Lake Cathie.

Why is Council discussing funding now, shouldn't it have been finalised before now?

Council has discussed funding options and methodologies throughout the project from its inception in 2007. During the consultation phase of the Stage 2 - Coastline Management Study in 2012, there was large support from the community for state and federal governments to pay for the revetment wall. The 2013 resolution of Council when Council adopted the CZMP reflected this public sentiment.

However, there are rules and guidelines about how funding for projects such as this should occur. Council must follow this process if it wishes to access contributions from other levels of government.

It is noted that the NSW Government introduced new legislation and new guidelines on how projects within CZMP's and CMP's can be funded. Whilst the CZMP was adopted before the new guidelines were endorsed, they now apply to this project.

FactSheet PORT MACQUARIE-HASTINGS COUNCIL

Will construction of the Revetment Wall commence following this community engagement period?

Council must wait for feedback from directly affected residents before proceeding any further with the revetment wall project. However, Council has made a commitment to the revetment wall by resolving at 12 August 2020 Ordinary Council meeting to roll the actions from the CZMP into the new CMP. Timing of construction of the revetment wall is still unknown at this time.

Further Information

A community meeting to engage with Council staff has been arranged for you on **Tuesday 23 February 2021**. For the latest information and to RSVP, visit pmhc.nsw.gov.au/illaroo-road

Community engagement is an important part of the proposed revetment wall

Council is committed to community engagement and making decisions based on the interests and concerns of the community.

Council must follow the NSW Government process for the implementation of CZMP

Council is following the process outlined by the NSW Government in its implementation of the CZMP. Council must consider the new funding arrangements implemented by the Coastal Reforms that were implemented by the NSW Government in 2018.

Port Macquarie-Hastings Council
PO Box 84
Port Macquarie
NSW Australia 2444
DX 7415
council@pmhc.nsw.gov.au

ABN 11 236 901 601

PORT MACQUARIE HASTINGS COUNCIL

8 February 2021 Refers to: SF21/369

MAIL MERGE

Dear Mr & Mrs,

Illaroo Road Rock Revetment Wall Proposal

As you may be aware we have been working for a number of years to find a solution to potential coastal erosion issues in Lake Cathie. In 2007 Council and the community commenced work on the Lake Cathie Coastal Zone Management Plan and in 2014, following extensive consultation with our community, a rock revetment wall was identified as the preferred option for Council to investigate further to address coastal erosion.

We are now writing to explain what this could mean for you and invite you to meet with us to discuss the project. Our focus is to work with you as a property owner on this important project so that together we can make the best possible decisions based on your interests and concerns.

Why are we investigating a revetment wall?

Based on coastal hazard studies along Illaroo Road between 2008 - 2012, it was confirmed that the coastline at Lake Cathie was retreating. We have been working to find a solution to potential coastal erosion issues and the development of a revetment wall in Lake Cathie for a number of years. Consequently, in 2012-13 Council considered a number of potential management solutions including the revetment wall. Ultimately, at the November 2013 Ordinary Council Meeting, Council resolved to proceed with a concept design for a rock revetment wall with beach nourishment. This preferred solution was then presented to the NSW Government, who requested a Cost Benefit Analysis (CBA) be prepared to analyse the viability of the project and a Funding Model to outline the distribution of costs to direct and indirect beneficiaries. At this stage no decision has been made by Council on how the revetment wall will be funded or if and when it would proceed.

Cost benefit analysis

Construction of the revetment wall, including associated infrastructure such as footpaths, seating, lighting and beach access is estimated to be $10 million. The findings of the CBA and Funding Model, were presented to Ordinary Council Meeting in August 2020. These findings attribute the costs of the wall to be:

- 80% residents (direct benefit)
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t 02 6559 9958

Refers to: SF21/369

Property owners identified to receive a direct benefit have been contacted separately and provided with potential cost details specific to their property. To assist in your understanding of these findings please refer to the attached documents.

Questions?

Whilst your property is not located behind the proposed revetment wall and is therefore not deemed a direct beneficiary, as per the Cost Benefit Analysis (CBA) or Funding Model, your property is in close proximity to directly affected residents of whom may be neighbours or friends. As such, we are writing to invite you to attend a community meeting to find out more about the project. Also so that you are aware we have also invited a range of other stakeholders to attend such as the local Progress Association, Chamber of Commerce, Federal and State Members and representatives of Council's Coast, Estuary and Floodplain Advisory Sub Committee.

We would like to clarify that **no decision has been made on how the revetment wall will be funded, or if and when it would proceed**. We would also like to clarify that no personal or property information will be released to the public.

Community Meeting

Date:	Tuesday 23 February 2021 - 5:30pm
Location:	Lake Cathie Bowling Club, Seaview Function Room
RSVP:	Essential visit: pmhc.nsw.gov.au/illaroo-road or call **6581 8111**
COVID:	Numbers are limited. Preference will be given to key stakeholders and indirectly impacted property owners/residents in surrounding streets. Due to COVID restrictions you must be pre-registered to attend this meeting.

Can't make the community meeting or have a specific question relating to your property that you want to discuss in private? Please contact our team via engagement@pmhc.nsw.gov.au and we will work on another option to suit you.

As an indirectly impacted resident we recommend you read through the information made available to you so that you are fully versed on the situation that neighbouring properties are facing right now.

A package of information is included with this letter:

- Illaroo Road Revetment Wall Project Overview
- Frequently Asked Questions

We encourage you to attend the Community meeting on 23 February 2021. At the meeting you will be able to share your views on the project, ask questions and hear directly from the project team.

Refers to: SF21/369

Yours sincerely

Melissa Watkins
Director Development & Environment

PORT MACQUARIE
HASTINGS
COUNCIL

WHAT IS THE PROPOSED REVETMENT WALL?

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Council engaged Marsden Jacob Associates (MJA) to prepare a funding model, based on the new NSW Government Coastal Management Manual, which would rely on the results of the 2015 Balmoral Group CBA. However, upon review of the Balmoral modelling, MJA advised us that the CBA produced by Balmoral Group on behalf of the OEH in 2015 could not be used due to issues with the modelling used. The main issues being, the CBA was based on a wall covering a longer geographical area than we proposed to NSW State Government in our CZMP and that the wall design life was limited to only 20 years, however the CZMP states the revetment wall has a design life exceeding 20 years, so the residual value should have been factored into the analysis.

Accordingly, a new CBA was then prepared by MJA, along with the Funding Model requested by Minister for Planning, Rob Stokes.

The findings of the CBA and Funding Model, were presented to Ordinary Council Meeting in August 2020 and it was resolved to undertake extensive community engagement on the Illaroo Road Revetment Wall.

2021

We are engaging with the properties directly benefitting from the construction of the revetment wall, along with the surrounding Lake Cathie community, to discuss the findings of the CBA and the Funding Model – and to see if the properties directly benefitting from the construction of the revetment wall have the capacity or willingness to fund the revetment wall that will mitigate the coastal erosion issue.

WHAT IS A FUNDING MODEL?

A funding model is a financial model created to determine a variety of reliable and sustainable funding sources that enables the product or service to be implemented. The funding model conclusion is narrowed down to only one or two funding sources based on the findings from a CBA report.

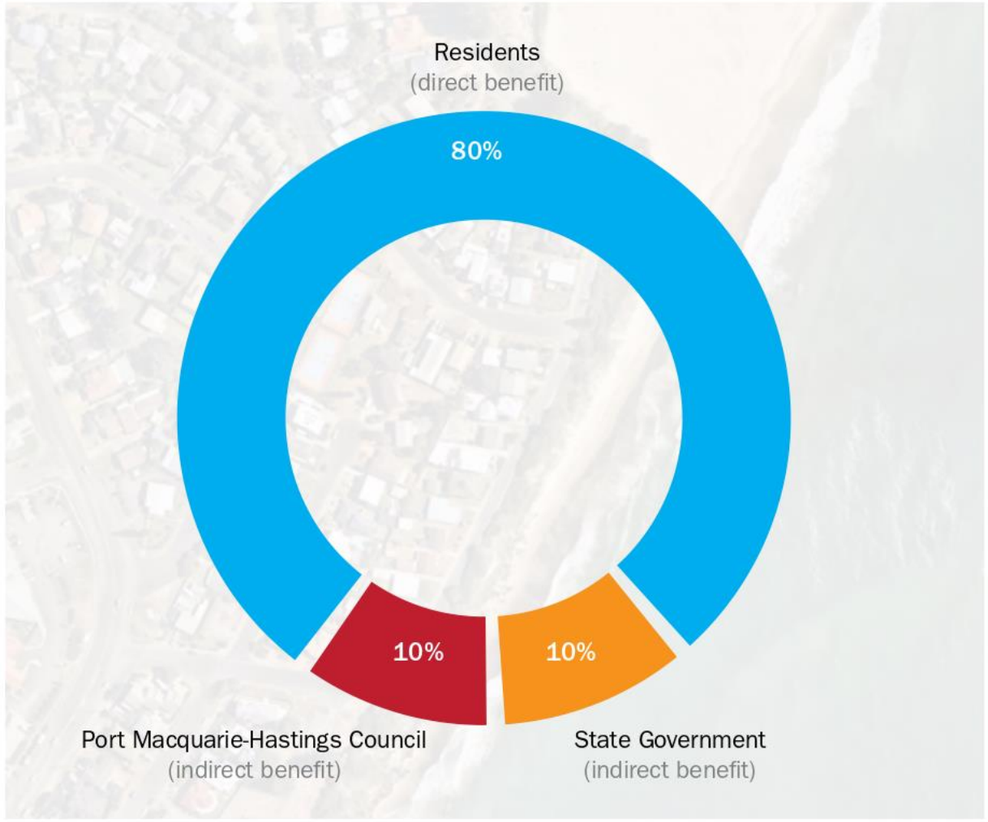

Figure 3: Suggested funding model for Illaroo Road Revetment Wall

WHAT IS A CBA?

Cost–benefit analysis (CBA) is a form of economic appraisal that can be used to estimate changes to the economic wellbeing of local and wider communities. A CBA is used to estimate and compare the costs and benefits of implementing a proposed project or management activity with the costs and benefits of a 'base case', which represents a continuation of current conditions under which the proposed project is not implemented.

In the analysis we modelled:

- Base Case = Business as usual
- Option Case = Revetment wall and beach nourishment to mitigate storm impacts

WHAT HAPPENS NOW?

Next, we encourage you to follow the three steps listed below. We want to reiterate no decision will be made without your input. Following these three steps, together we will work towards an outcome for this project.

Step 1 - Read the CBA & Funding Model reports, available online at haveyoursay.pmhc.nsw.gov.au/illaroo-road

Step 2 - Attend all the meetings made available to you by registering online at pmhc.nsw.gov.au/illaroo-road

Step 3 - Provide formal feedback in writing. To find out how, visit haveyoursay.pmhc.nsw.gov.au/illaroo-road

WHAT HAPPENS NEXT?

Once all the feedback has been received, this information will then be presented in an Ordinary Council Meeting, for the next course of action to be decided.


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Phone: 6559 9958
CUSTOMER SERVICE CENTRES
Open 8.30am - 4.30pm, Monday to Friday
CUSTOMER SERVICE CALL CENTRE
Operates 8.00am - 5.00pm, Monday to Friday
AFTER HOURS EMERGENCY CALLS
Phone 6583 2225

Illaroo Road Revetment Wall

Cost Benefit Analysis & Funding Model

Fact sheet

FREQUENTLY ASKED QUESTIONS

for residents of Lake Cathie and surrounds

Important Information about the Lake Cathie Revetment Wall for residents of Lake Cathie and surrounds.

What is the Illaroo Road Revetment Wall project?

The Illaroo Road Revetment Wall is the key action item from the Lake Cathie Coastal Zone Management Plan.

Where did the Revetment Wall project come from?

The Illaroo Road Revetment Wall comes from the Lake Cathie Coastal Zone Management Plan that was initiated in 2007 and was adopted by Council in 2013.

When did Council decide to proceed with the Revetment Wall project?

Council decided to proceed with the Revetment Wall in 2013, based on feedback from submissions received during the Stage 2 - Coastline Management Study that was undertaken in 2012.

Why has the Revetment Wall been proposed?

The revetment wall was identified as the primary action item that will protect private and public assets from the threat of coastal erosion from storms or long-term sea level changes.

pmhc.nsw.gov.au/illaroo-road

PORT MACQUARIE HASTINGS COUNCIL

FactSheet PORT MACQUARIE-HASTINGS COUNCIL

What would the Revetment Wall protect?

The revetment wall would protect 41 properties and the assets that service them from the impacts of coastal erosion due to storm events and climate change. The properties and their assets are largely bounded by Illaroo Road, Bundella Avenue, Kywong Street, Kalang Street and Chepana Street.

I thought more properties were impacted by the revetment wall?

A number of properties are located within the Coastal Erosion map under the Port Macquarie-Hastings Local Environmental Plan (LEP) 2011. This map shows the properties that are potentially subject to coastal erosion in a 100-year timeframe. Some properties were identified during the coastal hazard study phase which was undertaken in 2008-2009 and updated in later years to account for climate change impacts. There are a number of Lake Cathie properties that are not likely to be impacted by coastal erosion for some time, the revetment wall was not extended southward to provide protection to Jonathan Dickson Reserve. As a result, whilst some properties are within the Lake Cathie Coastal Zone Management Plan area, these properties will not be impacted by the revetment wall project.

What other options could be used to protect properties and the road?

During the 2012 Stage 2 Coastline Management Study, 13 options were assessed. These include:

1. Vertical Seawall (400 m)
2. Revetment Wall (400 m)
3. Vertical Seawall (entire beach to Middle Rock)
4. Revetment Wall (entire beach to Middle Rock)
5. Artificial Reef
6. Groyne (rock)
7. Groyne (geotubes)
8. Beach nourishment
9. Beach nourishment plus groyne
10. Beach nourishment plus groyne and revetment (400 m)
11. Beach nourishment plus revetment (400m).
12. Planned Retreat with voluntary purchase.
13. Reactive Management Response.

FactSheet PORT MACQUARIE-HASTINGS COUNCIL

Would the revetment wall keep Lake Cathie open to the ocean?

No, the revetment wall is only designed to provide protection to assets located behind the wall from coastal erosion events. The revetment wall is not intended to have any impact on the natural opening and closing cycle of the Lake Cathie/Lake Innes ICOLL system.

Would the revetment wall stop the sand from closing the Lake from the Ocean?

No, sand will still drift along the coastline and will accumulate in the mouth of the Lake. It is intended that the revetment wall will not have any impact on the accumulation of sand from the lake mouth and the lake will continue to open and close on an intermittent and irregular cycle.

What impact would the revetment wall have on the beach?

Any solid structure located within the surf zone of a beach will cause localised lowering of the beach. When waves hit a solid structure their energy is reflected by the object they hit (in this case a rock wall), this causes erosion directly in front of and around the wall meaning that the beach will be less useable than if the wall was not in place. This will have an impact on the amenity of the beach at Lake Cathie.

Why is Council discussing funding now, shouldn't it have been finalised before now?

Council has discussed funding options and methodologies throughout the project from its inception in 2007. During the consultation phase of the Stage 2 - Coastline Management Study in 2012, there was large support from the community for state and federal governments to pay for the revetment wall. The 2013 resolution of Council when Council adopted the CZMP reflected this public sentiment.

However, there are rules and guidelines about how funding for projects such as this should occur. Council must follow this process if it wishes to access contributions from other levels of government.

It is noted that the NSW Government introduced new legislation and new guidelines on how projects within CZMP's and CMP's can be funded. Whilst the CZMP was adopted before the new guidelines were endorsed, they now apply to this project.

FactSheet PORT MACQUARIE-HASTINGS COUNCIL

Will construction of the Revetment Wall commence following this community engagement period?

Council must wait for feedback from directly affected residents before proceeding any further with the revetment wall project. However, Council has made a commitment to the revetment wall by resolving at 12 August 2020 Ordinary Council meeting to roll the actions from the CZMP into the new CMP. Timing of construction of the revetment wall is still unknown at this time.

Further Information

A community meeting to engage with Council staff has been arranged for you on **Tuesday 23 February 2021**. For the latest information and to RSVP, visit pmhc.nsw.gov.au/illaroo-road

Community engagement is an important part of the proposed revetment wall

Council is committed to community engagement and making decisions based on the interests and concerns of the community.

Council must follow the NSW Government process for the implementation of CZMP

Council is following the process outlined by the NSW Government in its implementation of the CZMP. Council must consider the new funding arrangements implemented by the Coastal Reforms that were implemented by the NSW Government in 2018.

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PORT MACQUARIE HASTINGS COUNCIL

8 February 2021 Refers to: SF20/3096

Xx February 2021 Refers to: ???

xxx
xxx

Dear KEY STAKEHOLDER

Illaroo Road Rock Revetment Wall Proposal

As you may be aware we have been working for a number of years to find a solution to potential coastal erosion issues in Lake Cathie. In 2007 Council and the community commenced work on the Lake Cathie Coastal Zone Management Plan and in 2014, following extensive consultation with our community, a rock revetment wall was identified as the preferred option for Council to investigate further to address coastal erosion.

We are now writing to explain what this could mean for you and invite you to meet with us to discuss the project. Our focus is to work with you as a property owner on this important project so that together we can make the best possible decisions based on your interests and concerns.

Why are we investigating a revetment wall?

Based on coastal hazard studies along Illaroo Road between 2008 - 2012, it was confirmed that the coastline at Lake Cathie was retreating. We have been working to find a solution to potential coastal erosion issues and the development of a revetment wall in Lake Cathie for a number of years. Consequently, in 2012-13 Council considered a number of potential management solutions including the revetment wall. Ultimately, at the November 2013 Ordinary Council Meeting, Council resolved to proceed with a concept design for a rock revetment wall with beach nourishment. This preferred solution was then presented to the NSW Government, who requested a Cost Benefit Analysis (CBA) be prepared to analyse the viability of the project and a Funding Model to outline the distribution of costs to direct and indirect beneficiaries. At this stage no decision has been made by Council on how the revetment wall will be funded or if and when it would proceed.

Cost benefit analysis

Construction of the revetment wall, including associated infrastructure such as footpaths, seating, lighting and beach access is estimated to be $10 million. The findings of the CBA and Funding Model, were presented to Ordinary Council Meeting in August 2020. These findings attribute the costs of the wall to be:

- 80% residents (direct benefit)
- 10% Port Macquarie-Hastings Council (indirect benefit)
- 10% State Government (indirect benefit).

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LAURIETON OFFICE
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t 02 6559 9958

Refers to: SF20/3096

Property owners identified to receive a direct benefit have been contacted separately and provided with potential cost details specific to their property. To assist in your understanding of these findings please refer to the attached documents.

Questions?

We are writing to invite you to attend a community meeting to find out more about the project. We have also written to indirectly impacted residents to attend the community meeting. Indirectly impacted residents are defined as those within a close proximity to directly impacted houses. At the meeting, physical copies of the CBA and Funding Model will be available to you.

We would like to clarify that **no decision has been made on how the revetment wall will be funded, or if and when it would proceed**. We would also like to clarify that no personal or property information will be released to the public.

Community Meeting

Date:	Tuesday 23 February 2021 - 5:30pm
Location:	Lake Cathie Bowling Club, Seaview Function Room
RSVP:	Essential visit: pmhc.nsw.gov.au/illaroo-road or call **6581 8111**
COVID:	Numbers are limited. Preference will be given to key stakeholders and indirectly impacted property owners/residents in surrounding streets. Due to COVID restrictions you must be pre-registered to attend this meeting.

Can't make the community meeting or have a specific question relating to your property that you want to discuss in private? Please contact our team via engagement@pmhc.nsw.gov.au and we will work on another option to suit you.

As a key stakeholder resident we recommend you read through the information made available to you so that you are fully versed on the situation that directly impacted properties are facing right now.

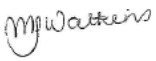
A package of information is included with this letter:

- Illaroo Road Revetment Wall Project Overview
- Frequently Asked Questions

We encourage you to attend the Community Meeting on 23 February 2021. At the meeting you will be able to share your views on the project, ask questions and hear directly from the project team.

Refers to: SF20/3096

Yours sincerely,



Melissa Watkins
Director - Development & Environment

PORT MACQUARIE-HASTINGS COUNCIL

Coastal Management Program

STAGE 1 - SCOPING STUDY

FEBRUARY 2021

TABLE OF CONTENTS

TABLE REFERENCE

ABBREVIATIONS

TERM	DEFINITION
ASS	Acid Sulphate Soils
CBA	Cost-Benefit Analysis
CEA	Coastal Environment Area
CE&F	Coast, Estuary & Floodplain Advisory Sub-Committee
CM Act	Coastal Management Act 2016
CM SEPP	State Environmental Planning Policy (Coastal Management) 2018
CMP	Coastal Management Program
CP Act	Coastal Protection Act 1979
CSP	Community Strategic Plan
CUA	Coastal Use Area
CVA	Coastal Vulnerability Area
CWLRA	Coastal Wetlands and Littoral Rainforest Area
CZMP	Coastal Zone Management Plan
DPI	Department of Primary Industries
DPIE	Department of Planning, Industry and Environment
EMP	Estuary Management Plan
ESD	Ecologically Sustainable Development
ICOLL	Intermittently Closed and Open Lakes and Lagoons
IP&R	Integrated Planning and Reporting Framework
KSC	Kempsey Shire Council
LEP	Local Environmental Plan 2011
LGA	Local Government Area
LSPS	Local Strategic Plannng Statement
Manual	NSW Coastal Management Manual
MCC	Mid Coast Council
NPWS	National Parks and Wildlife Service
NSW CP	NSW Coastal Policy 1997
NSW EP	NSW Rivers and Estuaries Policy
PMHC	Port Macquarie-Hastings Council
SEPP 14	State Environmental Planning Policy Coastal Wetlands No. 14
SEPP 26	State Environmental Planning Policy Littoral Rainforests No. 26
SEPP 71	State Environmental Planning Policy Coastal Protection No. 71
SES	State Emergency Services
TfNSW	Transport for NSW
UGMS	Urban Growth Management Strategy

1. INTRODUCTION

In NSW, coastal management is quickly becoming a high-profile area of concern for coastal councils, public and private asset owners, and the extended community.

Port Macquarie-Hastings Council (PMHC) recognises that the coastline is one of our greatest assets. It is a diverse, complex and dynamic environment made up of sandy open-coast beaches, dunes, rocky headlands, cliffs, rock platforms, estuaries, coastal floodplains, coastal lakes and lagoons. It has a range of unique values, natural and urban landscapes and cultural significance that support our vibrant, healthy and prosperous lifestyle.

The Port Macquarie-Hastings Coastal Zone, from Point Plomer in the north to Diamond Head in the south is characterised by its natural beauty, clear water and numerous inviting sandy beaches. An ever-increasing number of residents and tourists are attracted to the natural, cultural, social and economic values that our coastline offers.

The coastal zone is highly vulnerable to changes over time due to escalating environmental and socio-economic pressures. These pressures combined with social sensitivities to shifts in environmental conditions present unique challenges to coastal zone managers.

The NSW Government is delivering a new legislative and regulatory framework to better equip coastal communities to respond to the dynamic nature of the coast and sustainably manage the coastal environment. Local councils and public authorities are required to manage their coastal areas and activities in accordance with relevant state legislation, policies and plans.

PMHC has resolved to prepare a Coastal Management Program (CMP). A CMP aims to provide a long term, coordinated strategy for managing the coastal zone in accordance with the Coastal Management Act 2016 (CM Act) and local objectives. This management program will be implemented through the coordination between Council, state agencies and other key stakeholders.

In accordance with the NSW Coastal Management Framework, Stage 1 of preparing a CMP is to undertake a Scoping Study. The scoping study aims to consolidate information gathered both during Stage 1 and from previous management plans and outline the proposed pathway for the following stages of the CMP.

Key components of the scoping study include:

- **Strategic context for coastal management.**
- **Purpose, vision and objectives of the CMP.**
- **CMP scope - issues and areas, including maps of relevant CMAs**
- **Review of current management practices and arrangements.**
- **Identification of roles and responsibilities including other councils and relevant public authorities.**
- **First-pass risk assessment to identify where action is required, including studies to be completed in Stage 2.**
- **Stakeholder and community engagement strategy.**
- **Preliminary business case.**
- **Plan for future stages and timetable for CMP preparation. Include a timeframe for steps in the preparation of a planning proposal if changes to the LEP are proposed.**

The CMP will focus on and be guided by understanding, addressing and contributing to solutions around the following topics:

- How do we use our coastal zone?
- How do we balance environmental values with these uses?
- What do want our coastal zones to look like in the future?
- How do we adapt to the increasing challenges of living on the coast?
- Who is responsible for management of the coastal zone?

The methods used to develop the CMP will be guided by existing legislation, such as the CM Act, the NSW Coastal Management Manual and by the values and desires of our community.

1.1 COASTAL MANAGEMENT PROGRAM FRAMEWORK

In 2016, the NSW Government introduced a new framework to manage the coastal environment in an ecologically sustainable way for the social, cultural and economic wellbeing of the residents and visitors of NSW. The cornerstone of this framework, the Coastal Management Act 2016, contains provisions that should be followed to develop long-term strategies for the management of the coastal zone.

The CMP will set the long-term strategy for the coordinated management of the coastal zone. It will achieve the purpose and objectives of the CM Act. The process to write a CMP is prescriptive so that it provides consistency across the NSW.

Each CMP follows a five-stage program that is outlined in the NSW Coastal Management Manual *[see Figure 1]*.

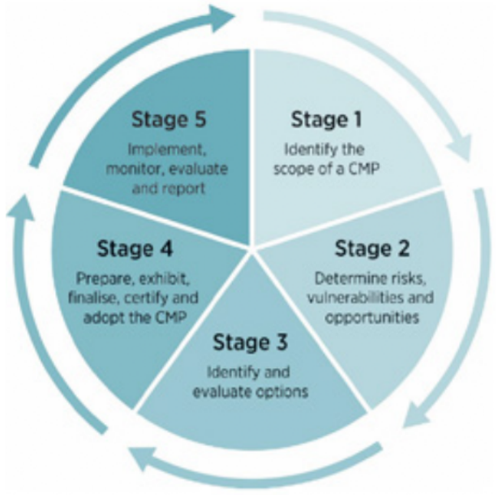


Figure 1: *Stages in preparing and implementing a CMP*

The scoping study is the first stage in the process of preparing a CMP. It will assist councils to identify the community and stakeholders and prepare an engagement strategy, determine the context of coastal management in the local area and establish roles, responsibilities and governance arrangements to deliver management actions across the Local Government Area (LGA). After the scoping study is completed, the remainder of the CMP will be divided into four 'chapters' based on geographic areas, to better manage localised issues. Each of the stages 2, 3, 4 and 5 will be done repetitiously for the four below chapters (areas) to ensure site-specific detail to enable best management of the on-ground issues.

The chapters include:

1. **Lake Cathie/Lake Innes & Bonny Hills Estuary & Coastline** - incorporating the open coastline from the 4 x 4 access track adjacent to Dirah Street, Lake Cathie to the southern side of Grants Head at Bonny Hills (referred to in this document as the Lake Cathie/Bonny Hills chapter for simplicity).
2. **Hastings River Estuary**
3. **Camden Haven River Estuary**
4. **Port Macquarie-Hastings Open Coastline** (excluding the open coastline that is covered in the Lake Cathie/Bonny Hills area

Refer to *[Section 13.6]* for further information on the proposed CMP areas.

Each chapter will identify management issues and the actions, specific to the local area, which are required to address these issues in a strategic and integrated way. Each chapter will contain detail regarding:

- Who is responsible for each action?
- How and when those actions are to be implemented?
- Costs and proposed cost-sharing arrangements for each action.

2. PURPOSE, VISION AND OBJECTIVES

2.1 LIMITATIONS

Much like all LGA's, PMHC faces limitations to the scale and extent of coastal zone management it can feasibly achieve. Limitations include land tenure, funding resources, the complexity of stakeholder engagement which requires a balance between multiple government agencies and community needs with possible competing priorities and the legislative complexities that take time to complete. A hurdle in all LGA's is finding a balance amongst the desires of all ratepayers in the LGA. The majority of income derived for projects is from ratepayers and must be divided into various priority areas and competing needs and desires. These priorities include roads, water availability, sewer, recreation, and arts and culture to name a few.

The CMP aims to provide a framework for management of the coastal zone, which acknowledges and reflects the needs of the coastal area but balances this with the reality of the competing needs of the LGA and the various desires/mandates of other stakeholders. Opportunities for funding will be sought often and communication and engagement will be top priority .

2.2 SCOPING STUDY PURPOSE

The purpose of preparing this scoping study is to identify how the coastal zone is currently managed and to consider if further investigations or changes to management actions are required. This assessment includes a review of existing Coastal Zone Management Plans (CZMP) and Estuary Management Plans (EMP) to identify any gaps in knowledge and determine if any further management actions are required in light of the objectives of the new Coastal Management Act 2016.

Stage 1 is designed to assist councils to:

- Review the strategic context for coastal management in the local area.
- Determine the purpose of the CMP and the key outcomes that it is intended to deliver.
- Identify the appropriate scope for the CMP, consider the area and range of issues to be dealt with and identify which organisations and communities need to be involved.
- Determine the adequacy of available information and management actions and identify subsequent stages in the preparation of the CMP, including the possibility of fast-tracking.

In accordance with the Coastal Management Manual:

The scoping study will guide the direction of stages 2, 3, 4 and 5 of the coastal management program. PMHC will engage both the community and relevant stakeholders throughout the process to develop a shared understanding of the current situation and identify any changes to coastal values so that they are integrated into the planning process.

2.3 VISION

Ensure the continued protection, use and enjoyment of Port Macquarie-Hastings's coasts, rivers and estuaries in an ecologically sustainable manner*

This vision aligns with PMHC's overarching vision of **"A sustainable high-quality of life for all"**. (*Source: Towards 2030 Community Strategic Plan - Port Macquarie-Hastings Council)*

* It is envisioned that the CMP vision will be refined during further community and stakeholder engagement.

2.4 OBJECTIVES

The purpose of the Coastal Management Program is to provide a framework for the long-term strategic and integrated management of priority coastal hazards, issues and risks to the Port Macquarie-Hastings Coastal Zone, in line with the community's needs, NSW state objectives and legislation. The successful development and implementation of a robust CMP will provide a range of short, medium and long-term outcomes. These objectives will be refined during Stage 2 in consultation with stakeholders and the community so that they are consistently reflecting local issues and conditions. The CMP will also identify who is responsible for delivery of key management actions.

Figure 2. *Tacking Point Lighthouse, Port Macquarie*

3. GOVERNANCE

The CMP covers a large geographic area in the PMHC LGA and lays over various land zones. Within Council's governance structure, the action or manner of governing, there are multiple land managers including the Natural Resources, Recreation and Building, Strategic Planning, and Infrastructure Planning sections that may all need to be consulted before works may be undertaken. In addition to internal consultation, numerous state agencies including Department of Planning, Industry and Environment, Department of Primary Industries Fisheries, National Parks and Wildlife Services, NSW Office of Water, Roads and Maritime, and Crown Lands also own, regulate certain activities and manage land within the coastal zone and must be consulted with before works can occur. These departments have governance decisions over their land on which Council must seek permission and licensing from before works are undertaken. Other key stakeholders are the Local Aboriginal Land Councils, which must be consulted and give permission for works on land that is owned and managed by the traditional owners of this land.

When discussing governance, it is also important to remember to be a good neighbour and as such when undertaking works near the LGA boundaries of Kempsey and MidCoast Councils, further discussions need to occur to manage the risks of shared estuaries and sediment compartments.

Consultation will always be a key factor in governance. One way to ensure Council is making sound management decisions is PMHC's internal Coast, Estuary and Floodplain Advisory (CE&F) Sub-Committee that is used for regular review and consultation of policies, projects and studies. Members of this committee consist of representatives from PMHC Councillors, waterways users, community members, development industry, oyster industry, Council staff, Crown Lands, DPI – Fisheries, NPWS, DPIE, TfNSW – Maritime division, and SES.

Figure 3. *Rainbow Beach, Bonny Hills*

4. PORT MACQUARIE-HASTINGS COASTAL ZONE

Figure 4. *Example of Coastal Wetlands and Littoral Rainforest map with proximity areas.*

The Coastal Management Act 2016 defines the coastal zone as the area of land comprised within the coastal management areas i.e. coastal wetlands and littoral rainforests area, coastal vulnerability area, coastal environment area and coastal use area. The Coastal Management SEPP 2018 (CM SEPP) identifies these areas and provides mapping for coastal wetlands and littoral rainforests area, coastal environment area and the coastal use area. The CM SEPP states that at the commencement of the policy, no coastal vulnerability area was adopted and therefore this area has not been identified or mapped.

The NSW State Government has generated mapping for the coastal wetlands and littoral rainforests area, coastal environment area and the coastal use area. The mapping for the coastal wetlands and littoral rainforest area includes a proximity area which is included in the definition. The proximity areas include land up to 100 metres area around the defined coastal wetlands and littoral rainforest area *[see Figure 4]*.

Coastal and estuaries within the LGA have historically been managed as separate areas i.e. EMP's and CZMP's. This same principle will be followed within the CMP in order to specify actions and determine priority areas. The following sections identify the Coastal Management Areas mapped or identified in the LGA in context to each area as it applies i.e. estuary, coast or catchment (covering both).

5. VALUES AND RESPONSIBILITIES

Council's Community Strategic Plan (CSP) is an overarching 10-year plan. It is prepared by Council and the community based around community priorities. The current CSP was prepared by Council in 2008 and subsequently reviewed and updated in 2012 and 2016. The plan enables Council to coordinate funding priorities, activities and services to align to community needs and desires. The CSP goals specifically for the Natural and Built Environment are to achieve a connected, sustainable, accessible community and environment that is protected now and into the future. Some of the key priorities of the CSP are:

- A community that is prepared for natural events and climate change.
- Sustainable and environmentally sensitive development outcomes that consider the impacts on the natural environment.
- Infrastructure provision and maintenance that meets community expectations and needs.
- Well planned communities that are linked to encourage and manage growth.
- Accessible and protected waterways, foreshores, beaches and bushlands.
- An environment that is protected and conserved for future generations.

Council is currently in the development of a new Community Strategic Plan (CSP) "Think 2050". This plan needs to be developed before June 2021 to align with the state governments Integrated Planning and Reporting (IPR) framework.

How does the CSP affect the CMP?

In preparing the CMP, Council must integrate the various planning documents and strategies that affect the local community and the state. Being mindful that the CMP will become a reference tool for Council, the community, government agencies and other stakeholders, the document must be practical, achievable and must integrate the actions of the CMP into the larger scope of the Council in order to manage the PMHC coastal zone.

As a way of both understanding the community needs and wants as well as providing guidance to the community regarding how the CMP works, Council staff as well as members of the Coast, Estuary and Floodplain Advisory Committee (including government agency representatives) will be responsible to undertake broad community consultation. This consultation will focus on specific geographical areas and will assist in identifying important assets, issues, risks, solutions and the values and priorities of the community.

Figure 5: *Wildlife at Lake Cathie - Photo: Brett Dolsen*

An overview of some of the identified community values that will be used to guide the long-term outcomes for the CMP are outlined below, Council welcomes more suggestions as we work through the community engagement:

- Unique coastal zone character
- Amenities
- Public access
- Equity and fairness
- Water quality
- Biological diversity
- Ecosystem integrity and resilience
- Recreational use
- Business/employment benefits
- Community benefits

In addition to the broader community, Council is also acutely aware of our neighbouring Councils as we share estuaries and sediment compartments across our Council boundaries. The Camden Haven River Estuary and Tacking Point-Crowdy Head sediment compartment is shared with Mid Coast Council (MCC) and the Hastings River Estuary and the South West Rocks-Port Macquarie sediment compartment is shared with Kempsey Shire Council (KSC). The Coastal Management Act 2016 requires consultation with other local Councils where those Councils share a coastal sediment compartment or estuary. As such, consultation will be undertaken with neighbouring Councils specifically for those actions that effect either a shared estuary or a shared sediment compartment.

6. STRATEGIC CONTEXT

6.1 BACKGORUND

NSW & Local Government have historically managed coasts and estuaries in accordance with the following legislation:

- Coastal Protection Act 1979 (CP Act)
- NSW Coastal Policy 1997 (NSW CP)
- State Environmental Planning Policy Coastal Wetlands No. 14 (SEPP 14)
- State Environmental Planning Policy Littoral Rainforests No. 26 (SEPP 26)
- State Environmental Planning Policy Coastal Protection No. 71 (SEPP 71)
- NSW Rivers and Estuaries Policy (NSW EP)

The NSW State Government undertook coastal reforms in 2016. These reforms repealed the CP Act and replaced it with the Coastal Management Act 2016 (CM Act).

The new framework for managing the NSW coast primarily consists of:

- Coastal Management Act 2016 (CM Act)
- State Environmental Planning Policy (Coastal Management) 2018 (CM SEPP)
- NSW Coastal Management Manual (Manual).
- Coastal Management Programs (CMPs)
- NSW Coastal Council

A CMP is being developed which will provide integrated management of defined coastal areas within the Port Macquarie-Hastings Local Government Area and will replace existing Coastal Zone Management Plans (CZMP) and Estuary Management Plans (EMP) once implemented.

The Manual provides guidance on the development of CMPs and divides the development into five (5) stages, with Stage 1 being a scoping study *[see section 1.1]*.

Figure 6. *Nobby's Point, Port Macquarie*

6.2 EXISTING & FORMER MANAGEMENT PLANS

6.2.1. COASTAL ZONE MANAGEMENT PLANS

The Coastal Protection Act 1979 & Coastal Policy suggested that Councils develop and implement Coastal Zone Management Plans (CZMPs) to manage their coastlines. CZMPs were intended to provide management guidance for coastal zones including understanding coastal processes and how the coastal zones were used. For detailed information on existing CZMPs and EMPs refer to Chapter 16 of this scoping study.

The following CZMPs were developed:

- Town Beach Coastal Zone Management Plan (2006). NB. This CZMP was not gazetted as it was not certified by the NSW state government.
- Lake Cathie Coastal Zone Management Plan (2016). NB: This CZMP was gazetted on 27 January 2017.

6.2.2. ESTUARY MANAGEMENT PLANS

The NSW Rivers and Estuaries Policy required Councils to develop EMPs in order to achieve integrated, balanced, responsible and ecologically sustainable use of estuaries which formed a key part of coastal catchments.

The following EMPs were developed:

- Lake Cathie-Lake Innes Estuary Management Plan (1994)
- Hastings River Estuary Management Plan (2001)
- Camden Haven River Estuary Management Plan (2002)
- Saltwater Creek Management Plan (2005)

6.2.3. FLOODPLAIN MANAGEMENT PLANS

Councils also have a role managing floodplain risk. Although these plans coincide with the same geographical area as the coastal zone at times, these management plans are still in effect. No changes in legislation or policy have altered these plans.

The following floodplain risk management plans have been developed and are still in effect:

- Camden Haven Floodplain Risk Management Plan, Bewsher Consulting Pty Ltd, 2004
- Hastings Floodplain Risk Management Plan, Worley Parsons Services Pty Ltd, 2014

6.2.4. OTHER MANAGEMENT PLANS

There are a large number of reserves located in the coastal zone that PMHC manages using Masterplans and Plans of Management. *[See section 16.2.5]* for other Plans and Reports for further information.

7. NEW COASTAL MANAGEMENT FRAMEWORK

7.1 COASTAL MANAGEMENT ACT 2016

The CM Act establishes the framework and overarching objects for coastal management in New South Wales.

The purpose of the CM Act is to manage the use and development of the coastal environment in an ecologically sustainable way, for the social, cultural and economic well-being of the people of New South Wales.

The CM Act also supports the aims of the Marine Estate Management Act 2014, as the coastal zone forms part of the marine estate.

The CM Act defines the coastal zone, comprising four (4) coastal management areas:

- **Coastal wetlands and littoral rainforests:** areas which display the characteristics of coastal wetlands or littoral rainforests that were previously protected by SEPP 14 and SEPP 26.
- **Coastal vulnerability area:** areas subject to coastal hazards such as coastal erosion and tidal inundation.
- **Coastal environment area:** areas that are characterised by natural coastal features such as beaches, rock platforms, coastal lakes and lagoons and undeveloped headlands. Marine and estuarine waters are also included.
- **Coastal use area:** land adjacent to coastal waters, estuaries and coastal lakes and lagoons.

The CM Act establishes management objectives specific to each of these coastal management areas, reflecting their different values to coastal communities.

Different management objectives exist across the four coastal management areas. New maps defining the coastal management areas were released with the commencement of the Coastal Management SEPP. If multiple areas apply to a single parcel of land, the CM Act imposes a hierarchy as to which coastal management objectives apply.

A Coastal Management Manual has been developed as part of the reform package. The manual contains the mandatory requirements which must be imposed when developing Coastal Management Programs (CMPs).

The Act has abolished the NSW Coastal Panel, and established a new NSW Coastal Council.

TRANSITION FROM OLD TO NEW

The Act has introduced CMP's to replace the Coastal Zone Management Plans (CZMPs) that were implemented under the Coastal Protection Act 1979. Council's must have new CMPs in place and adopted before works can qualify for grant funding. As part of the legislation change no transition arrangements were provided meaning all existing Council adopted Estuary Management Plans are now no longer capable of receiving grant funding.

Hence until a CMP is adopted, no estuary management works will be funded by the NSW State Government. Coastal management works that are contained within a certified CZMP are still eligible for funding, but only until December 2021.

Estuary management works have not been capable of receiving NSW state government grant funding since April 2018 which has significantly impacted on Council's ability to undertake estuary management works.

7.2 STATE ENVIRONMENTAL PLANNING POLICY (COASTAL MANAGEMENT) 2018

The State Environmental Planning Policy (Coastal Management) 2018 (CM SEPP) identifies and maps the coastal zone according to definitions in the CM Act and aims to streamline coastal development assessment requirements.

The CM SEPP identifies development controls for consent authorities to apply to each coastal management area to achieve the objectives of the CM Act. And as such, the CM SEPP establishes the approval pathway for coastal protection works.

Statewide mapping is available for:

- Coastal wetlands and littoral rainforest area
- Coastal environment area
- Coastal use area

At the commencement of the CM SEPP, no Coastal Vulnerability Area Maps were adopted and therefore no coastal vulnerability areas are identified in this policy.

7.3 COASTAL MANAGEMENT PROGRAMS

CMPs will set the long-term strategy for coordinated management of the coast with a focus on achieving the objects of the CM Act. Local Councils in consultation with their communities and relevant public authorities prepare them. Councils are not required to develop a CMP if they choose not to.

If a CMP is proposed, it must:

1. Identify the coastal management issues affecting the areas to which the program is to apply
2. Identify the actions required to address those coastal management issues in an integrated and strategic manner
3. Identify how and when those actions are to be implemented
4. Identify the costs of those actions and proposed cost-sharing arrangements and other viable funding mechanisms for those actions
5. Include a coastal zone emergency action sub-plan if the local Council's LGA contains land within the coastal vulnerability area and beach erosion, coastal inundation or cliff instability is occurring on that land.

A CMP may also include other matters as may be authorised or permitted by the Manual.

7.4 NSW COASTAL MANAGEMENT MANUAL

The Manual provides mandatory requirements and guidance for the preparation, development, adoption, implementation, amendment and review of CMPs.

It provides systematic guidance on how to prepare a CMP and integrate coastal management actions with Councils other strategic and land-use planning processes.

The Manual is comprised of three parts:

PART A
Outlines the mandatory requirements in the CM Act, and the essential elements that councils are required to follow.

PART B
Describes in detail the process for preparing a CMP.

PART C
Provides a technical toolkit with advice on a range of topics.

7.5 NSW COASTAL COUNCIL

The NSW Coastal Council is appointed by the NSW Government to provide independent advice to the Minister on coastal issues. The NSW Coastal Council replaces the NSW Coastal Panel and the Coastal Expert Panel.

7.6 COASTAL AND ESTUARY GRANTS PROGRAM

The Coastal and Estuary Grants program provides funding assistance to help Councils prepare and implement CMPs. Funding has historically been provided for planning and implementation works at a ratio of 1:1, meaning for every one-dollar Council commits, the NSW government will provide a matching one-dollar.

In April 2020 the NSW Government announced that it was increasing financial assistance to Councils to help mitigate coastal erosion risks and restore degraded coastal habitats.

Minister for Local Government Shelley Hancock said the funding ratio for eligible projects under approved Coastal Management Programs will increase to 2:1 meaning the State will now contribute two-dollars to every one-dollar put in by Councils.

These changes are part of 32 supported recommendations from a recent review that examined ways of improving Councils access to funding under the Coastal and Estuary Management program.

The 2:1 funding ratio will bring the Coastal & Estuary Management grants program in line with the Floodplain Management Grants Program.

The 2:1 funding ratio is only applicable to planning and implementation projects where they are in an approved CMP, as such the action items from the certified Lake Cathie CZMP are not eligible for 2:1 funding and will only be able to access funding from the NSW Government at a 1:1 ratio.

Current Coastal & Estuary Grant Program funding is only available until the end of the 2020/2021 financial year. Grant funding arrangements after this time are unknown.

Figure 7. *Oxley Beach, Port Macquarie*

8. COUNCILS STRATEGIC PLANNING FRAMEWORK

8.1 STRATEGIC PLANS

PMHC is guided by a number of key strategies and plans which will assist with integrating the aspects of population growth, land use, community values and expectations into the CMP. These strategies and plans are summarised below.

INTEGRATED PLANNING AND REPORTING FRAMEWORK (IP&R)

The Integrated Planning and Reporting (IPR) framework was legislated by the New South Wales Office of Local Government in 2009. It provides councils with a planning framework that is guided by the vision of the community for a 10 year period and gives local governments a structure for establishing local priorities and to link this information to operational functions.

The framework includes a suite of integrated plans that set out a vision and goals and strategic actions to achieve them. It involves a reporting structure to communicate progress to council and the community as well as a structured timeline for review to ensure the goals and actions are still relevant.

The framework is made up of four major elements, which are linked and continually assessed through regulatory reporting channels.

These are the:

- Towards 2030 Community Strategic Plan (CSP) 2017-2021
- Delivery Program (DP) (Revised)
- 2020-2021 Operational Plan (OP)
- Resourcing Strategy (RS)

Under the framework, councils are required to give due regard to State Plan NSW 2021 and other Relevant Regional Plans to inform Council in identifying relevant issues for its Community Strategic Plan. Likewise, Council also have a wide range of plans for consideration, which highlight key local community issues. A number of examples include Coastal Management Programs, Urban Growth Management Strategy, Economic Development Strategy, Recreation Action Plan, Biodiversity Strategy, and Cultural Plan.

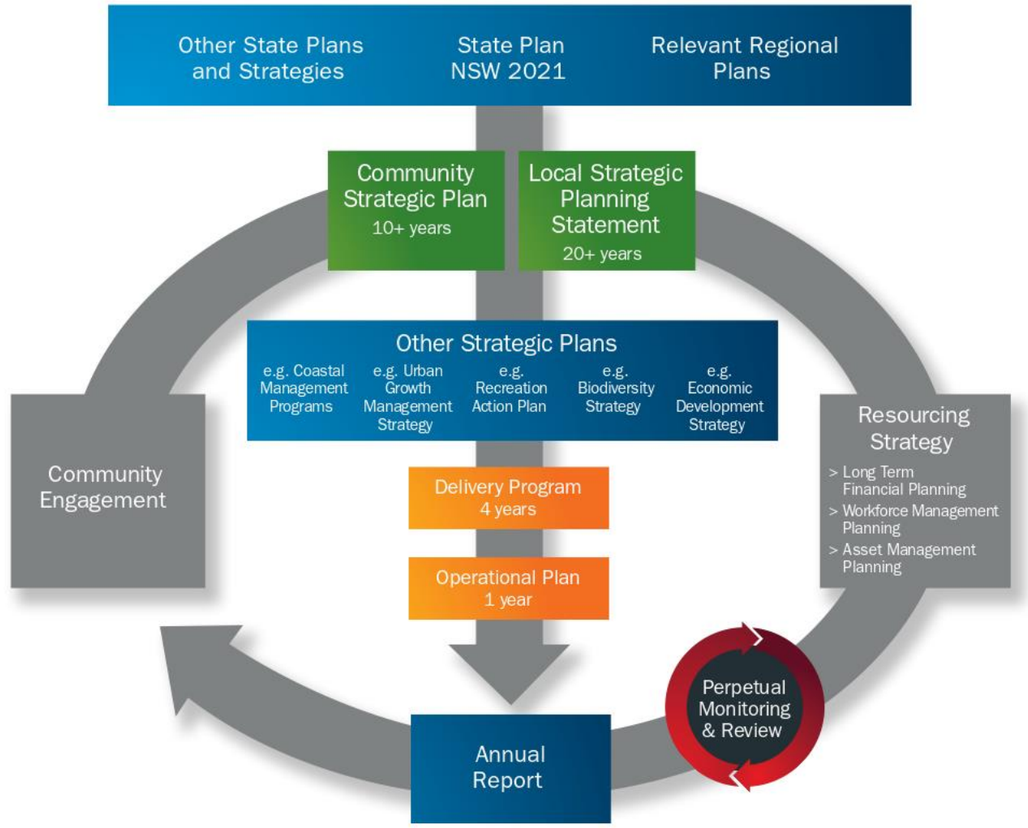


Figure 8. *Integrated planning and reporting framework*

NORTH COAST REGIONAL PLAN 2036

The North Coast Regional Plan 2036 is a broad strategic plan that reflects the community's aspirations and opportunities for the north coast of NSW until 2036.

MID NORTH COAST REGIONAL STRATEGY 2006 - 2031

The Mid North Coast Regional Strategy 2006 – 2031 was released by NSW Department of Planning in March 2009. The primary purpose of the regional strategy is to ensure that adequate land is available and appropriately located to accommodate projected housing and employment needs of the region's population over the next 25 years.

In summary the aims of the strategy are to:

- Protect high value environments and habitat corridors, cultural and Aboriginal heritage and scenic landscapes.
- Provide up to 58,400 new homes by 2031 to cater for a forecast population increase of 91,000. With smaller households and an ageing population, a more suitable mix of housing will be encouraged, including more multi-unit style dwellings.
- Ensure an adequate supply of land is available to support economic growth and an additional 47,000 jobs.
- Encourage the growth and redevelopment of the Region's four major regional centres (Grafton, Coffs Harbour, Port Macquarie and Taree) and six major towns (Maclean, Woolgoolga, Bellingen, Macksville, Kempsey and Forster–Tuncurry) through urban design and renewal strategies.
- Protect the coast by focusing new settlement in areas identified on local strategy maps. Development in places constrained by coastal processes, flooding, wetlands, important farmland and landscapes of high scenic and conservation value will be limited.

PMHC URBAN GROWTH MANAGEMENT STRATEGY (UGMS) 2017-2036

The PMHC UGMS aims to identify opportunities for new economic development and housing that will meet the needs of the growing community. The Community Vision for the Port Macquarie-Hastings is "A sustainable high quality of life for all". The strategy focuses on the coastal area and major towns and villages where urban growth is expected to take place over the next 20 years.

TOWARDS 2030 COMMUNITY STRATEGIC PLAN 2017

The CSP identifies what the community wants for the future of the LGA and what should be prioritised. This plan should be reviewed every 10 years and is the overarching guidance for Councils strategic direction. The Delivery Program and the Operational Plan are the underlying plans of the CSP, which provide more detailed targets and actions to be delivered and how they can be achieved.

The CMP must consider the strategic direction of the Community Strategic Plan to ensure that it coincides with what the community wants for the LGA. This will then have to be integrated into the Delivery and Operational Plans once specific actions are determined.

PMHC's Towards 2030 Community Strategic Plan (CSP) for the natural and built environment aims "to achieve a connected, sustainable, accessible community and environment now and into the future". The results of the CSP will be:

- Effective management and maintenance of essential water, waste and sewer infrastructure
- A community that is prepared for natural events and climate change
- Sustainable and environmentally sensitive development outcomes that consider the impact on the natural environment
- Accessible transport network for our communities
- Infrastructure provision and maintenance that meets community expectations and needs
- Well planned communities that are linked to encourage and manage growth
- Accessible and protected waterways, foreshores, beaches and bushlands
- An environment that is protected and conserved for future generations
- Renewable energy options that are understood and accessible by the community

PMHC continues to look to the future and therefore has already begun preparing the "Think 2050 CSP" which will supersede the current CSP when completed.

THINK 2050 COMMUNITY STRATEGIC PLAN

Port Macquarie-Hastings Council launched the Think 2050 Community Strategic Plan and commenced community engagement on 4 December 2019.

Think 2050 is centered on engaging with everyone in our community including those that live, work, study, attend school or do business, as well as those that shop or visit our beautiful region.

Throughout 2020 and the first half of 2021 Council will be engaging with community members and asking for ideas, suggestions, and feedback to help plan for the ongoing and future needs of the region. These findings will be incorporated into the CMP as they develop.

9. PORT MACQUARIE-HASTINGS LGA 0VERVIEW

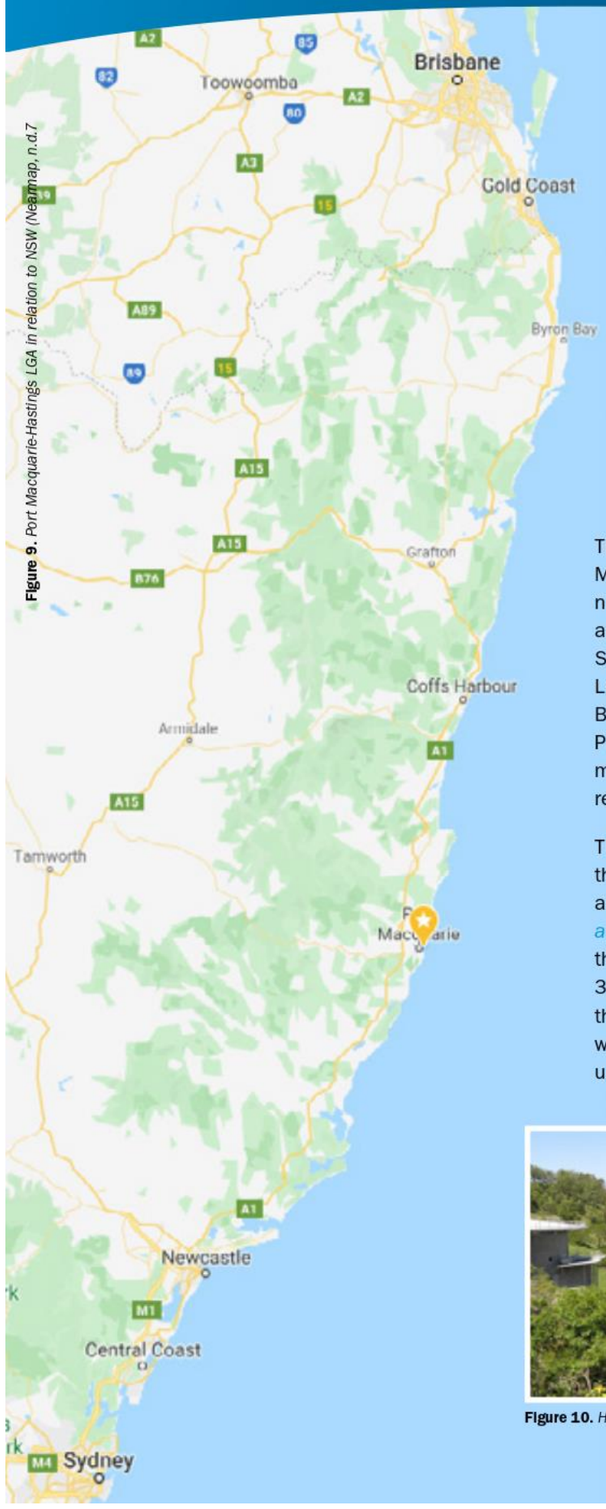


Figure 9. *Port Macquarie-Hastings LGA in relation to NSW (Nearmap, n.d.7*

The Port Macquarie-Hastings LGA is located on the Mid-North Coast of NSW, about 320 kilometres north of Sydney, 420km south of Brisbane, QLD and has an area 3,687 km2 *[Refer to Figure 9]*. Significant localities situated on the coast in the LGA are North Shore, Port Macquarie, Lake Cathie, Bonny Hills, North Haven, Dunbogan and Laurieton. Port Macquarie is the most populous and attracts most of the coastal activity, especially activities related to tourism.

There are three main catchments in the LGA: the Hastings River, Lake Cathie/Lake Innes and the Camden Haven *[see Figures 10, 11 and 12]*. The Hastings River is the largest of all these catchments and encompasses an area of 3,864km2. The river itself is 165km long and is the source of the majority of the LGA's drinking water supply which is pumped from Koree Island, upstream of Wauchope.

The mouth of the Hastings River is located at Town Beach Port Macquarie while the Camden Haven River comes out between North Haven and Dunbogan. The Lake Cathie/Lake Innes catchment does not have a major river feeding the system, but instead is fed by a number of small creeks that flow into both lakes. Lake Cathie is an Intermittingly Closed and Open Lake or Lagoon (ICOLL) meaning it does not permanently have open access to the ocean.

The Port Macquarie-Hastings LGA has a remarkable coastline extending from Point Plomer in the north to Diamond Head in the south *[see Figure 13]*. There are numerous beaches in the LGA and among some of the finest in the state, offering a mixture of fine sandy shores, rocky headlands and rainforests. Some of the most visited beaches include Town Beach (Port Macquarie), Lighthouse Beach (Port Macquarie to Lake Cathie) and Shelly Beach (Port Macquarie). Other notable beaches include Rainbow Beach (Bonny Hills), North Haven Beach, Middle Rock Beach (Lake Cathie) and Pilot Beach (Dunbogan).

Figure 13. *Port Macquarie-Hastings LGA showing coastal areas*

Figure 10. *Hastings River from Koree Island*

Figure 11. *Lake Cathie looking west*

Figure 12. *Camden Haven River looking towards North Brother mountain*

10. ENVIRONMENTAL CONTEXT

10.1 CLIMATE

The PMH LGA is located in the subtropical region of Australia where it experiences a warm temperate climate. Summers are moderately warm and humid with coastal storms often occurring in the evening during the later summer months. Winters are generally mild with frosts often occurring in the inland areas.

Weather data sampled at the Port Macquarie Airport shows the mean maximum temperature is 23.8° C and the mean minimum temperature is 12.7° Celsius. The mean annual rainfall for the LGA varies depending on proximity to the coast and the higher peaks inland. Generally speaking, the mean annual rainfall for the LGA is approximately 1500mm.

As is the rest of NSW and Australia, PMHC is prone to experiencing prolonged droughts with significantly less than average rainfall occurring throughout the region at times. This leads to lower river levels and increased bushfire intensity and frequency.

10.2 SIGNIFICANT CLIMATIC EVENTS

PMHC experiences a number of coastal storm events with the latest significant event being the East Coast Low of June 2016. This event included strong north-easterly winds (gusts up to 120km/h) with the highest individual wave recorded on the NSW coast of 17.7m at Eden (BOM, Manly Hydraulics Laboratory and OEH, 2016). This event occurred at the same time as the winter solstice spring tide and significant rainfall which both compounded the erosive damage and storm debris to PMHC's coast.

PMHC has experienced some major flood events (1963 and 1968) as well as more frequent relatively minor events (1978, 1995 and 2013). The 1963 flood was the worst in the lower catchments (Hastings & Camden Haven) due to high ocean conditions. This was estimated to be a "1 in 100-year" event and anecdotally the worst Wrights Creek flood recorded. The 1968 flood was also estimated to be a "1 in 100-year" event and mostly affected the upper catchments due to high rainfall. The 1978, 1995 and 2013 Hastings River floods were all approximately "1 in 20 year" events.

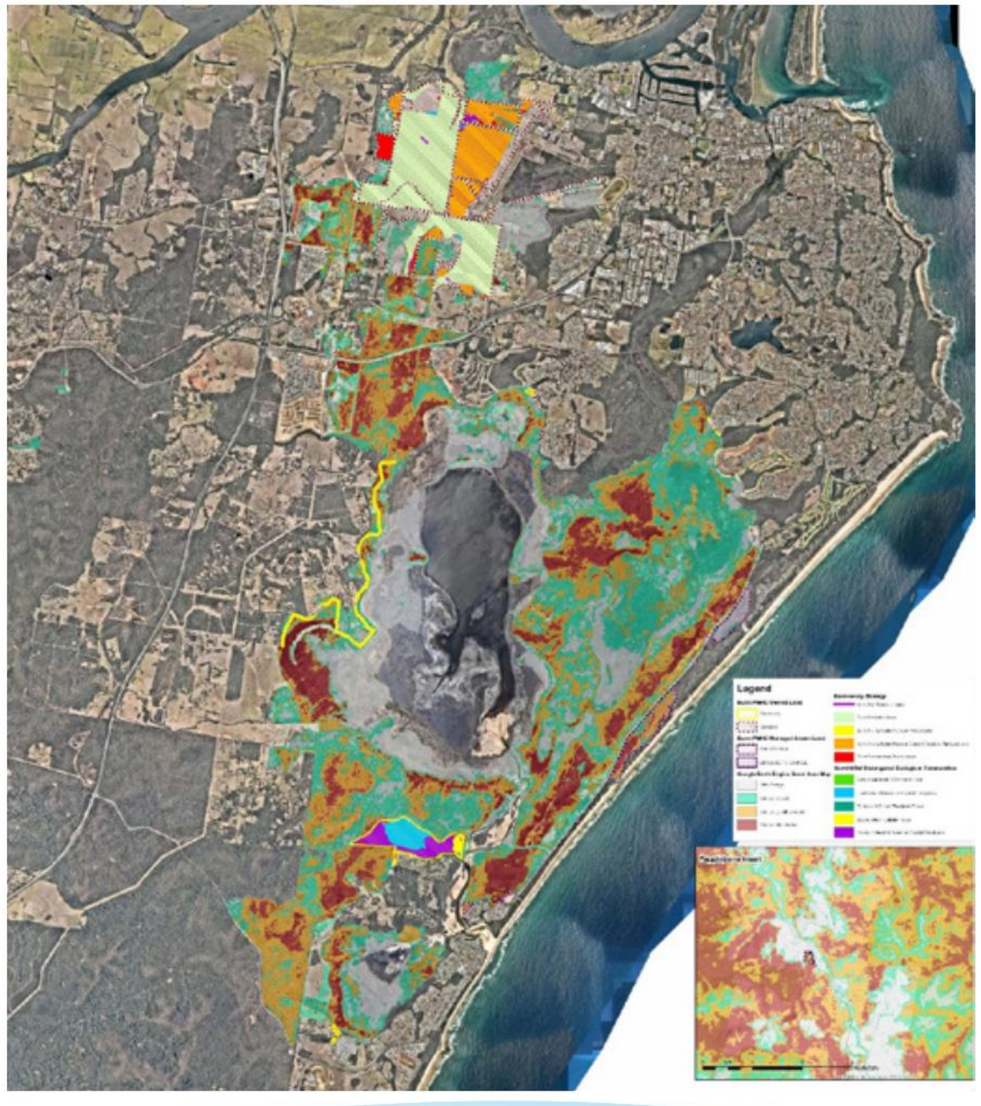
Drought has affected most of New South Wales since early 2017 and in 2019 the PMH LGA experienced its lowest recorded amount of annual rainfall (514mm) since 1870. The rainfall deficiencies contributed to the stoppage of water flow in the Hastings River which meant that PMHC and private landholders were unable to extract water for domestic and irrigation purposes from the system. This also led to heavy water restrictions being placed on the local community by PMHC. The Lake Cathie/Innes estuarine system was also adversely affected by the ongoing drought conditions. Council last artificially opened the lake entrance in July 2018 as the lake reached 1.6m AHD and began affecting properties that are susceptible to nuisance flooding. Post opening, a lack of rainfall and small depositional waves naturally closed the entrance and with high temperatures and high evaporation rates following the closure, the lake dropped to very low levels. The lowered water levels within the system exposed extensive foreshore areas comprising ASS, caused elevated water temperatures, low dissolved oxygen levels, hypersalinity and fish kills, therefore highlighting the need to review the Entrance Opening Strategy.

During the extraordinarily damaging bushfire season of 2019-20 approximately 140,000 Ha of land was burned within the PMH LGA. This included 3,572 Ha around the Lake Innes Nature Reserve south to Lake Cathie and around the Queens Lake Conservation Area *[refer to Figure 14]*. There has been considerable debate regarding the underlying cause of the intensity and scale of the recent fires, including the role of fire management practices and climate change. Bushfires however, are not new to the area, major bushfire events being experienced in the past.

Since 2000 there have been significant fires in Limeburners National Park (2002, 2010), Christmas Bells Plains (2002), Bonny Hills (early 2000's), Dunbogan (2005) and Pappinbarra (2017, 2019).

Bushfires can have various impacts on waterways both during and post fires. The key contaminants of concern for managers include increased suspended solids and turbidity, increased nutrients, increased risk of toxic algal blooms and increased metal concentrations. Fire also increases the potential for runoff and erosion as well as unburnt organic matter washing into waterways and reducing dissolved oxygen as it decomposes.

Figure 14. *Bushfire map depicting burnt land in the Port Macquarie area during 2019-20*



10.3 PHYSICAL FEATURES AND COASTAL PROCESSES

The coastline is subject to a high energy wave climate. The offshore swell wave climate (wave height, period and direction occurrences) has been recorded by the NSW Government Manly Hydraulics Laboratory with Waverider buoys located at Sydney, Crowdy Head and Coffs Harbour for many years. The wave data show that the predominant swell wave direction is south-southeast (SSE) with over 70% of swell wave occurrences directed from the SSE. The average deep-water significant wave height is measured at 1.6m with the average wave period being 10 seconds as recorded at Crowdy Head (SMEC, 2008).

East Coast Lows (ECLs) have occurred in the area causing coastal erosion and washing up of debris. One large event was recorded in June 2016 *[see Figures 15 to 18 to the right]*. ECLs are intense low-pressure systems that occur off the east coast of Australia. They can form at any time of the year and significant ECLs occur on average about 10 times each year. These storms can have severe consequences in terms of wind damage, storm surge, heavy and damaging surf and flash flooding (AdaptNSW). Climate modelling projects a decrease in the number of small to moderate ECLs in the cool season with little change in these storms during the warm season. However, extreme ECLs in the warmer months may increase in number but extreme ECLs in cool seasons may not change.

The open coastline is made up of sandy beaches and rocky headlands with significant portions of the coastline made up of the Coastal Wetland and Littoral Rainforest Area (CWLRA), and National Parks. Parts of the coast are susceptible to coastal erosion, in particular, Town Beach and Lake Cathie Beach (Lighthouse Beach). For example, a conservative estimate of future long term recession of 0.20 m/year was adopted for the beach at Lake Cathie (Coastal Hazard Study, SMEC 2010).

Lighthouse Beach at Lake Cathie is comprised of underlying consolidated or indurated sands (coffee rock) which is more resistant to erosion than typical unconsolidated beach sand.

Figure 15. *Town Beach East Coast Low event June 2016 (before and during)*

Figure 16. *And after looking east towards Kiosk*

Figure 17. *Lake Cathie East Coast Low Event June 2016. Pictured at intersection of Kalang Drive and Bundella Avenue, Lake Cathie. Left photo taken 8 September 2015 and right photo taken 26 July 2016.*

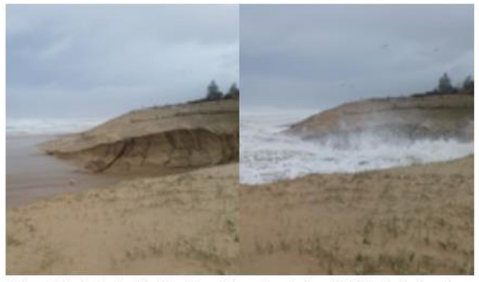


Figure 18. *Lake Cathie East Coast Low Event June 2016 - during early and later phases of event, looking south along Illaroo Road.*

Despite this, erosion of the sand dune happens often after storm events and the close proximity of privately owned houses and public assets to the shoreline means it requires management. Town Beach is the main beach in the LGA. While there are no residential properties under threat, there are a number of assets such as roads and park infrastructure that are exposed to this risk. Flynns Beach is one such beach that contains assets that are exposed to risks, which has been confirmed via coastal hazard studies. The existing sea wall is not adequate in protecting the assets behind the beach, so a new sea wall is required. The first stage of the sea wall replacement has occured at Flynn's beach which now protects the surf club, kiosk, road access and open space reserve. Other beaches where erosion has been identified, though not studied, are Rainbow Beach, Shelly Beach, North Shore Beach (Corilla Estate) and Dunbogan Beach. These are areas where investigations will be considered during the CMP process.

10.4 SEDIMENT COMPARTMENTS

Coastal sediment compartments are defined areas that have similar coastal processes and are based on sediment flows and landforms.

The Australian Government initiated the Coastal Compartments Project which aimed to establish a consistent approach in managing Australia's coastline (Thom, N.D.). This project resulted in sediment compartments being mapped along Australia's entire coastline. These sediment compartments are divided into three levels:

- **Primary level** defined by large landforms e.g. headlands and rivers
- **Secondary level** defined by sediment movement within and between beaches
- T**ertiary level** where sediment moves in the nearshore area e.g. individual beaches

PMHC shares two coastal sediment compartments with neighbouring Councils that are defined as secondary level compartments. The South West Rocks-Port Macquarie sediment compartment *[see Figure 19]* is shared with KSC and the Tacking Point-Crowdy Head sediment compartment *[see Figure 20]* is shared with MCC. These sediment compartments are identified in Schedule 1 of the CM Act.

Figure 19. *South West Rocks-Port Macquarie sediment compartment (Geoscience Australia, 2016)*

Figure 20. *Tacking Point-Crowdy Head sediment compartment (Geoscience Australia, 2016)*

ESTUARY CATCHMENTS AND RIVER CONDITION

Estuaries in the PMHC LGA are the Hastings River estuary, Camden Haven River estuary and Lake Cathie-Lake Innes estuary. PMHC shares two estuaries with neighbouring Councils. The Camden Haven River Estuary is shared with MCC and the Hastings River Estuary and Maria River Estuary are shared with KSC.

Consultation with other local councils on the draft CMP is required by s16 (1) (b) (i) and (ii) of the CM Act where those councils share a coastal sediment compartment or estuary as specified in Schedule 1 of the CM Act. Consultation will occur with each Council in developing management actions for these shared areas which will be developed through the stakeholder enagement and consultation strategies as part of future stages of the CMP.

ECOHEALTH MONITORING

Ecohealth reports determine the health of estuaries and rivers in the LGA based on effects from diffuse sources. They are assessed based on Ecohealth indicators (water quality, riparian vegetation, geomorphic condition, macroinvertebrates and plankton) and are provided with a score. Ecohealth Reports were prepared in 2012 & 2017.

The 2017 Ecohealth report (Darren Ryder, 2017) gave the LGA an overall score of “C” which is rated as fair. The Lake Innes/Lake Cathie catchment slightly declined from 2011, the Hastings River catchment declined and the Camden Haven River catchment had no change (Darren Ryder, 2017). Across the Hastings and Camden Haven catchmentsthere was a typical decline in geomorphic condition which highlights the importance of maintaining healthy riparian vegetation to promote bank stability. The best riparian condition was surrounding the coastal lagoons where it was assessed as being in very good condition. The Camden Haven catchment was assessed as having moderate riparian condition while the Hastings River catchment was moderate in the freshwater reaches, but was poor in the Hastings River main stem. Main issues identified were the dominance of invasive weeds, vegetation clearing that has reduced riparian connectivity and damage from livestock.

Water quality was moderate across both Hastings and Camden Haven catchments and had declined from 2011 to 2015, driven largely by high nutrient concentrations, more acidic pH and low dissolved oxygen - all of which were directly linked to very low flows experienced during the study. Aquatic macroinvertebrate condition was moderate across the catchments with a small decline between the two assessments in abundance and richness. Again this was the result of low flows and macroinvertebrate condition did improve in the latter stages of the assessment when stream flows increased, indicating a resilience to extreme low flows. It is noted though that this resilience is reliant on good habitat quality which is linked to good riparian condition.

The management priorities identified in the Ecohealth report (freshwater and estuarine reaches) included:

HASTINGS RIVER CATCHMENT

- Weed monitoring for the movement and spread of weed species.
- Weed control for the removal of various noxious and environmental weed species.
- Native riparian plantings for site rehabilitation, native regeneration assistance, increased riparian width, continuity and connectivity to larger tracts of remnant vegetation.
- Riparian fencing to reduce livestock impact and reduce bank erosion, encourage regeneration of native vegetation, accumulation of woody debris and to increase riparian width, continuity and connectivity to larger tracts of remnant vegetation.
- Investigate subcatchment sources of TN, TP, NOx and SRP to the river.

CAMDEN HAVEN CATCHMENT

- Weed monitoring for the movement and spread of weed species.
- Weed control for the removal of various noxious and environmental weed species.
- Investigate subcatchment nonpoint sources of TN and NOx to the river.
- Phase out exotic dominants - planting of native canopy species to replace strategic removal of exotic canopy and midstory species.
- Riparian fencing to reduce livestock impact and reduce bank erosion, encourage regeneration of native vegetation, accumulation of woody debris and to increase riparian width, continuity and connectivity to larger tracts of remnant vegetation.
- Native riparian plantings: to replace exotic dominants, site rehabilitation and native regeneration assistance, increased riparian width, continuity and connectivity to larger tracts of remnant vegetation.

LAKE CATHIE AND LAKE INNES CATCHMENT

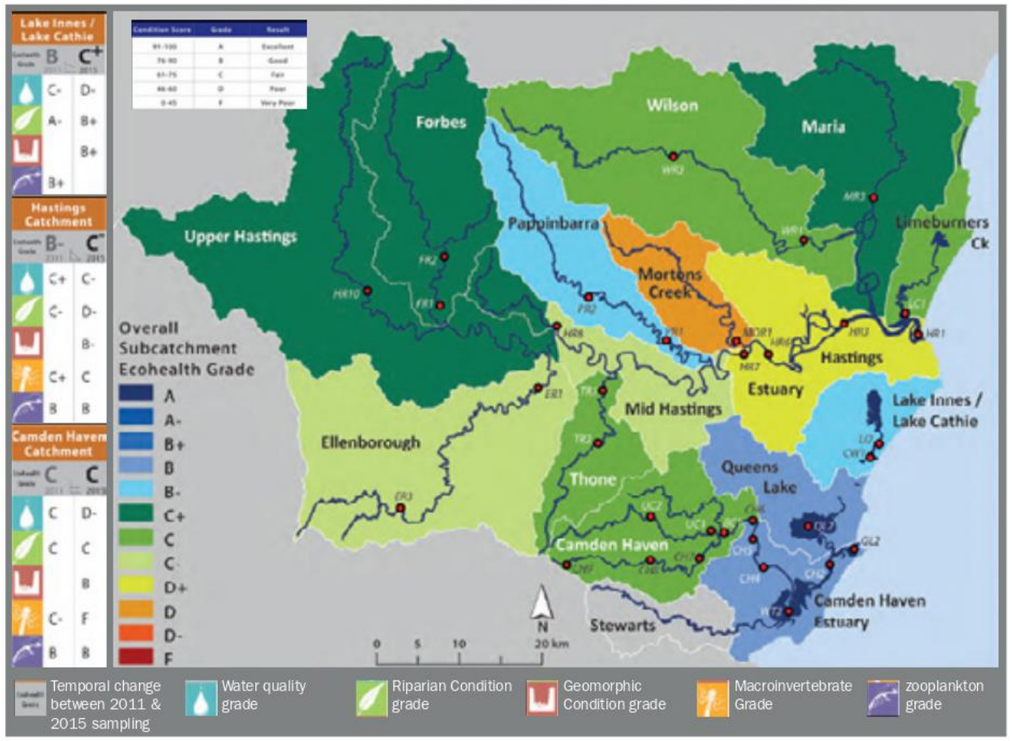
- Weed monitoring for the movement and spread of weed species.
- Weed control for the removal of various noxious and environmental weed species.
- Maintaining adequate riparian width - supports ecological function by buffering against exotic species and environmental impacts while allowing for the accumulation of woody and non-woody debris, which through the provision of niche habitats supports native woody regeneration and native animal species.
- Investigate sub-catchment nonpoint sources of TN, TP and NOx to the estuarine lagoons.

All other sites/sub-catchments investigated produced similar management actions seen in the following table:

Sites	Weed monitoring	Weed control	Native plantings	Fencing	Weed species phase-out	Woody debris	Maintain Riparian width	Water quality	High nutrient concentrations
Black Creek (BC1)	Y	Y	Y	Y	Y		Y	*Poor*	*TN, NOx*
Camden Haven (CH2)	Y	Y	Y				Y	*Moderate*	*TN, NOx*
Camden Haven (CH4)	Y	Y					Y	*Poor*	*TN, NOx*
Camden Haven (CH5)	Y	Y			Y		Y	*Very poor*	*TN, NOx*
Camden Haven (CH6)	Y	Y					Y	*Moderate*	*TN, NOx*
Camden Haven (CH7)	Y	Y		Y	Y		Y	*Poor*	*TN, NOx*
Camden Haven (CH8)	Y	Y		Y			Y	*Moderate*	*TN, NOx*
Camden Haven (CH9)	Y	Y					Y	*Poor*	*TN, NOx*
Lake Cathie (CW1)	Y	Y					Y	*Poor*	*TN, TP, NOx*
Ellenborough River (ER1)	Y	Y	Y	Y			Y	*Moderate*	*TN, TP, NOx*
Ellenborough River (ER3)	Y	Y		Y			Y	*Poor*	*TN, TP, NOx*
Forbes River (FR1)	Y	Y	Y	Y	Y		Y	*Good*	*TN, NOx*
Forbes River (FR3)	Y	Y		Y			Y	*Moderate*	*TN, NOx*
Gogleys Lagoon (GL1)	Y	Y					Y	*Moderate*	*TN, NOx, TP, SRP*
Hastings River (HR1)	Y	Y			Y	Y	Y	*Moderate*	*TN, NOx, SRP*
Hastings River (HR3)	Y	Y	Y	Y		Y	Y	*Moderate*	*TN, NOx, SRP*
Hastings River (HR6)	Y	Y	Y	Y	Y		Y	*Poor*	*TN, NOx, SRP*
Hastings River (HR7)	Y	Y	Y	Y	Y		Y	*Poor*	*TN, NOx, SRP*
Hastings River (HR8)	Y	Y	Y	Y			Y	*Moderate*	*TN, TP, NOx*
Hastings River (HR10)	Y	Y	Y	Y			Y	*Poor*	*TN, TP, NOx*
Limeburners Creek (LC1)	Y	Y					Y	*Moderate*	*TN, NOx, SRP*
Lake Innes (LI1)	Y	Y					Y	*Poor*	*TN, TP, NOx*
Mortons Creek (MOR1)	Y	Y		Y	Y		Y	*Moderate*	*TN, NOx*
Maria River (MR1)	Y	Y		Y			Y	*Very poor*	*TN, NOx*
Pappinbarra River (PR1)	Y	Y		Y	Y		Y	*Moderate*	*NOx*
Pappinbarra River (PR2)	Y	Y		Y			Y	*Good*	*NOx during low flows*
Queens Lake (QL2)	Y	Y					Y	*Poor*	*TN, NOx, TP, SRP*
Thone River (TR1)	Y	Y	Y	Y			Y	*Moderate*	*TN, TP, NOx*
Thone River (TR2)	Y	Y	Y	Y			Y	*Moderate*	*TN, TP, NOx*
Upsalls Creek (UC1)	Y	Y		Y	Y		Y	*Moderate*	*TN, NOx*
Upsalls Creek (UC2)	Y	Y					Y	*Moderate*	*TN, NOx*
Watson Taylors Lake (WT2)	Y						Y	*Poor*	*TN, NOx, TP, SRP*
Wilson River (WR1)	Y	Y	Y	Y	Y		Y	*Poor*	*TN, NOx*
Wilson River (WR3)	Y	Y	Y	Y	Y		Y	*Moderate*	*TN, NOx*
Total	**34**	**33**	**13**	**21**	**12**	**2**	**34**	**N/A**	**N/A**

Table 1. *A summary of recommendations to improve riparian condition at each of the 34 Hastings - Camden Haven Ecohealth study sites.*

Figure 21. *Echohealth 2017 rating of each catchment. (Darren Ryder, 2017)*



The University of New England (UNE) with funding from PMHC has historically undertaken the Ecohealth reports. Consideration will be provided to committing to long-term funding for this project.

NSW ESTUARY HEALTH RISK DATASET

The NSW Government is leading a water quality initiative to improve the management and co-ordination of urban and rural diffuse source water pollution in New South Wales (NSW) as part of their requirements to implement the Marine Estate Management Strategy 2018–2028 (MEM Strategy). A key approach to delivering this initiative is to adopt the Risk-based framework for considering waterway health outcomes in strategic land use planning decisions (Risk-based Framework).

In May 2017, the former Office of Environment and Heritage (OEH) and the NSW Environment Protection Authority released an introductory resource on the Risk-based Framework in response to 3 years of consultation on urban planning and wider catchment management.

The former OEH applied the first two steps of the Risk-based Framework and produced the NSW Estuary Health Risk Dataset to help inform Stage 1 scoping studies during the preparation of coastal management programs under the NSW Coastal Management Manual (2018). The dataset can be used to map (spatially prioritise) where further studies and/or management actions in a catchment would help achieve outcomes for coastal environment areas and coastal wetlands and littoral rainforests areas specified in the Coastal Management Act 2016. These outcomes are specifically to:

- protect and enhance the coastal environmental values and natural processes of coastal waters, estuaries, coastal lakes and coastal lagoons
- enhance natural character, scenic value, biodiversity and ecosystem integrity of coastal environments
- reduce threats to and improve the resilience of coastal waters, estuaries, coastal lakes and coastal lagoons, including in response to climate change
- maintain and improve water quality and estuary health
- support social and cultural values of coastal waters, estuaries, coastal lakes and lagoons
- protect coastal wetlands and littoral rainforests in their natural state, including their biodiversity and ecosystem integrity
- promote the rehabilitation and restoration of degraded coastal wetlands and littoral rainforests
- improve the resilience of coastal wetlands and littoral rainforests to the impacts of climate change, including opportunities for migration
- support the social and cultural values of coastal wetlands and littoral rainforests
- promote the objectives of NSW Government policies and programs for wetlands or littoral rainforest management.

ACID SULPHATE SOILS (ASS) MANAGEMENT

The LGA has 19,513ha of high risk ASS and 6,874ha of low risk mapped ASS. Many management actions were undertaken in past EMPs and 5,122ha of ASS has been remediated including 145km of excavated drains and channels.

There are multiple solutions for managing ASS issues. These may include engineered weir structures such as what was installed in partnership with Partridge Creek landholders or to fill the drains completely but many of these are on private land. Future remediation works in Maria River may involve a joint venture with Kempsey Shire and with Mid Coast Council to achieve management actions for Watson Taylor Lake, Stewarts River and surrounding lands.

POSSIBLE FUTURE ACTIONS

An audit and development of a maintenance plan may be completed for all existing ASS infrastructure.

Estuaries and rivers in the LGA are under an ever-growing threat of encroaching development. Managing development and its impacts is a key management action for the CMP.

10.5 HABITAT CONDITION

The PMHC LGA is an area rich in biodiversity supporting a diverse range of both terrestrial and aquatic plants and animals. The area includes specific areas of biological importance. Limeburners Creek Nature Reserve for example, is one of only two coastal wilderness areas in NSW. Lake Innes Nature Reserve has been considered the ‘engine room’ for Koala populations in the LGA and has historically contained a ‘nationally significant population’ (as defined by Federal Government criteria). Sea Acres Nature Reserve and adjoining council land are some of the largest remaining patches of littoral rainforest, particularly outside far northern Queensland.

The estuaries and foreshores of the Camden Haven and Hastings Rivers are of immense importance for migratory shorebirds listed under international conventions and agreements.

The PMHC LGA has, until recently, been identified as an area that held the largest remaining coastal population of koalas. A lot of work has been done, and continues to be done, in maintaining these populations which continues to be challenging given the significant increase in development over a number of years and increased bushfire severity and intensity.

SEAGRASS MAPPING

Seagrass meadows are a vital habitat for many estuarine species and make valuable contributions to estuarine ecology. Multiple studies have shown that seagrasses within NSW estuaries have suffered long-term declines over the last 50 – 60 years. NSW estuaries have even had reported losses of up to 85% of seagrasses during this time (West, 2006). A review of the existing literature suggests that the long-term decline in seagrass biomass is likely a result of anthropogenic impacts on our estuarine systems and their catchments. Urbanisation, dredging and poor catchment management practices are perhaps the leading contributors to the decline and these issues need to be addressed and closely managed if the long-term losses are to be reduced.

Seagrass mapping was undertaken in 2012 and meadows exist in both the Hastings River Estuary and the Camden River Estuary. No seagrass meadows are mapped in Lake Cathie/Lake Innes, which is not uncommon for an ICOLL. Anecdotally, there have been sightings of seagrass within Cathie Creek. Reports in fish and prawn stock declines in the Camden Haven Estuary may be associated with a decline in seagrass and may also be associated with known Acid Sulphate Soil (ASS) discharge emanating from the western side of Watson Taylor Lake. Collaborating with Mid Coast Council will be necessary to investigate management options for the ASS. An investigation may be undertaken on an LGA-wide scale to try to identify changes in seagrass distribution and abundance.

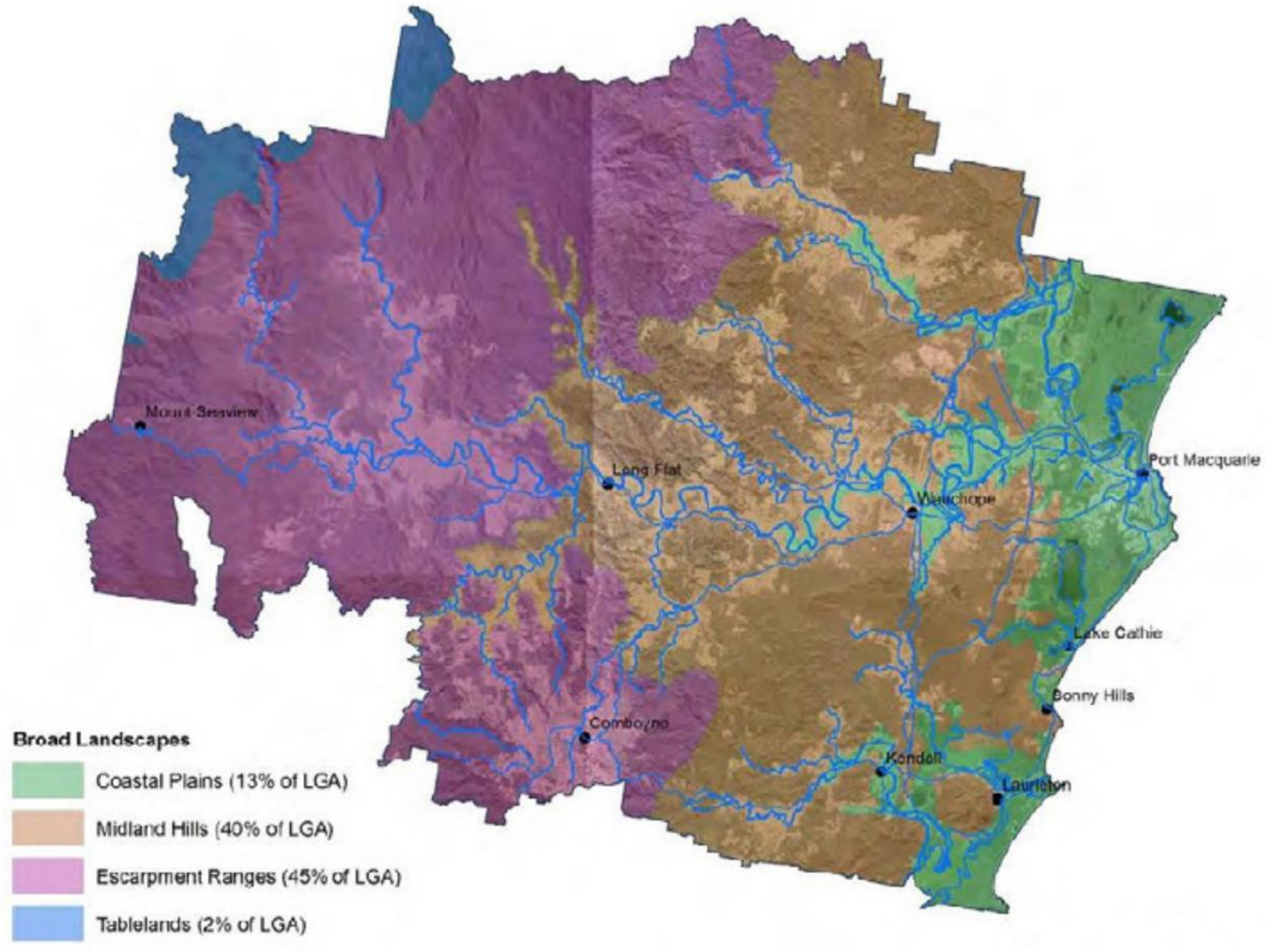
NATIVE VEGETATION

The PMHC LGA can be broadly divided into four landscapes: Coastal Plains, Midland Hills, Escarpment Ranges and Tablelands *[see Figure 22]*. Each of these different landscape units has different biophysical factors (e.g. geology and climate) and therefore supports a different assemblage, or mix, of plants and animals.

Broadly speaking, PMHC has a good coverage of remaining native vegetation however the Coastal Plains Landscape has undergone the most extensive development and has the lowest percentage (56%) of remaining vegetation.

PMHC has completed detailed vegetation mapping which shows all remnants outside state forests and national parks. There are 83 vegetation communities that have been mapped. There are approximately 1,890 native plant species and 621 native animal species recorded in the PMHC LGA.
Of these, there are approximately 140 threatened animals, 50 threatened plants and 9 threatened ecological communities. These numbers are approximations only given the dynamic nature of these lists and limited knowledge.

Figure 22. *Broad Landscapes of PMHC LGA (Port Macquarie-Hastings Council, 2017).*



PMHC is attempting to align the Port Macquarie Vegetation Communities with the plant community types used under the Biodiversity Conservation Act. The Biodiversity Conservation Act 2016 dictates that environmental impacts be calculated relative to these plant community types. At the local level, Councils may wish to conduct their own vegetation community mapping, which further splits NSW plant community types into locally recognised discrete communities. Mapping plant community types is not easy because areas frequently include components of two community types — this is particularly true where the communities occur adjacent to each other (in what are called ecotones).

10.6 ESTUARINE AND COASTAL WETLANDS AND COASTAL LAKES

Estuarine wetlands, coastal floodplain wetlands and coastal lakes are ecologically, socially and economically important. They provide many ecosystem functions, ecosystem services and habitats for a wide range of animals (e.g. waterbirds, fish, frogs and invertebrates) and water-dependent plants (e.g. sedges, rushes and various tree species), including many threatened species and ecosystems. Estuarine and coastal wetlands and coastal lakes also provide shelter, breeding grounds and nurseries for a variety of fauna, particularly insects, fish, frogs and waterbirds, including migratory birds listed under various international agreements including the Bonn Convention and the bilateral migratory bird agreements with Japan, China and the Republic of Korea.

The PMH LGA has some very significant estuarine and coastal wetlands and coastal lakes located along its coastal strip. These include wetlands within Limeburners Creek Nature Reserve (listed on the Directory of Important Wetlands in Australia), Partridge Creek, Lake Innes, Saltwater Lake, Lake Cathie, Googleys Lagoon (Watson-Taylor Lake) and Queens Lake. Such areas are highly valued by the community and biodiversity alike. Saltwater Lake is considered to be in near pristine condition as per 'EcoHealth' Assessments undertaken by the University of New England (Darren Ryder, 2017). The location of these important biological assets (as identified and classified by the Northern Rivers Biodiversity Management Plan (Northern Rivers Catchment Management Authority, 2010)) is shown in *[Figure 23]*. (Port Maquarie-Hastings Council, 2017).

With its coastal location and long history of agriculture and housing development on the rich coastal floodplains, the PMHC LGA supports numerous Threatened Ecological Communities (TECs) & Endangered Ecological Communities (EEC's). The LGA is an important stronghold for many types of TEC's & EEC's, such as Littoral Rainforest, Lowland Rainforest, Coastal Floodplain Forest communities and various Wetland communities.

Historical and ongoing threats to habitat include clearing of vegetation, increased development, restricted distribution of habitats and feral species invasions.

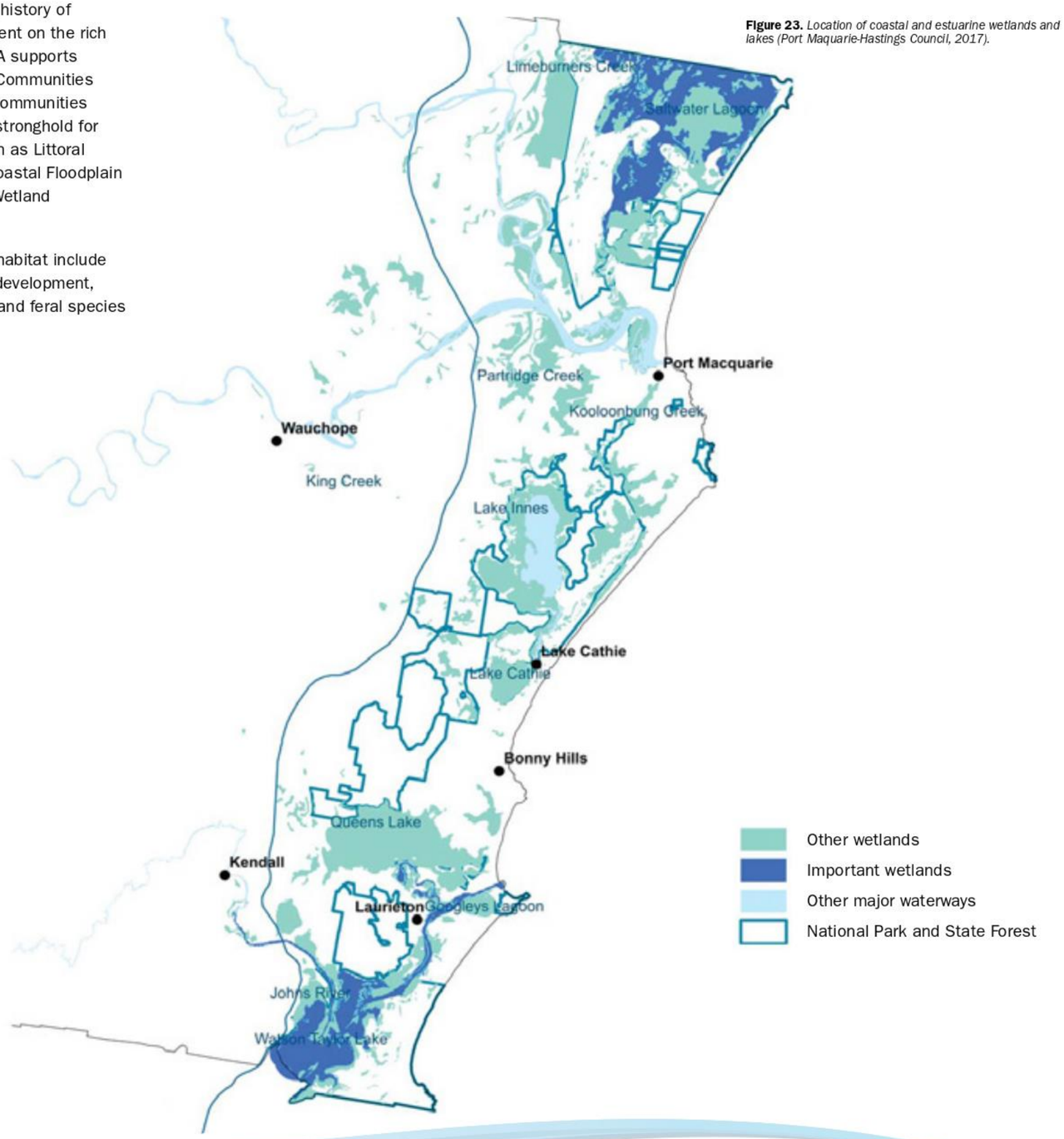


Figure 23. *Location of coastal and estuarine wetlands and lakes (Port Maquarie-Hastings Council, 2017).*

10.7 CLIMATE CHANGE

The future threats of sea level rise, increasing temperatures and changes to rainfall will place increasing pressure on species, ecosystems and human settlements in general. The range of potential impacts due to climate change is significant for coastal areas and it is necessary that they be considered in coastal management planning.

The changes in rainfall will directly impact on PMHC's water supply planning due to Council relying heavily on extraction from the Hastings, Wilson, Thone and Camden Haven for its water supply.

By 2050:

- Temperatures are expected to rise by an average of 1.5 degrees
- Rainfall is expected to reduce by 3.5% pa with significant seasonal changes
- Evaporation is expected to increase by 6% pa
- Annual streamflows are expected to reduce by 10.8% pa but will be affected by seasonal differences
- Annual water demands are expected to increase by 4.3% pa (mostly in spring).

There are also assumed changes in river flows which may be coupled with rising residential water demands. The modeling suggests that there is an expected increase on residential water demand by 4.3% pa while streamflows are predicted to drop by more thatn 10% pa. In a drought event both predicted changes are likely to coincide, making the impacts on water supply and the environment are potentially worse off.

Climate change projections for the north coast of NSW have been modelled by the NSW and ACT Regional Climate Modelling (NARCliM) project. The following snapshot provides climate predictions for 2020-2039 (near future) and for 2060-2079 (far future).

Long-term trends on the North Coast indicate that temperatures in the region have been increasing since around 1960, with the largest increase in temperature occurring in the most recent decades. It is expected that the North Coast will experience an increase in all temperature variables (average, maximum and minimum) for the near future and the far future, with projections of more hot days (maximum temperature greater than 35°C) and fewer cold nights (minimum temperature less than 2°C) (OEH, 2014).

Climate change impacts will have multiple implications for the development of a CMP including increases to inundation extents, effect on parameters for the Lake Cathie Entrance Strategy, and coastal and estuarine hazard classifications.

10.7.1 RAINFALL

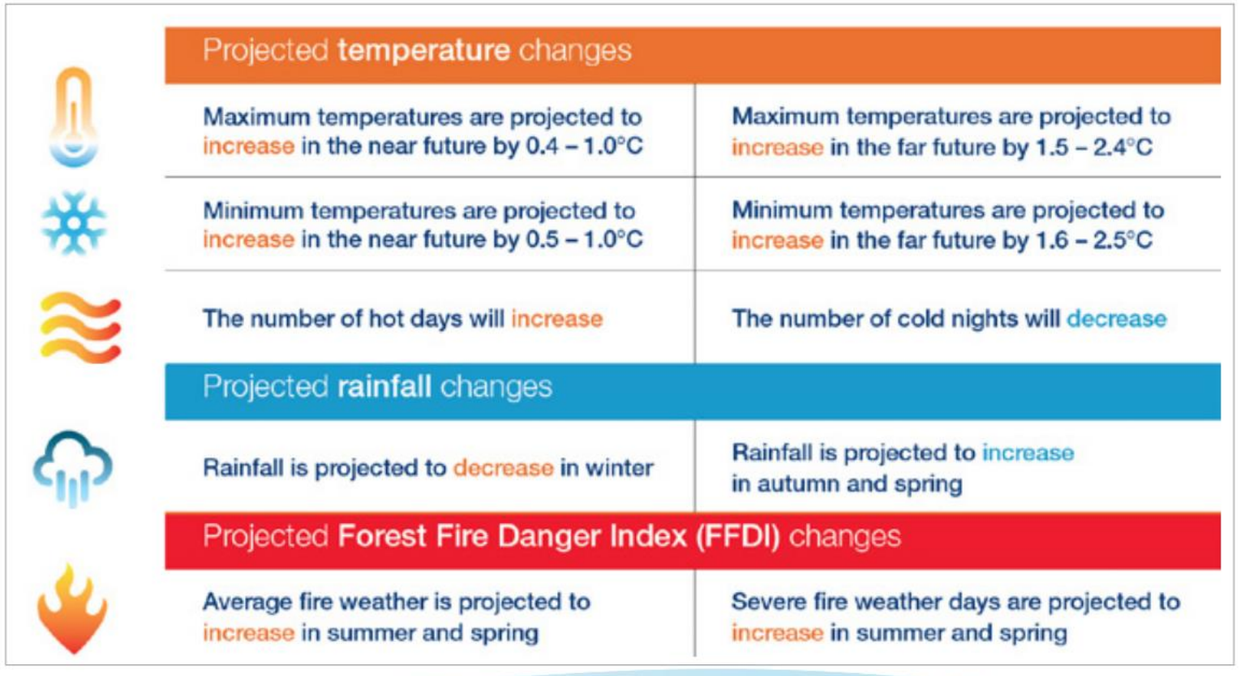
Extreme rainfall events are often associated with large storms and can cause damage to property and infrastructure, flash flooding, soil erosion and impacts on water quality. In recent research by the NSW and ACT Regional Climate Modelling (NARCliM) to assess the potential for the frequency and intensity of extreme rainfall events in the future it was found that:

- Rainfall extremes are projected to increase in the near future (2030) and far future (2070).
- The increases in the near future are not considered significant - the changes fall within the range of inter-annual rainfall variability recorded in the past.
- In the far future, significant increases in several rainfall extreme indices are projected for some regions of NSW.
- The Simple Precipitation Intensity Index (SDII) is the only index to have significant increases over large parts of NSW. This suggests that the mean rainfall intensity will increase even though the more extreme indices do not show significant changes.
- Over most of NSW, little change is projected in the maximum wet spell. A small but not significant increase projected in the maximum dry spell is a reverse of the decreasing trend apparent in past rainfall records.

The frequency and intensity of floods and storms are likely to be affected by climate change and whilst these events as well as East Coast Lows (ECLs) can be damaging and costly, it is important to remember they are also essential for water security bringing the heavy soaking rainfall that fills dams along the coast and tablelands (AdaptNSW, n.d.).

In the past NSW has experienced periods of very stormy weather and this should be considered in future risk assessment and planning.

Figure 24. *Projected climate change. Source: OEH 2014*



10.7.2 SEA LEVEL RISE

On a global scale, sea levels are rising which is increasing the risk to coastal communities from inundation and erosion. Of all the potential impacts from climate change, the projected rise in sea levels is concerning for long-term management of the coastal zone.

Some potential impacts over time due to sea level rise include:

- Higher projected storm surge and inundation levels.
- Landward recession of sandy shorelines. Depending on the rate and scale of sea level rise, the environmental, social and economic consequences of recession within low lying inter-tidal areas, in particular, may be significant in the medium-long term.
- Migration of marine vegetation (mangroves and saltmarsh) and other riparian vegetation upslope (i.e. shoreward). This landward migration resulting from sea level rise may be impacted by existing/future infrastructure (e.g. retaining walls, roads etc.).
- Salt water intrusion and landward advance of tidal limits within estuaries. This may have significant implications in the medium-long term for freshwater and saltwater ecosystems and development margins, particularly building structures and foundation systems within close proximity to the shoreline. *[Refer to Section 13.3]* for further information
- Existing coastal gravity drainage, stormwater infrastructure and sewerage systems may become compromised over time as mean sea level rises.
- Sea level rise will influence the entrance opening regimes for intermittently closed and open lakes and lagoons (ICOLLs) and alter catchment flood behavior over time.
- The level of protection provided by existing seawalls and other hard engineering structures will decrease over time due to the increasing threat from larger storm surges and inundation at higher projected water levels.

The potential implications of climate change and sea level rise will be considered by PMHC during all Stages of the CMP. Whilst the NSW Government has repealed the NSW Sea-level rise Policy Statement 2009, PMHC believes this is the best available information and work will be undertaken using the benchmarks of 400mm sea level rise above 1990 mean sea levels by the year 2050 and 900mm rise by the year 2100.

10.7.3 FIRE

There is considerable uncertainty surrounding the nature and effects of climate change on fire regimes and fire management, particularly the effectiveness of prescribed burning and the effects on biodiversity. Future climate change is expected to increase bushfire risk through more adverse fire weather including a projected increase in the number of days of severe fire danger, and a potential lengthening of the fire season, over much of New South Wales.

Fire weather is largely monitored in Australia using the Forest Fire Danger Index (FFDI). The Bureau of Meteorology issues Fire Weather Warnings when the FFDI is forecast to be over 50 and average FFDI values are often used to track the status of fire risk.

The North Coast region is expected to experience an increase in both severe and average FFDI values in the near future and the far future (OEH, 2014).

Hazard reduction burning and wildfires under a changing climate will affect the ability of species to persist under a changing fire regime, which has potential implications for catchment management strategies. It is critical to identify likely thresholds of species decline for each component of the fire regime and apply these thresholds to ongoing fire management. *[Refer to Section 10.2]* for impacts relating to the recent 2019/20 bushfire season.

10.7.4 WATER QUALITY

Increased water temperatures and an increase in extreme hydrological events including floods and droughts are anticipated to affect water quality and intensify various forms of water pollution - from nutrients, pesticides, pathogens, dissolved organic carbon, sediments and sewage, as well as changes to thermal pollution with possible implications for ecosystems and human health. Ocean acidification is also linked to climate change as carbon dioxide (CO2) from the atmosphere is being absorbed in larger amounts. As sea water takes up more CO2, it becomes more acidic which lowers pH and affects the chemistry of the water making it harder for many animals to build skeletons and shells. This process could potentially be damaging for oyster production in our estuaries.

When considering the impacts of climate change, it will be important for planning and management programs to be adaptive and able to respond to a wide range of possible climate futures.

The Ecohealth program currently provides high level water quality assessment and expansion of this program to provide higher resolution data will be investigated to provide a better understanding of water quality impacts and mitigation issues.

Figure 25. *Looking across the Back Channel of the Hastings River towards Settlement Point Reserve*

11. SOCIAL CONTEXT

11.1 COMMUNITY DEMOGRAPHICS AND POPULATION

The PMH LGA has an estimated population of 84,525 as of 30 June 2019 (*ABS, ERP 2019*) with a population density of 0.23 persons per hectare. The population is expected to grow to approximately 104,000 by 2036 *[as shown in Table 2]*. This growth is expected to be concentrated in the major towns and villages, particularly in Port Macquarie which is comprised of many significant coastal areas. This population increase will create demand for approximately 10,000 more dwellings by 2036.

PMH Council area	Forecast year				
	2016	2021	2026	2031	2036
Population	79,905	86,183	92,240	98,123	103,993
Change in population (5yrs)	–	6,278	6,057	5,884	5,870
Average annual change	–	1.52%	1.37%	1.24%	1.17%
Households	34,097	36,646	39,185	41,649	44,077
Average household size	2.31	2.31	2.31	2.31	2.31
Population in non-private dwellings	1,277	1,639	1,899	2,019	2,229
Dwellings	37,024	39,626	42,273	44,899	47,496
Dwelling occupancy rate	92.09	92.48	92.70	92.76	92.80

Table 2. *Forecast population, households and dwellings (.id, 2017)*

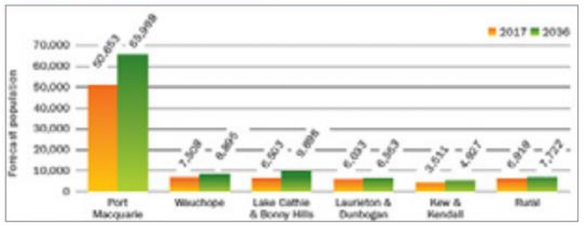


Figure 26. *Forecast Population Growth for key centres in PMHC LGA to 2036, UGMS. PMHC, 2018.*

PMHC has developed an Urban Growth Management Strategy (UGMS) to ensure that land use and population growth will be managed to maintain and enhance quality of life for all persons in the community in a balanced way for current and future generations. A “balanced way” means that social, economic and ecological objectives are balanced with each other (Urban Growth Management Strategy - Port Macquarie-Hastings Council). This strategy is closely integrated with PMHCs Towards 2030 Community Strategic Plan

The UGMS has identified that the main areas planned for new residential development are located in Port Macquarie, Lake Cathie/Bonny Hills and near Kew in the Camden Haven. Future growth is being directed westward of Port Macquarie due to several constraints including national parks and flood-prone lands. (PMHC, 2018). The majority of existing developed land is within close proximity to the coast and needs to be managed for any risks accordingly.

The PMHC LGA experiences a large influx of tourists during the summer months and school holidays, with a year on year growth of 15.9% (Source: Destination NSW, National and International Visitor Surveys, Tourism Research Australia). Port Macquarie is the most affected by this influx along with other key coastal centres such as the Camden Haven, Lake Cathie and Bonny Hills. Coastal areas are used extensively throughout these periods,
especially beaches and foreshore reserves, which places pressure on PMHC to ensure that these areas are not adversely affected. Similarly, population growth projections will place pressure on existing infrastructure (notably, water, sewer and stormwater) as well as pressure on recreational facilities and over time which will challenge how we maintain values important to the local community.

On a national scale, if current population trends continue, in Australia we will continue to increasing our population by about 400,000 per year (1 canberra each year) will result in a population of 40 to 70 million by 2100, with a significant portion of this growth potentially occurring along the coastline.

Port Macquarie-Hastings Council area Total persons (usual residence)	2016			2011			Change
	Number	%	Regional NSW %	Number	%	Regional NSW %	2011 to 2016
Babies and pre-schoolers (0 to 4)	3,820	4.9	5.8	3,985	5.5	6.3	-165
Primary schoolers (5 to 11)	6,473	8.2	8.9	6,165	8.5	9.0	+308
Secondary schoolers (12 to 17)	5,694	7.2	7.3	5,715	7.9	8.2	-21
Tertiary education and independence (18 to 24)	4,637	5.9	7.9	4,338	6.0	8.1	+299
Young workforce (25 to 34)	6,634	8.4	11.0	5,706	7.8	10.4	+928
Parents and homebuilders (35 to 49)	13,023	16.6	18.0	13,322	18.3	19.5	-299
Older workers and pre-retirees (50 to 59)	10,903	13.9	13.8	10,156	14.0	13.9	+747
Empty nesters and retirees (60 to 69)	11,852	15.1	13.1	10,549	14.5	11.9	+1,303
Seniors (70 to 84)	12,523	15.9	11.4	10,315	14.2	10.3	+2,208
Elderly aged (85 and over)	2,981	3.8	2.7	2,446	3.4	2.3	+535
Total	78,540	100.0	100.0	72,697	100.0	100.0	+5,843

Table 3. *PMHC's age structure from the 2011 and 2016 Census compared with Regional NSW. PMHC generally has a higher proportion of older age groups.(.id, 2017)*

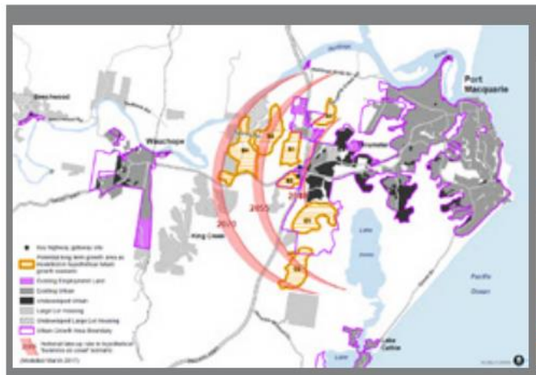


Figure 27. *Forecast growth areas for Port Macquarie & Wauchope, 2036 & beyond,UGMS. PMHC, 2018*

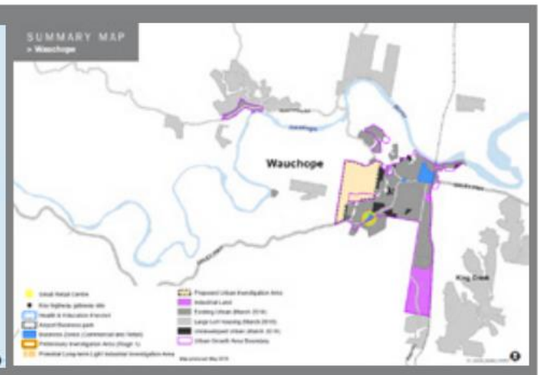


Figure 28. *Forecast Wauchope & Beechwood growth areas to 2036, UGMS. PMHC, 2018.*

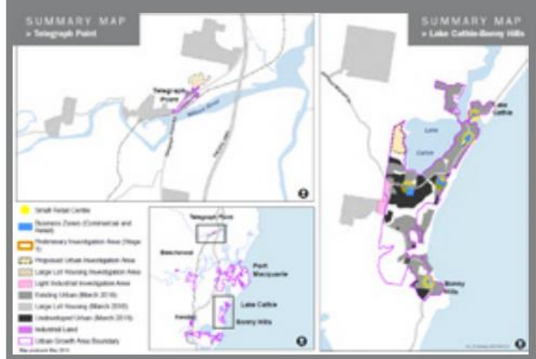


Figure 29. *Forecast Telegraph Point, Lake Cathie & Bonny Hills growth areas to 2036, UGMS. PMHC, 2018.*

Figure 30. *Forecast Camden Haven growth areas to 2036, UGMS. PMHC, 2018.*

11.2 CULTURE AND HERITAGE

The LGA has four Aboriginal representative bodies under the Aboriginal Land Rights Act 1983:

- Birpai Local Aboriginal Land Council
- Bunyah Local Aboriginal Land Council
- Kempsey Local Aboriginal Land Council
- Taree-Purfleet Local Aboriginal Land Council

At this time there is little information available on aboriginal heritage and cultural deposits within the LGA. Site specific projects and planning approvals have been undertaken in consultation with Local Aboriginal Land Councils, including at Lake Cathie for the Stormwater Redirection project and Town Green for the foreshore upgrade projects. Further work will be required to study the cultural connection of aboriginal prople to the land within our LGA and beyond. An LGA wide Aboriginal heritage study has been identified by Council. Once completed it is anticipated that the results of this work will inform future projects undertaken within the Coast & Estuary areas of the LGA and help guide decisions in further stages of the CMP. Having a deeper understanding of the Aboriginal cultural and heritage considerations relevant to the study areas and the broader LGA will ensure the CMP properly incorporates these in developing future management strategies.

The Birpai people are the original occupants and inhabitants of the land in and around the Hastings area and have been for more than 40,000 years. The Birpai land was a rich luscious area of open forests and grasslands with pockets of thick eucalypt forests and rainforests that harboured an abundance of food and wildlife. Fire was a valuable tool in restraining the rampant rainforest with many rivers, creeks, lakes, lagoons and swamps to help control the spread of fire. They exercised traditional rights over the area including the lands and waterways of the Hastings. The Birpai people relied on these lands and waterways to provide them with much of their food and sustenance for life. They constructed temporary huts along the river and around the lakes in which they lived as they followed the seasonal food trail within their tribal boundaries. Numerous middens are still found in the area giving recognition to the gathering of the traditional owners and inhabitants. PMHC's Statement of Reconciliation and Commitment is built on the legacy of the traditional owners and the continuing contribution of the Birpai and other Aboriginal people to the local area.

Surveyor-General John Oxley changed traditional Birpai life with the mapping and naming of this area in 1818. In 1821 Port Macquarie was established as a place of secondary punishment under the Governorship of Lachlan Macquarie. In 1830 Port Macquarie was proclaimed open to free settlement.

The timber industry has driven the area's development from the convict timber cutters to the cedar cutters of the hinterland in the 1870's through to the supply of hardwood for use as railway sleepers and electricity poles. The North Coast Railway reached Wauchope in 1915.

The extensive local river systems provided highways for commerce. In the early part of the 1900's log dumps dotted the banks of the Hastings, Maria, Wilson and Camden Haven Rivers only to be rendered obsolete when road transportation began in earnest following World War II.

The LGA boasts a significant amount of heritage locations located in the coastal zone, particularly with Port Macquarie being settled in the early 19th century. The Municipality of Hastings Heritage Study was completed in July 1991 to identify heritage items related to European settlement and does not include issues related to Aboriginal or natural heritage. No comprehensive LGA-wide Aboriginal heritage study has ever been undertaken. It is recognised that the identification and assessment of Aboriginal heritage sites needs to be undertaken by a professional archaeologist and not left to "fortuitous" discovery.

The PMHC LEP lists known European heritage items in the PMHC LGA and limits development where these items are located. These locations are mapped in PMHC's GIS system.

11.3 COMMUNITY VALUES AND USES

Previous community consultation has been undertaken for CZMPs and EMPs. The values that were identified in these consultations *[as shown in Table 4]*.

The findings exemplify that the community values the unique natural beauty of the LGA, access and facilities for recreational activities and the rich biodiversity. It is intended that additional community and stakeholder engagement sessions will be undertaken in Stage 2 of the CMP process to further build on this information.

Plan Reference	Community Values
Hastings River EMP	· *Sustainably maintain the estuary's ecological quality* · *Protecting the marine environment* · *Maintain a viable mix of business, lifestyle and recreation* · *Maintain naturalness* · *Support lifestyles* · *Be responsible for future generations*
Camden Haven EMP	· *Visual aesthetics such as North Brother backdrop* · *Rural landscapes* · *Areas of open waterways* · *Recreational boating* · *Historical and heritage sites* · *Mooring facilities* · *Recreational fishing* · *Unique urban environment* · *Fisherman's Co-operative* · *Shoreline vegetation* · *Tourism*
Lake Cathie EMP	· *Recreational Values (Swimming, wading & pick-nicking)* · *Recreational fishing* · *Commercial fishing & prawning* · *Nature observation (canoeing, walking, birdwatching)* · *Tourism* · *Visual amenity*
Lake Cathie CZMP	• ***Natural environment:*** *Ocean, beach, estuary and lake, littoral rainforest, climate and natural beauty.* • ***Lifestyle:*** *Relaxed coastal environment, the quietness, the ambience, its peacefulness, living close to the water, the community, the village atmosphere, a place to raise children and the recreational opportunities* • ***Community Uses:*** *Swimming and surfing - family orientated swimming and wading downstream of the Ocean Drive Bridge which is the most intensively used area of the lake. Swimming at the beach and surfing. Middle Rock provides reasonable waves during east and southeast swells (Short 2007).* *Walking along the beach and foreshore reserves as well as bushwalking near Lake Cathie. Nature observation, including bird watching.* *Fishing – popular areas are at 'the drain' and either side of Ocean Drive Bridge.* *Prawning when the entrance is open, at which time good gutters form either side of the entrance for beach fishing (Short 2007).* *Boating upstream of the Ocean Drive Bridge - paddle craft and small powerboats in deeper areas.* *Beach driving - permitted north of Dirah Street and south of Middle Rock subject to a Council permit (Short 2007).*
Town Beach CZMP	• ***Environmental:*** *North-facing beach* *Protected during southerly winds and swell* *One of Port Macquarie's best beaches* *Bush setting and bird life* *Mosaic of landscapes* *Views from higher ground* *Natural amphitheatre from hills* *Access to natural areas* • ***Social:*** *Accessibility* *Safe swimming* *Patrolled beach* *Proximity to CBD* *Focal point for tourists and locals* *Embodies Port Macquarie image* *Good beach for bodyboarding and surfing* *Historical significance* *Sunbaking* *Fishing off break wall* *The name encapsulates the beach* *Surrounding paths are well uses* • ***Economic:*** *Important resource for tourism* *Family tourist town* *International tourists visit* *Visibility and accessibility* *Connectivity to CBD* *Central part of economic development strategy*

Table 4. *Community values and uses identified from CZMP's and EMP's.*

12. ECONOMIC CONTEXT

Approximately 29,000 people work within the PMH LGA with over 2,500 of those jobs supported by tourism. The largest employer by industry is the Health Care and Social Assistance sector (5,419 or 18%) followed by the Retail Trade (3,295 or 11.2%), Construction (2,995 or 10.19%) and Education and Training (2,755 or 9.38%) *[see Figure 31]*.

TOURISM

Tourists are generally drawn to the scenic beaches and accessible coastal walks with Port Macquarie the main destination. An increasing local population combined with abundant and frequent tourist visitors will inevitably put more pressure on the coastal environment. Many businesses rely on the continued use of the coastal zone for predominantly tourist activities such as tour boats, whale watching, stand-up paddle boarding, surfing lessons, cafés and restaurants, deep-sea fishing and scuba diving.

Promoting Port Macquarie-Hastings as a tourist destination is a significant contributor to the local economy, but in doing so it is important to maintain the naturalness and environmental attributes that keep visitors coming to the area.

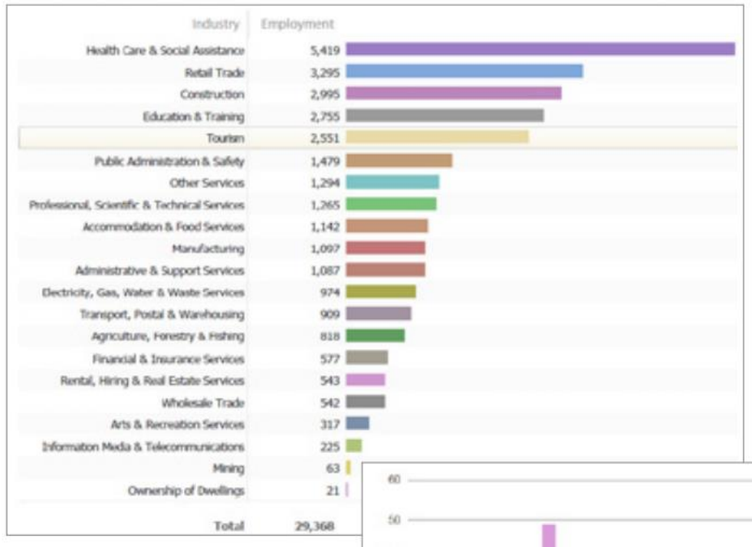


Figure 31. *REMPLAN PMHC Industry Estimates. (REMPLAN, n.d.).*

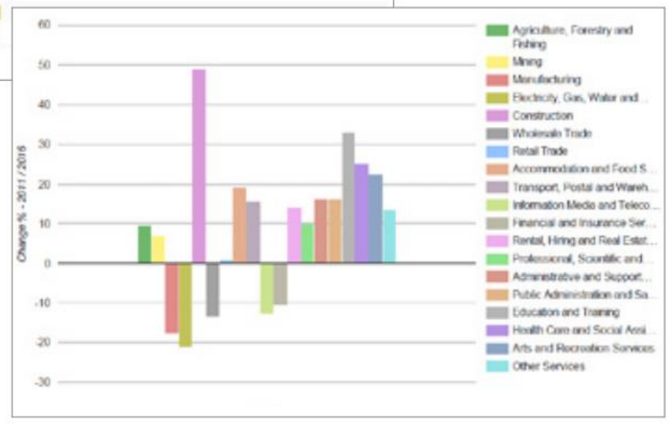


Figure 32. *REMPLAN PMHC Percentage Change in Jobs 2011 - 2016. (REMPLAN, n.d.).*

Figure 33. *Port MAcquarie Hastings Coastal Walk*

AGRICULTURE, FORESTRY AND FISHING SECTOR

The Agriculture, Forestry and Fishing sector makes up approximately 818 jobs in the LGA. Commercial fishing, prawning and oyster farming are still active throughout the LGA. Oyster leases are prevalent in the Hastings River extending to Munns Channel, Blackmans Point and Limeburners Creek, and in the Camden Haven River extending from Gogleys Lagoon at the entrance into Watsons Taylor and Queens Lake. Oyster production in the Hastings River peaked in 1987/88 producing 433.9 tonnes and in the Camden Haven River the peak was in 1977/78 producing 285.6 tonnes. Since then, there has been a steady decline with the Hastings River and Camden Haven River producing 176.5 tonnes and 285.6 tonnes respectively. In comparison to the surrounding estuaries of the Manning and the Macleay River, The Hastings River and the Camden Haven River appear to have remained commercially viable *[see Table 5]*. Oyster production in NSW has declined since the mid 1970's, which has been attributed to many factors such as oyster disease, the effects of Pacific Oyster introduction and the degradation of water quality in many coastal rivers, lakes and estuaries.

In 2018, Fishing, Hunting and Trapping and Aquaculture contributed $46.971 million to the total PMH LGA revenue *[see Table 6]* (NSW DPI, 2016).

Estuary	Historic Peak (tonnes)	2014/2015 (tonnes)
Macleay River	*367.6 (1974/75)*	*19.8*
Hastings River	*433.9 (1987/88)*	*176.5*
Camden Haven	*229.5 (1977/78)*	*285.6*
Manning River	*428.4 (1960/61)*	*70.5*

Table 5. *Oyster Production in the Macleay, Hastings, Camden Haven and Manning Rivers from historic peaks to 2015/2015. (NSW DPI, 2016).*

	Port Macquarie-Hastings (A) (2018 Release 1)		Port Macquarie-Hastings (A) (2012 Release 2)	
Industry sector	**$M**	**%**	**$M**	**%**
Fishing, Hunting & Trapping	$16,199	0.2%	$4,352	0.1%
Agriculture	$30,772	0.3%	$32,886	0.5%
Total	$46,971	0.5%	$37,237	0.6%

Table 6. *2012 - 2018 Revenue for Fishing, Hunting & Trapping and Aquaculture. (REMPLAN, n.d.).*

13. LEGISLATIVE AND PLANNING CONTEXT

13.1 LAND-USE PLANNING INSTRUMENTS

LOCAL ENVIRONMENT PLAN 2011

The Port Macquarie-Hastings Local Environment Plan 2011 (LEP) contains provisions to protect and conserve the environment in the LGA. The LEP provides development restrictions and provisions in certain lands as defined in the LEP.

For the protection of PMHC's coastline, it has the following restrictions or provisions:

a. Development consent is required for works on land identified in the Acid Sulphate Soils Map. The types of allowable works vary depending depth and adjacency to higher classes. Any works on ASS require an Acid Sulphate Soils Management Plan in accordance with the Acid Sulphate Soils Manual.
b. Exempt or complying development cannot be carried out in environmentally sensitive areas including coastal waters of the State, a coastal lake, the Coastal Wetland and Littoral Rainforest Area (CWLRA), an aquatic reserve or marine park, land within a wetland of international significance, land within 100m of the previously mentioned, as well as areas of aboriginal and cultural significance and high biodiversity values. Development consent is required for any development above the mean high-water mark of tidal waters.
c. Land on which aboriginal or heritage items are located require an assessment in order to preserve the cultural significance.
d. Development consent is required for land defined in the Flood Planning Area and cannot be granted if detrimental increases are identified to other properties or environmental factors.
e. Development consent is required for any land mapped as having a coastal erosion risk and cannot be granted unless impacts from the hazards are not increased and the risk is managed appropriately.

DEVELOPMENT CONTROL PLAN 2013

At present, there are two development control plans in force: 2011 and 2013. The Port Macquarie-Hastings Development Control Plan 2011 (DCP 2011) applies to specific areas within the LGA while the Port Macquarie-Hastings Development Control Plan 2013 (DCP 2013) has conditions that apply to all land within the LGA as well as some area-specific parts. The DCP 2013 is the primary development control plan and is the key supporting document to the LEP and provides detailed guidance on design considerations and general standards.

The DCP makes provision for various aspects relating to protection of the coastal zone including:

- Protection Endangered Ecological Communities (EEC) close to waterways or wetlands
- Compliance with Council's Flood Policy
- Stormwater controls (Council's AUSPEC Design Specifications)
- Coastal Hazard Management for Lake Cathie

13.2 COASTAL WETLANDS AND LITTORAL RAINFORESTS

The Coastal Wetland and Littoral Rainforest Area (CWLRA) is land that displays the hydrological and floristic characteristics of coastal wetlands and littoral rainforest communities and lands adjoining those features (OEH, 2018).

Coastal wetland and littoral rainforest communities have high biodiversity values and are of regional and state significance. These communities are very sensitive to certain types of development and environmental threats.

COASTAL WETLANDS

Coastal Wetlands are identified in low-lying areas throughout the LGA. In the Hastings River catchment, they run along Koolonbung Creek, the floodplains along the Hastings River in close proximity to the airport, extending to the north along the banks of the Maria River, Wilsons River and Limeburners Creek area. Locations adjacent to some tributaries to the Hastings River such as King Creek, Sarahs Creek and Stoney Creek are mapped as Coastal Wetlands. There are also isolated patches mapped in the upper catchment near Rollands Plains and Upper Rollands Plains.

In the Lake Cathie/Bonny Hills area, Lake Cathie and Lake Innes both have Coastal Wetlands mapped on the outer boundaries of both lakes including some isolated patches west of the Pacific Highway. In the Camden Haven Coastal Wetlands extend along the Camden Haven River up to the township of Kendall. They border both Queens Lake, Watson Taylor Lake and areas of Gogleys Lagoon *[see Figure 34 below]*.

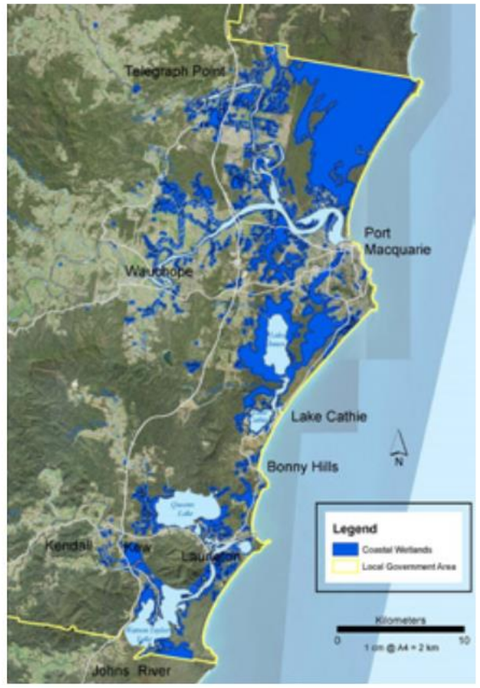


Figure 34. *Coastal Wetlands Areas*

Figure 35. *Littoral Rainforests Areas*

LITTORAL RAINFOREST

Some remnants of Littoral Rainforests are located along the coastline. Areas where they are located in PMH are the North Shore, Port Macquarie, Lake Cathie, Bonny Hills, North Haven and Dunbogan. All of these areas are prone to development pressures with greater emphasis on Port Macquarie and Lake Cathie/Bonny Hills localities *[see Figure 35 above]*.

POSSIBLE FUTURE ACTIONS

Complexity of development controls associated with development in the Coastal Wetland Littoral Rainforest Areas hinder Council's ability to undertake protection or environmental enhancement works, future actions will be to review the coastal SEPP mapping layers in PMHC and examine how to streamline approval pathways for environmental protection.

13.3 COASTAL VULNERABILITY AREAS

The Coastal Vulnerability Area (CVA) is land which is subject to current and future hazards (OEH, 2018). These hazards (defined in the CM Act) are:

- Beach erosion
- Shoreline recession
- Coastal lake or watercourse entrance instability
- Coastal inundation
- Coastal cliff or slope instability
- Tidal inundation
- Erosion and inundation of foreshores caused by tidal waters and the action of waves, including the interaction of those waters with catchment floodwaters

Studies into each of the abovementioned hazards will be addressed in future stages of the CMP.

The Coastal Erosion in New South Wales State-wide Exposure Assessment (OEH, 2017) identified a broad overview of coastal erosion potential impacts on assets along the NSW coastline. This assessment includes the PMHC LGA. The assessment is limited to beach erosion on open-coast beaches. It uses three methodologies:

1. **Proximity analysis (First Pass):** This identifies sandy shorelines and proximity buffer distances to potentially exposed assets.
2. **Regional Analysis (Second Pass):** This uses a sediment compartment-based approach and probabilistic framework to estimate the volume of potential coastal erosion. These hazard lines differ from local government hazard lines used in the Third Pass.
3. **Local government hazard lines (Third Pass):** This is the result of coastal hazard studies undertaken in an LGA using the Zone of Slope Adjustment as the hazard lines. This pass only considers hazard lines produced after 2008 due to SLR projection differences.

Council has focused its attention on areas that have had recorded events of significant coastal erosion, with and without storm events and which have sensitive infrastructure and assets at risk. The reason the investigations have been focused onto the areas is because these areas have shown to actively erode in normal coastal processes and even more so as the result of storm events. As such, PMHC has undertaken coastal hazard mapping for Town Beach and Lake Cathie (for their associated CZMPs).

This mapping shows hazard lines for various current (at the time of study) and future scenarios including sea-level rise *[see Figures 36 - 38]*

Further to the above-mentioned coastal hazard mapping two additional beaches have had further investigations completed due to specific project needs. These beaches include Rainbow Beach at Bonny Hills via a coastal hazard study (under a Part 3A approval) and the investigation of Flynns Beach during the Flynns Beach Seawall Detailed Design Report.

PMHC has incorporated the coastal hazard mapping for Lake Cathie into the LEP. The mapping completed for Town Beach, while still useful, is now outdated and therefore PMHC will not seek to map this in the LEP. Considering that the erosion issues at Town Beach are known and reasonably well defined, PMHC does not see the need to undertake further hazard studies on this area in the near future. Instead efforts may be directed towards other areas of coastline where hazards may exist, i.e. Lighthouse Beach, North Haven beach, Rainbow Beach (Bonny Hills), Shelly Beach, North Shore Beach (Corilla estate).

PMHC shares coastal sediment compartments *[Section 10.3]* with Kempsey Shire Council (KSC) and Mid Coast Council (MCC). *[Section 16 (1) (b) (i)]* of the *Coastal Management Act 2016*, states that if a shared coastal sediment compartment is within the CVA zone, the neighbouring Councils should consult with each other before adopting a CMP. Only two areas have been identified as having coastal hazards (Town Beach and Lake Cathie) and these areas are not in close proximity to the LGA boundaries. Therefore, PMHC considers that further consultation on this specific matter is not required. Nevertheless, PMHC will consult with KSC and MCC if any future identified issues or works are considered to potentially affect either Council.

PMHC also share and must consult with NPWS regarding mutual issues and associated management of 4WD access north to Queens Head

Figure 37. *Lake Cathie Coastal Hazard Mapping (north) (Lake Cathie CZMP, Port Macquarie-Hastings Council, 2016)*

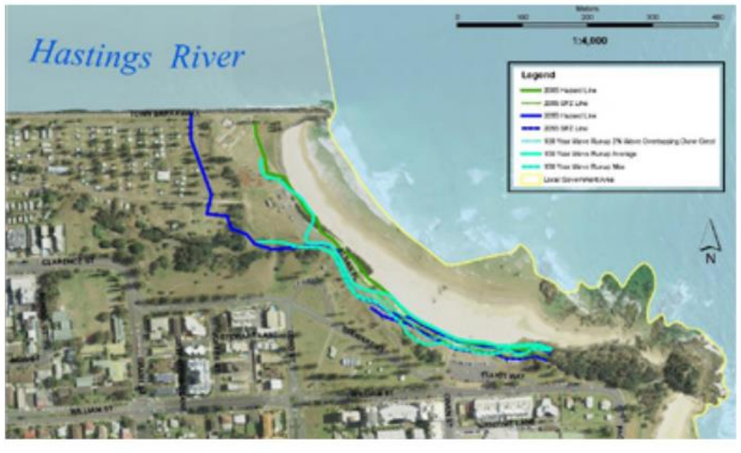


Figure 36. *Town Beach Coastal Hazard Mapping (Town Beach CZMP, Port Macquarie-Hastings Council, 2010)*

Figure 38. *Lake Cathie Coastal Hazard Mapping (south) (Lake Cathie CZMP, Port Macquarie-Hastings Council, 2016)*

BMT WBM was commissioned by Port Macquarie-Hastings Council (PHMC) in 2013 to undertake an estuary and coastline inundation mapping study to assist in the assessment of areas at risk from sea level rise.

The aim of the study is to determine the estuarine and coastal inundation extent for a range of design ocean events including: spring tide; king tide; 1 year Average Recurrence Interval (ARI); 50 year ARI, and; 100 year ARI.

The three epochs and associated mean sea levels (MSL) included in the study are: **Current** (MSL = 0.0 m AHD), **2050** (MSL = 0.4 m AHD), and **2100** (MSL = 0.9 m AHD).

These levels are based on the previous NSW Government planning benchmarks which are a projected rise in sea level (relative to the 1990 mean sea level) of 0.4 metres by 2050 and 0.9 metres by 2100 (DECCW, 2009). It is important to note that due to the inherent difficulty in forecasting actual rates of sea level rise (SLR) the mapping in this study shows the impact of 0, 0.4 and 0.9 m of SLR but does not specify the timing of these changes to mean sea level. The best available estimates of sea level rise projections indicate that these increases in mean sea level will occur by the year 2050 and 2100 as presented in the former NSW Planning Guidelines and adopted by Council (along with many other coastal Councils in NSW).

The study uses three numerical models of the major estuaries in the LGA including:

- Hastings;
- Lake Cathie/Lake Innes, and;
- Camden Haven.

High quality mapping of the inundation extents for the estuaries and coastal areas was undertaken using LiDAR ground elevation data collected for Council in October 2005 *[see Figure 39]*.

A discussion of changes to predicted tidal inundation extents due to sea level rise for each of the three (3) estuaries and the coastline is presented in the report. In particular an attempt was made to highlight key areas that are susceptible to tidal inundation which will be exacerbated by rising sea levels. It is important to note that the purpose of the study is to produce a "first-pass" assessment of areas that may be at risk from tidal inundation due to SLR. This "first-pass" assessment may be used by Council to undertake further studies in order to evaluate potential risks associated with future events. The areas identified below are based on interpretation of the mapped inundation extents provided in the report and are meant as a broad-scale (locality) assessment only.

Areas of specific interest were identified as:

Lake Cathie/Innes Catchment:

- Kenwood Drive
- Lakeside Way

Hastings River Catchment:

- North Shore
- Riverside
- Hibbard/Hastings River Drive
- Settlement Point
- CBD/Short Street
- The Hatch
- Blackmans Point

Camden Haven River Catchment:

- Dunbogan
- North Haven
- Laurieton

Bonny Hills:

- Duchess Creek

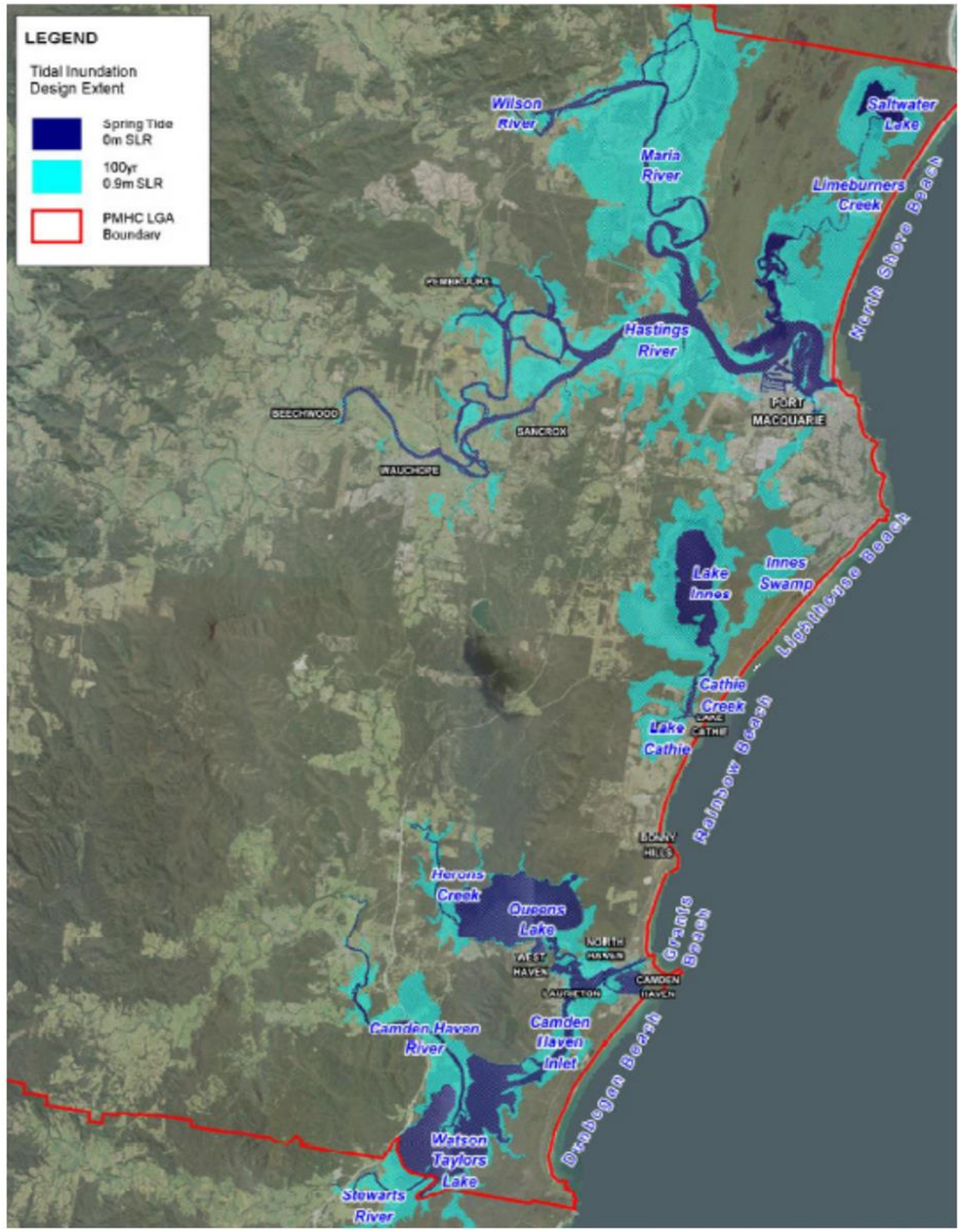


Figure 39. *PMHC LGA Sea Level Rise Mapping (BMT WBM, 2014)*

13.4 COASTAL ENVIRONMENT AREAS

Coastal Environment Areas (CEA) are made up of environmental features such as state waters, estuaries, coastal lakes and lagoons. It also includes land adjoining those features such as headlands and rock platforms. (OEH, 2018) *[see Figure 40]*.

Section 16(1) (b)(i) of the Coastal Management Act 2016 states that if two or more Councils share an estuary then consultation with each other is required before adopting a CMP. PMHC shares estuaries with KSC (Hastings River Estuary) and MCC (Camden Haven River Estuary). As such, Council will be working in consultation with these neighbouring LGA's before any works are undertaken.

The CM SEPP identifies sensitive coastal lakes where development constraints are needed to limit adverse impacts on water quality. The Port Macquarie Hastings LGA contains a sensitive coastal lake listed in the CM SEPP. This being Saltwater Lake in the Limeburners Creek Nature Reserve.

Other coastal lakes exist within the LGA, these being Queens lake, Watson Taylor Lake, Lake Cathie & Lake Innes. These lakes are all sensitive receivers which are highly susceptible to degradation from poor water quality inputs from inappropriate land and water management practices.

Figure 40. *Coastal Environment Area*

13.5 COASTAL USE AREAS

Coastal Use Areas (CUA) are lands adjacent to coastal waters, estuaries, costal lakes and lagoons, where impacts of development on the use and enjoyment of the beaches, foreshores, dunes, estuaries, coastal lakes and lagoons, and the ocean, need to be considered (OEH, 2018) *[see Figure 41]*.

The CM SEPP restricts development in these areas to ensure that adverse impacts on access, overshadowing, visual amenity, Aboriginal heritage and built environment heritage.

Management of CUAs involves ensuring access, use and amenity is maintained for the community. This includes ensuring that there is sufficient beach access, car parks, boat launching ramps, reserves, signage, etc. Fortunately, these themes are addressed through the Community Strategic Plan and the underlying Plans of Management or Masterplans associated with site specific areas. These plans allow for the community's input into the design of foreshore reserves and coastal recreational areas and will be considered during the design and development of the CMP.

The desires, outcomes and values of each of these plans will be used in future stages of the CMP.

Figure 41. *Coastal Environment Area*

13.6 COASTAL MANAGEMENT PLAN AREAS

A CMP applies to all, or part thereof, land within the coastal zone as defined by the Coastal Management Act 2016. A Council must decide whether to include all land mapped as the coastal management areas in the CMP.

The historical legislative framework has divided management of estuaries and open coasts as separate management areas. PMHC will maintain this approach when developing the CMP.

PMHC are proposing to develop one CMP comprised of the following four chapters:

1. Lake Cathie/Lake Innes & Bonny Hills Estuary & Coastline - incorporating the open coastline from the 4 x 4 access track adjacent to Dirah Street to the southern side of Grants Head (referred to in this document as the Lake Cathie/Bonny Hills chapter for simplicity).
2. Hastings River Estuary
3. Camden Haven River
4. Port Macquarie-Hastings Open Coastline (excluding the open coastline that is covered in the Lake Cathie/ Bonny Hills

Lake Cathie has experienced an ever-growing amount of community concern regarding the management of environmental issues and the opening of the lake. Given this increasing focus, along with the results of the Risk Assessment for Threats/Issues *[see Tables 11.1-11.4]* and the pending Stage 2 studies, Lake Cathie/ Bonny Hills chapter of the CMP will be prioritised over other chapters.

The spatial extent and management actions of the CMP will cover:

1. **Lake Cathie/Bonny Hills chapter**
   This chapter will cover the Lake Cathie/Lake Innes estuarine system as well as the open coastline from the 4 x 4 access track adjacent to Dirah Street to the southern side of Grants Head. This will ensure that the existing CZMP is included as it directly interacts with the lagoon entrance and its management in times of flood mitigation. It will also cover Bonny Hills. Preparation of the CMP will enable transitioning of Lake Cathie Open Coast certified CZMP which is due to expire in December 2021.

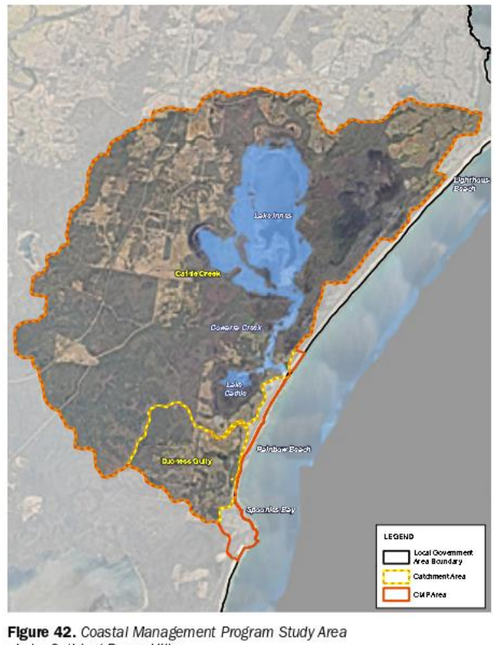


Figure 42. *Coastal Management Program Study Area - Lake Cathie / Bonny Hills*

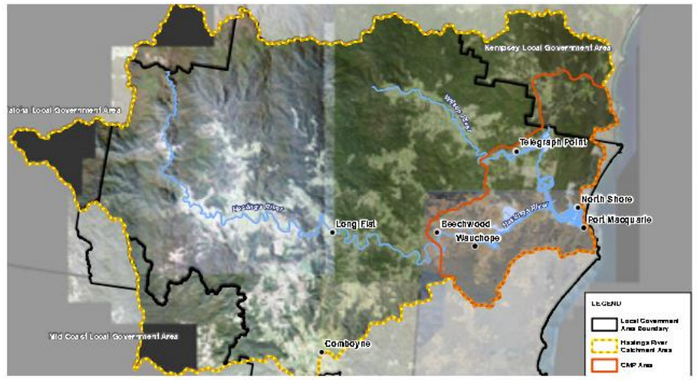


Figure 43. *Coastal Management Program Study Area - Hastings River Catchment*

2. **Hastings River Estuary chapter**
   This chapter will cover the Hastings River Estuary extending from the entrance at the Town Beach to the tidal limits of the Hastings River. Further investigations into the distance and amount of upper catchment extent will be explored during this chapter's development.

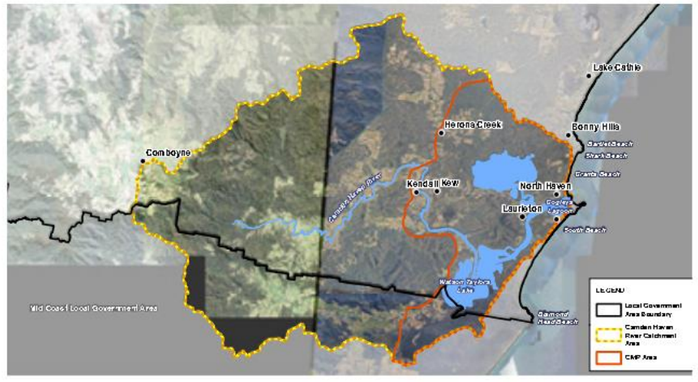


Figure 44. *Coastal Management Program Study Area - Camden Haven River*

3. **Camden Haven River chapter**
   This chapter will cover the Camden Haven River Estuary extending from the entrance between North Haven and Dunbogan to the tidal limits of the Camden Haven River. Further investigations into the distance and amount of upper catchment extent will be explored during this chapter's development.

Figure 45. *Coastal Management Program Study Area - Open Coastline*

4. **Port Macquarie-Hastings Open Coastline chapter**
   This chapter will cover all of the open coastline within the PMHC LGA with a focus on areas identified as being prone to coastal hazards. These areas include Town Beach, North Shore Beach, Flynns Beach, Shelly Beach, Lighthouse Beach and North Haven Beach. The open coastline from the 4 x 4 access track adjacent to Dirah Street (Lake Cathie) to the southern side of Grants Head is not included as it is covered in the Lake Cathie/Bonny Hills chapter.

14. BARRIERS AND OPPORTUNITIES

Funding, legislation, land ownership and management responsibilities are predominantly the main barriers for undertaking management actions. Broadly speaking, previous management actions undertaken under EMP's have not had a significant impact on estuary health due to the scale of the actions and the large amount of funding required. An exception to this is the ASS remediation works that were successfully carried out in the 2000's and early 2010's. Those actions identified in the EMP provided means to seek the employment of an ASS project officer, resulting in many benefits to waterway health and sustainable land management practices. This work which brought about large-scale benefits relied heavily upon dedicated PMHC staff members, significant funding and landowner buy-in. In order to continue large scale projects, such as the ASS program, large amounts of funding and dedicated resources will have to be a priority. These programs have proven to be and will continue to have the greatest effects in improving and maintaining estuarine health.

Working with landowners and various government stakeholders can be a potential barrier as well as an invaluable opportunity. At times, differing opinions, perspectives and desires can conflict. Financial burdens, ongoing maintenance requirements and legislative hurdles can place challenges in the way of successful programs. However, in reviewing existing management plans there is a good opportunity to renew relationships and continue to work towards better environmental outcomes.

For landholders, it has been over 15 years since they have been specifically consulted with and given the time that has lapsed, any previous arrangements may have ceased, been forgotten or have unknowingly been dismissed by new landholders through ownership transfers. PMHC views working with the community as an essential and valuable component of the CMP process.

For NSW government agencies they may have competing responsibilities and priorities they need to address and manage on the land and in the waterways, which may not align with Council and local community expectations.

The CM SEPP, among other legislation, imposes a requirement for development consent for all development (including the clearing of native vegetation) on land mapped within a CWLR Area. The CM SEPP also declares that development in a CWLR area is designated development for the purpose of the EP&A Act, which requires an Environmental Impact Statement and gives rise to merit appeal rights to people who object to the proposed development. Also where development is carried out with a 100 metre-proximity area of a CWLR area where development consent is required, additional considerations apply.

The CWLR area is also included in a biodiversity value map and as such automatically requires the preparation of a Biodiversity Development Assessment Report (BDAR) to be prepared with the designated development application in accordance with the Biodiversity Conservation Act (2016).

The consequence of land being mapped as within a CWLR Area is that it also must be mapped as Category 2 – Regulated Land (Sensitive regulated land) under Part 5A of the Local Land Services Act 2013, when in a rural zone. This makes it an offence to clear native vegetation on the land unless it is undertaken in accordance with the Land Management (Native Vegetation) Code 2018, or the works are authorised pursuant to another relevant approval.

Mapping inconsistencies have been identified within the LGA where CM SEPP mapping interacts with roads, carparks and other assets. For example there are a total of eight bridges in the area that have been included in the mapping, which results in the necessity of taking different environmental approvals for maintenance and upgrades.

PMHC staff have recently met with DPIE to discuss a possible amendment to the SEPP mapping and guiding policies. Consultation is ongoing at the time of writing this scoping study.

DPIE which includes NPWS, Fisheries, Crown Land, LLS, others, are key stakeholders in the management of the coastal area. These stakeholders have ownership, primary control and/or regulate certain activities that can be undertaken over much of the coastal land, including National Parks and Nature Reserves, waterways, Crown Lands and the like. Council must work closely with these departments since nature knows no land tenure boundaries.

Although there are barriers and challenges to this work there are also immense opportunities. Working with government stakeholders in DPIE, environmental organisations, landowners and the Indigenous community provides Council with a rich tapestry of information and perspective from which to draw. This perspective and knowledge allow well rounded management decisions to achieve the triple bottom line of environment, economy and social needs. It ensures that decisions are made collectively rather than by an individual organisation. It allows the manifestation of partnerships and collaborative work relationships which achieve on-ground solutions to difficult problems. It may also assist in leveraging funds or resource sharing to assist in the financial burden and can result in a more rigorous review of an action, giving a better environmental outcome.

Figure 46. *Flynn's Beach, Port Macquarie*

15. SCOPE OF THE CMP

PMHC has already completed an extensive number of plans and supporting studies in relation to coastal management. This includes two CZMP's (one of which has been gazetted), three, EMP's, vegetation mapping, sea-level rise mapping, and floodplain mapping.

The scope of the CMP should build upon existing knowledge of environmental, economic and social issues and the effectiveness of any management plans currently in place.

The Manual indicates that CMP's should consider the following factors when determining the scope:

- **Local management issues, challenges and opportunities identified for each coastal management area, including the spatial extent**
- **Effectiveness of existing management approaches and land use planning instruments to address current and future challenges**
- **Responsibilities and capacities of Council, public authorities, communities and other stakeholders to address coastal management issues**
- **Future population growth and development pressures**
- **Risks and liabilities associated with coastal hazards and threats to coastal environments**
- **Vulnerability of coastal assets, environments and social and economic systems**
- **Potential opportunities to adapt to change and thereby enhance the resilience of natural features and coastal communities.**

The purpose of a CMP, as defined by the CM Act is 'to set the long-term strategy for the co-ordinated management of land within the coastal zone with a focus on achieving the objects of the Act'. The Manual also imposes mandatory requirements as per the CM Act.

PMHC intends creating a CMP that is representative of community values and can sustainably manage issues affecting the present time and future.

Figure 47. *Town Beach, Port Macquarie. Photo: Matt Cramer*

16. CURRENT & FORMER COASTAL & ESTUARY MANAGEMENT ARRANGEMENTS

16.1 COASTAL ZONE MANAGEMENT PLANS

16.1.1 TOWN BEACH CZMP

PMHC commissioned a preliminary appraisal of Town Beach coastal hazards in 2001. The preliminary appraisal suggested that changes to the offshore entrance bar have resulted in an increased penetration of north-easterly swell to Town Beach and a subsequent realignment of the beach to reflect this change in wave direction. The investigations and wave refraction modelling carried out show that, while there has been a change in offshore bathymetry, there is an increased wave energy reaching the northern end of the beach under most offshore swell wave directions and that it is this increase in wave energy that has resulted in the erosion. (SMEC, 2005).

Following the preliminary findings, PMHC engaged SMEC to undertake the Town Beach Hazard Definition Study in 2005. This was a detailed hazard definition study which included photogrammetric analysis, wave transformation modelling and storm bite determination. The study quantified the observed long-term beach recession at Town Beach and estimated the beach recession that would be caused by climate change induced sea-level rise.

The Town Beach CZMP was finalised in 2010 and built on the findings of the 2005 Hazard Definition Study. The Town Beach CZMP was developed to create a strategy to integrate effective management of long-term coastal processes with the further realisation of the recreational and economic potential of Town Beach and associated coastal reserves (Port Macquarie-Hastings Council, 2010) *[see Figure 48]*.

The Town Beach CZMP was prepared in accordance with NSW guidelines at the time and was submitted for certification in August 2008 & September 2010 but was never certified by the NSW Government which at that time was going through a significant policy shift on coastal management.

CZMP Key Issues

Key issues were identified in the CZMP following input from the community, Council and other government agency officers. These issues include:

- Ongoing management of coastal hazards, particularly coastal erosion and overtopping of the back beach area at the northern end of the beach;
- High levels of usage of the beach and adjacent reserves, often with competing interests in the use of the area;
- Pressure to improve lookouts, reserves and facilities; and
- Management and maintenance of beach access points, amenities and facilities.

The northern section of Town Beach has been subject to ongoing erosion since approximately the 1980s. Indications are that the construction of the northern break wall at the entrance to the Hastings River at Port Macquarie has altered the near shore wave climate along the beach. This lowered the offshore ocean bar, resulting in larger waves reaching the shore than would have done so previously. Consequently, sand is being eroded from the beach, causing recession of the back-beach escarpment and undermining part of the southern break wall *[as shown in Figure 50 over page]*. Analysis shows that the back-beach escarpment at the northern end of the beach is now approximately 30 metres landward of its 1980 position. In addition, the low back beach escarpment is occasionally overtopped by storm wave run-up, inundating the reserve lands behind the beach *[refer to Figure 49]*.

Figure 48. *Town Beach CZMP Study Area (Port Macquarie-Hastings Council, 2010).*

Figure 49. *Town beach depicting break walls, back-beach escarpment and offshore ocean bar.*

The photogrammetric analysis (1971 to 2003) completed by SMEC in 2005 as a part of the Town Beach Hazard Definition Study identified that Town Beach has:

- Built up by approximately 15 to 25 metres at the southern end
- Remained reasonably constant where the kiosk is located
- Undergone approximately 15 to 20 metres of recession north of Gaol Rock
- Undergone approximately 30 metres of recession for approximately 50m south of the southern break wall.

The northern break wall was built in 1979 and the greatest period of recorded change in the beach was in the 10 years following. The northern section of the beach is presently not subject to active erosion as a result of rock protection works undertaken in the 2006, however continues to be affected by wave overtopping and tidal surges and remains to be an ‘at risk’ area

Modelling was done to assess the risk of inundation and hazards from wave run-up in a 1 in 100 year Average Recurrence Interval (ARI) storm event. This modelling indicated that:

- The kiosk at the time of modelling is landward of the average and 2% wave run-up levels but some inundation would be expected at maximum wave run-up levels.
- The car parking area at the southern section of the beach average would not be inundated.
- A section of road around the base of Gaol Point would be inundated at average wave run-up levels.
- The northern end of the beach and adjoining foreshore will be subject to wave overtopping and subsequent inundation.

Management Actions

Several management recommendations were included in the report. The highest priority actions were:

1. Control of erosion and coastal hazards at the northern section of beach
2. Redevelopment of the kiosk in the southern section
3. Actions to upgrade various amenities.

Works completed since the report was commissioned include:

1. Extension of the southern break wall approximately 100m further south to alleviate the erosion of the foreshore reserve.
2. Reconstruction of the northern dune in 2006 to protect the foreshore reserve from significant wave overtopping.
3. In partnership with Crown Land, PMHC have periodically accepted the dredged material from the Hastings River, which provides sand nourishment to the beach. This has historically occurred sporadically, and the sand has only been accepted on Town Beach when the beach needs nourishing.
4. The Town Beach Kiosk was upgraded in 2016 with the provision of new public toilets and upgraded sea rescue facilities.
5. A new Skate Park was constructed in 2012
6. A new Kiosk was built on the northern end of Town Beach in 2016. Both the kiosk and the skate park are within areas which are at significant risk of inundation in storm events.

In addition to the works completed, an Emergency Action Plan was developed for the Town Beach area in response to coastal hazards. This plan focuses on the evacuation of at-risk areas in significant storm events and beach closure. While PMHC has closed the beach to the public in storm events, evacuation procedures have not yet proven to be necessary.

Management action status

Of the 30 management actions in the existing CZMP, 10 have been completed, 7 are ongoing, 8 have been started (but not completed) and 5 have not been started.

Key issues ongoing

Of the 19 management issues relevant to the open coastline identified for the future, the equal highest-ranking risks with high level of risk in the present day are:

- Impacts of public access and recreational usage on the environment
- Inadequate / need for maintenance of public access and recreational infrastructure;
- Terrestrial weeds and pests; and
- Equity in distribution of costs and benefits from coastal management activities.

A total of seven issues are categorised as high in the 100-year planning horizon; this includes those listed above, as well as:

- Impacts of climate change and sea level rise;
- Coastal cliff or slope instability; and
- Open coast erosion.

This is due to the ongoing impacts of climate change, resulting in issues such as long-term trends of shoreline recession, which places more assets at risk from coastal hazards.

Figure 50. *Town Beach showing wave overtopping rock revetment wall during June 2016 East Coast Low event.*

16.1.2 LAKE CATHIE CZMP (2016)

Lighthouse Beach (adjacent to Lake Cathie) is approximately 2 km long. The beach south of the estuary entrance is backed by residential development along Illaroo Road and by Johnathon Dixon Reserve which is seaward of development along Chepana Street (Port Macquarie-Hastings Council and SMEC, 2016).

The Lake Cathie Coastal Zone Management Plan (CZMP) was initiated by Council in 2007 following coastal erosion along the coastline at Lake Cathie which damaged stormwater infrastructure and beach access points and threatened to undermine Illaroo Road. The Lake Cathie CZMP was prepared in accordance with the former CP Act, NSW Coastal Policy, NSW Sea Level Rise Policy 2009 and the 2010 Guidelines for Preparing Coastal Zone Management Plans 2010 and was overseen by the CE&F sub-committee.

Figures 51 and 52. *Coastal erosion at Lighthouse Beach causing damage to stormwater infrastructure at Jonathan Dickson Reserve.*

Goals

The Lake Cathie CZMP was proposed and written in order to achieve the following goals:

- Protect and restore natural areas through stormwater and foreshore management.
- Provide community access and opportunities to enjoy our natural environment through reserve improvements, continuing public access and beach nourishment.
- Plan and take action to minimise the impact of natural events and climate change through further investigations, contingency measures and construction of a revetment to protect private development and Illaroo Road.
- Manage development outcomes to minimise the impact on the natural environment through development controls.

General Issues Identified

A broad list of issues identified in consultation with community members, discussions with various NSW state agencies and a review of the literature and information at hand yielded the following list:

- Erosion and erosion control
- Safe beach access
- Maintaining recreational amenity
- Soil/sand stability at stormwater outlets
- Property values
- Increased tourism

- Revegetation/weeds

Detailed review of issues

Upon completion of the general list of issues Council began to have a more detailed review of the following two issues:

- Erosion and erosion control
- Soil/sand stability at stormwater outlets

These were addressed through the following studies.

Coastal Hazard Study - 2008

This first study undertaken was to work on ways to solve the erosion and erosion control issues. This was the priority since it dealt with the highest issues of risk, that being risk to life and property. The study identified 17 properties with immediate coastal hazard risk.

In order to understand these issues of erosion more comprehensively Council commissioned SMEC in 2008 to complete the Lake Cathie Coastal Hazard Study.

Coastline Management Study - Stage 1 - 2009

Following the 2008 Hazard Study, a two stage Management Study was undertaken. The Lake Cathie Coastline Management Study - Stage 1 was completed by SMEC in 2009 and focused on obtaining information from the community about their values and opinions on how the Lake Cathie coastline was used. Thirteen potential management option were assessed and after a period of public exhibition and consultation (where 344 submissions were received), four primary management options were endorsed for further investigation.

The shortlisted options from stage 1 were:

1. Planned Retreat (services relocation, development controls, voluntary purchase and property acquisition)
2. Beach Nourishment
3. 400m Revetment Wall for Illaroo Road
4. Groyne

Coastal Hazard Study - 2010

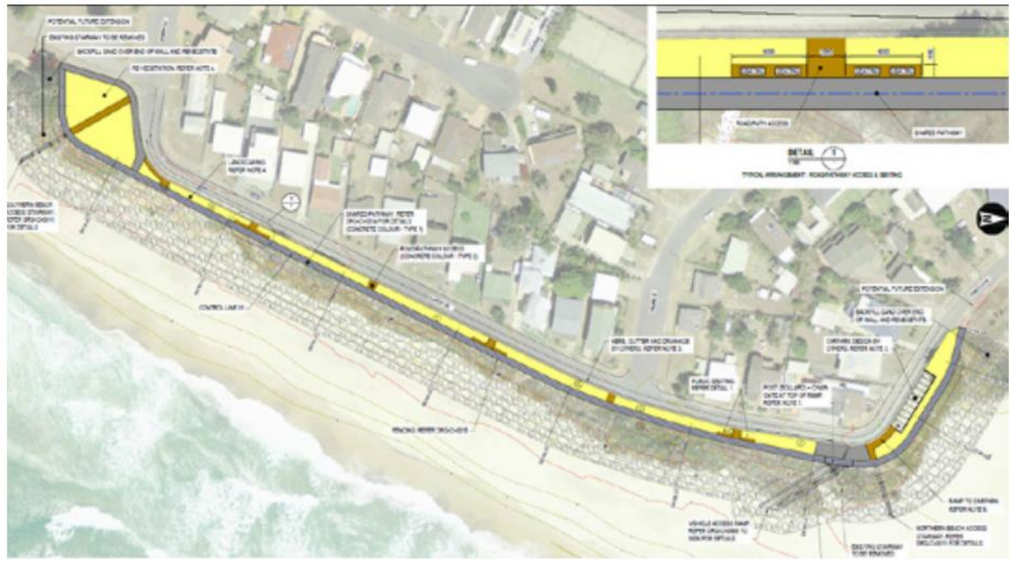
SMEC were engaged again in 2010 to revise the hazards to take into account the sea level rise planning benchmarks contained in the NSW Sea Level Rise Policy Statement 2009. The 2009 NSW Government Sea Level Rise Policy required that Council consider, as a minimum, 400mm sea level rise above 1990 mean sea levels by the year 2050 and 900mm rise by the year 2100. Following a review of the science behind the benchmarks, the NSW Chief Scientist and Engineer (2012) found that the science was 'adequate' in light of the evolving understanding of the associated issues. However, the Chief Scientist and Engineer also highlighted uncertainty associated with sea level rise projections and the possibility of undertaking more regionally specific calculations. Following these findings, the NSW government repealed the NSW Sea-level rise Policy Statement 2009 and its associated benchmarks, instead recommending that individual Councils could adopt a range of locally relevant projections commensurate with competent scientific opinion, and that these could be used for risk assessment under local planning instruments with suitable development controls.

It should be noted that although the NSW Government has repealed the Sea Level Rise Policy (benchmarks), PMHC feels this is the best available information and all work has been undertaken on this basis.

Coastline Management Study - Stage 2 - 2012

The Stage 2 Management Study (2012) assessed the four management options in detail. PMHC held public consultation and exhibited the report in mid-2012. Following large public support received via submissions (over 4500 submissions were received), PMHC resolved to proceed with the preparation of the Lake Cathie Coastal Zone Management Plan incorporating a revetment and beach nourishment as the management option for Illaroo Road.

Figure 53. *Illaroo Road Rock Revetment Wall Detailed Design, Aurecon 2015*



Illaroo Road Rock Revetment Wall - Detailed Design - 2013

As a result of the adoption of a revetment wall in 2012 under the Stage 2 Management Study and the resolution to proceed with a CZMP Council engaged Aurecon to investigate and design revetment wall for Illaroo Road *[see Figure 53]*.

The detailed design for a rock armoured revetment was completed in 2015. The rock revetment wall included pedestrian footpaths, beach access points, and additional car parking. The wall was estimated to cost $8.1M in 2015, however this estimate was heavily dependent on the availability of hard, durable rock from nearby quarries.

Lake Cathie Coastal Zone Management Plan - 2013

Council prepared Coastal Zone Management Plan (CZMP) for Lake Cathie due to the Lake Cathie Beach being designated a coastal erosion hotspot. The purpose of a CZMP is to describe proposed actions to be implemented to address priority management issues including:

- Managing risks to public safety and built assets,
- Pressure on coastal ecosystems, and
- Community uses of the coastal zone.

Council has previously undertaken the abovementioned studies in preparation for the CZMP. On the basis of considerable public support for a revetment with sand nourishment to mitigate coastal erosion risks at Illaroo Road, Council adopted the Coastal Zone Management Study (Stage 2) in July 2012. This is the preferred management option referred to in the current CZMP and forms the focus of this document.

The CZMP was adopted by Council in 2013 on the basis that funding for the total cost of the revetment wall construction would be provided by both the NSW and Commonwealth Governments.

Certification of the CZMP by the NSW State Government was requested in March 2014. In March 2015 the Minister for Planning requested a number of actions be undertaken before the CZMP would be certified.

Of particular note, Council was requested to:

- include updated costs for the construction of the revetment wall which was based on Aurecon's detailed design,
- incorporate the results of a Cost Benefit Analysis (CBA) that was being prepared by OEH on Council's behalf, and
- consider reviewing the management of stormwater to minimise the direct outflow of stormwater onto the beach.

Hazard Study Review - 2014

The Lake Cathie Coastal Zone Management Plan included actions for further investigation. One such action related to geotechnical investigation targeting indurated sands "coffee rock" within the study area. The main issue being the uncertainty relating to the influence of regional coffee rock formations on long term shoreline recession and storm erosion demand at the study site.

This review included:

- A geotechnical investigation of the indurated sand (coffee rock) strength and extent.
- Producing a conceptual sediment transport model for the site.
- Undertaking photogrammetric analysis of the exposed coffee rock over time.

Results of the review showed that there was no justification to change the previously adopted hazard lines from the 2008 and 2010 SMEC reports.

Lake Cathie Coastal Zone Management Plan - 2016

Council revised the CZMP to incorporate the actions requested by the minister. The plan was adopted by Council in April 2016 and ministerial certification was subsequently requested.

Ministerial certification of the Lake Cathie Coastal Zone Management Plan 2016 was provided in November 2016 and was Gazetted in January 2017.

The certification again came with a list of actions which were required to implement the plan. The letter advised that the next critical step was the development of a workable funding model based on a distributional analysis that accords with the provisions of the new Coastal Management Manual.

The CZMP is the final document of the coastal zone management process and as such is a summarising document containing important information gathered from the three previous studies.

Implementation of CZMP Actions as at March 2020

a. 440m Revetment Wall for Illaroo Road

As mentioned above, at the direction of the Minister, OEH (now DPIE) engaged Balmoral Group in 2015 to undertake a Cost-Benefit Analysis (CBA) of management options along with a socio-economic profile of Lake Cathie. The analysis concluded that beach nourishment had the greatest net social benefit for the community, closely followed by the option of building a revetment wall.

Following the direction from the Minister in 2016 Council engaged Marsden Jacob & Associated to prepare a funding model which would rely on the results of the 2015 Balmoral Group CBA. However, upon review of the Balmoral modelling a number of fundamental issues with the modelling were uncovered. Accordingly, a new CBA and Funding Model needed to be completed.

The revised CBA & funding model:

- synthesized and accurately reported cost components based on the results of the Cost Benefit Analysis and associated engineering studies.
- identified and evaluated the strengths and limitations of alternative funding models. The assessment focuses on current opportunities and alternative management options and strategies that could result in a budget neutral outcome for the Council or identify long-term alternative sustainable funding.
- described the public and private beneficiaries and the extent of the benefits to each beneficiary associated with the preferred option.
- identified funding options and models that could support the development of the revetment and that are founded on the Council's statutory ability to levy fees and charges under relevant state government legislation.
- recommend a preferred funding model. In developing this model, we note that we would need to consider the capacity of beneficiaries to pay apportioned costs.

At this time, a preferred funding model has been recommended, but further consultation with residents is required before an assessment can be made on their willingness and capacity to pay for coastal protection measures (i.e. the revetment wall). Community engagement is planned to be undertaken in order to inform the directly impacted residents and community at large of the outcome. This project has not been finalised or adopted by Council at the time of writing this Scoping Study.

b. Short-term beach management

Short-term beach management includes monitoring the beach for erosion following storm events, continuing interim development controls, continuing beach nourishment with sand from dredging activities in Lake Cathie, foreshore management and construction of Illaroo Road stormwater realignment.

c. Illaroo Road Stormwater realignment

Council successfully sought grant funding to undertake construction works to redirect stormwater away from two outlets that currently discharge water directly onto the beach at Illaroo Road. The project aims to capture this stormwater and discharge the water into a single outlet in Bundella Avenue.
The stormwater realignment is currently on-hold due to dumped asbestos (building waste) and Aboriginal archaeological findings at the site which are undergoing further investigation.

d. Emergency Action Plan

A plan has been developed under this plan which identifies actions to manage risks to public safety in the event of a coastal erosion emergency. It has not been necessary to implement any of these response actions to date.

Figure 54. *Lake Cathie CZMP Study Area (Port Macquarie-Hastings Council and SMEC, 2016)*

Management action status

Of the 39 management actions in the existing CZMP and EMP, 17 have been completed, 11 are ongoing, 2 have been started (but not completed) and 9 have not been started.

Key issues ongoing

Of the 26 management issues relevant to Lake Cathie to Bonny Hills area and the adjacent open coastline identified for the future, the equal highest-ranking risks with an extreme level of risk in the present day are:

- The impacts of ASS;
- Need for strategic land use planning and development controls to minimise impacts on the coastal zone; and
- Need for sustainable ICOLL entrance opening strategy.

Many risks increase over time as the impacts of climate change are realised and a greater number of people (in part due to increased population/development and seasonal visitation).

A total of four issues are categorised as extreme in the 100-year planning horizon:

- Need for sustainable ICOLL entrance opening strategy;
- Estuary / river flooding and inundation places natural and built assets at risk;
- Open coast erosion places natural and built assets at risk; and
- Impacts of climate change and sea level rise on the coastal zone and estuaries (which is effectively captured in all the above risks).

16.2 ESTUARY MANAGEMENT PLANS

The NSW Government introduced the Estuary Management Policy in 1992 which was consistent with the former Catchment Management Act 1989. The Estuary Management Policy was introduced in order to achieve an integrated, balanced, responsible and ecologically sustainable use of estuaries. Preparation of Estuary Management Plans was in accordance with the NSW Estuary Manual which saw the establishment of coast and estuary management committees.

16.2.1 HASTINGS ESTUARY MANAGEMENT PLAN

The Hastings EMP was prepared for PMHC and overseen by the Hastings Council Estuary Management Committee (now Port Macquarie-Hastings Council Coast, Estuary and Floodplain Advisory Sub-Committee) in 2001 by Umwelt (Australia) Pty Limited. The EMP was developed in accordance with the NSW Estuary Management Manual 1992.

The Hastings EMP was created to provide integrated management of the estuarine system by obtaining information about system processes and current conditions and designing management actions to address any issues identified.

The Hastings Estuary Management Plan covered the following areas:

- The waterways of the Hastings estuary and its tributaries (e.g. the Maria River, Limeburners Creek and Kooloonbung Creek), up to the limit of tidal influence.
- The foreshore and other lands adjacent to the estuary, including all wetlands and floodplain areas that are functionally related to the estuary; and
- The catchment areas of the estuarine waterways, in relation to the impacts of catchment processes on the estuarine environment. The interaction of the catchment and estuary as parts of a single system is a fundamental concept for sustainable estuary management.

Key Issues

Key issues that affected the Hastings Estuary were identified as:

- Estuary form and processes
- Acid sulphate soils
- Bank erosion
- Riparian vegetation and conservation values
- Water quality
- Scenic value
- Aquatic primary production
- Floodplain production
- Dredging
- Population growth and age structure
- Tourist and recreational use
- Community views about the value of the estuary
- Sea Level Rise and Climate Change Impacts
- Sedimentation and shoaling
- Sustainable management of commercial fisheries

Management Actions

Numerous actions were adopted under this plan with many being completed. Some notable actions include:

- The appointment of an Acid Sulphate Soils Officer
- Development of a Hydrodynamic Model
- Rocks Ferry upgrade
- Completion of the Partridge Creek Management Strategy and subsequent remediation of the Partridge Creek Acid Sulphate Soil hotspot.

Management action status:

Of the 76 management actions in the existing CZMP and EMP, 60 have been completed, 11 are ongoing, 3 have been started (but not completed) and 3 have not been started.

Key issues ongoing:

Of the 24 management issues relevant to the Hastings River identified for the future, there were seven issues that represented the equal highest risks in the present day:

- Impacts of public access and recreational usage on the environment;
- Estuary / river bank erosion;
- Impacts on estuarine macrophytes (e.g. seagrass) and wetlands;
- Acid sulfate soils;
- Need for strategic land use planning and development controls;
- Impacts on riparian zone; and
- Terrestrial weeds and pests.

Many risks increase over time as the impacts of climate change are realised and a greater number of people (in part due to increased population/development), and built and natural assets are impacted.

The highest ranking risk in the 100-year planning horizon is estuarine / river flooding and inundation due to a combination of catchment and coastal processes, which increases under climate change and has potential to impact a large area due to the low-lying nature of parts of the catchment.

A total of three other issues also emerge extreme risks in the 100-year planning horizon:

- Estuary / river bank erosion;
- Impacts on estuarine macrophytes (e.g. seagrass) and wetlands; and
- Impacts of climate change and sea level rise on the coastal zone and estuaries.

16.2.2 CAMDEN HAVEN ESTUARY MANAGEMENT PLAN

The Camden Haven EMP was developed in 2002 for PMHC, overseen by Camden Haven Estuary Committee (now merged into the CE&F committee).

The plan involved significant community consultation and stakeholder engagement throughout the process.

Key Issues

Key issues that affected the Camden Haven Estuary were identified as:

- Development and Human Impacts - growing pressures from urban growth adjacent to the estuary. Clearing and drainage of land has resulted in oxidation of acid sulphate soils.
- Water Quality - stormwater and acid runoff can deteriorate water quality even during minor rainfall and flood events. The poor flushed parts of the estuary such as Mirror Bay and Gogleys Lagoon are most susceptible to these impacts.
- Bank Erosion - continued erosion of shoreline, in particular along Stingray Creek at Henry Kendall Reserve
- Estuary Sedimentation - infilling of the estuary, particularly at locations where navigation is important such as the Camden Haven River entrance to Watsons Taylor Lake
- Fishery - Decline in fish stocks and effects to oyster farming
- Preservation of Wetlands, Mangroves, Saltmarsh and Seagrass
- Maintenance of the aesthetic attributes - the close proximity of tall mountains (the 'Three Brothers') to the estuary is a unique feature.

Management Actions

The plan incorporated both long-term and short-term strategies for managing the estuary. Long term strategies focused on regional issues such as reversing larger scale human impacts whilst short term strategies related to work or measures that could be implemented as soon as funding became available. Several strategies were created ranging from Priority 1 Actions (initiated over the next 2 years) to Priority 3 Actions (initiated over the next 5-10 years).

These actions included

- Implementing water quality monitoring programs.
- Community education relating to estuarine processes and responsible stormwater runoff management.
- Design and construction of pollution control devices.
- Development controls.
- Bank stabilisation for erosion control
- Further studies/reviews relating to vegetation mapping, priority conservation areas, acid generation, biological assessment of seagrass beds, significant wetlands and reported reduction in fish stocks.
- Estuarine/lakeside linkages project aimed at reducing feral pests and invasive weeds.

Management action status

Of the 46 management actions in the existing CZMP, 19 have been completed, 17 are ongoing, 5 have been started (but not completed) and 5 have not been started.

Key issues ongoing

Of the 24 management issues relevant to the Camden Haven River estuary, the top 3 highest ranking were:

- Need for strategic land use planning and development controls;
- Inadequate / need for maintenance of public access and recreational infrastructure; and
- Declines in water quality.

Many risks increase over time as the impacts of climate change are realised and a greater number of people (in part due to increased population/development), and built and natural assets are impacted.

The four highest ranking risks in the 100-year planning horizon, with a rating of extreme, are:

- Estuary / river bank erosion places natural and built assets at risk;
- Impacts on estuarine macrophytes (e.g. seagrass) and wetlands;
- Estuary / river flooding and tidal inundation places natural and built assets at risk; and
- Impacts of climate change and sea level rise on the coastal zone and estuaries.

The next highest-ranking risks are the same three listed above for the present day highest ranking risks.

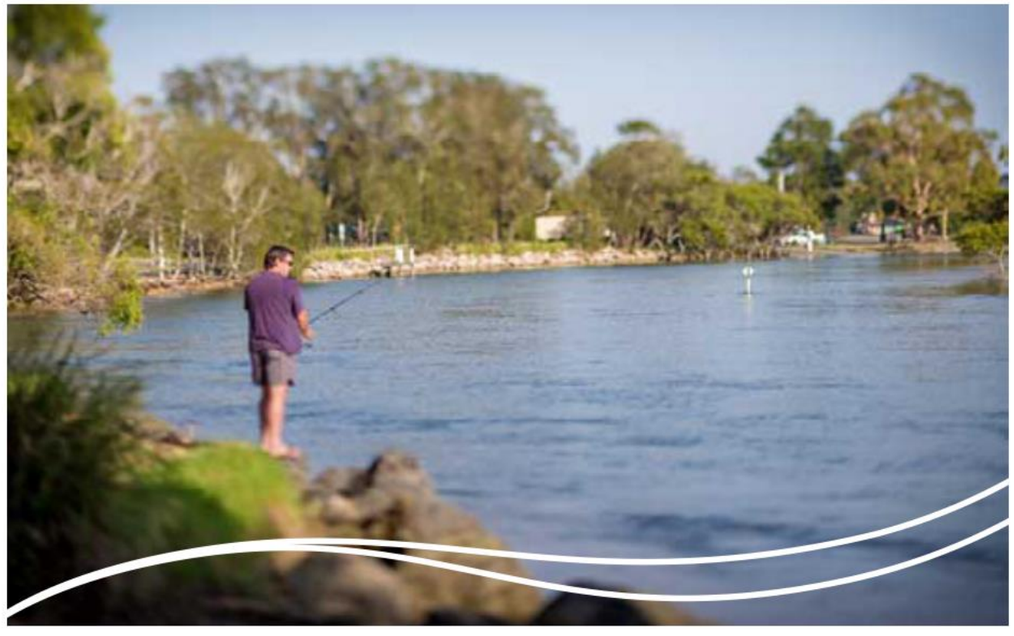


Figure 55. *Camden Haven Estuary fishing. Photo: Lindsay Moller*

16.2.3 LAKE CATHIE/LAKE INNES ESTUARY MANAGEMENT PLAN

The Lake Cathie/Lake Innes EMP was created in 1994 in collaboration with NSW Public Works (now Public Works Advisory) and the National Parks and Wildlife Service (NPWS).

Key Issues

Issues that were identified were discussed with the Lake Cathie-Bonny Hills Estuary Management Committee along with the community and environmental groups to determine and prioritise management actions.

The key issues identified are listed below:

- Entrance opening - increased salinity when lake is closed, waterbirds nesting and seasonal feeding, organic staining of waters when lake is closed, recreational activities, fish and prawn migration, deoxygenation of waters and pollution build up.
- Shoaling in the lower estuary - the construction of the Ocean Drive and Kenwood Drive bridge have changed the shoaling patters and tidal and flood flows and sand infeed from the ocean entrance
- Closing of Lake Innes - based on Lake Innes historically being freshwater system and may impact fisheries, salt marsh populations, flood and tidal hydrodynamics, water quality, biology and lake opening/closing frequencies.
- Water quality - surrounding residential development results in increased stormwater runoff impacting on gross pollutants, nutrients, bacteria and particulate matter.
- Flooding - several properties are flood prone particularly in relation to the lake opening frequency
- Waterway uses - recreational, commercial, access
- Sedimentation - limited volumes for fine suspended sediments (clays and silts) enter the estuarine system with surrounding wetlands acting as barriers

Management Actions

EMP management actions included:

- Implement combined entrance opening strategy and modified entrance opening procedure
- Potential reversion of Lake Innes into a freshwater system by installing a levee
- Establish run-off quality guidelines
- Adoption of flood policy changes
- Water quality monitoring and establish nutrient budgets
- Facility and access upgrades
- Dredging of lower estuary

Further studies have been completed to understand the complex processes in the estuarine system, some of which are listed below:

- Nutrients in the Lake Cathie / Lake Innes Lagoonal System, Port Macquarie (Southern Cross University, 1994)
- Cathie Creek Maintenance Dredging Environmental Review, (Webb, McKeown & Associates, November 1994)
- Lake Cathie/Lake Innes Water Quality Study, (Department of Public Works and Services, Manly Hydraulic Laboratory, November 1995)
- Lake Cathie/Lake Innes Entrance Opening Strategy Environmental Review, (Webb, McKeown & Associates, May 1995)
- Lake Cathie/Lake Innes Waterway Users Study, (Webb, McKeown & Associates, July 1998)
- Lake Innes Nature Reserve Plan of Management, (NPWS, November 1999)
- A Tale of Two Lakes - Managing Lake Innes and Lake Cathie for Improved Ecological and Community Outcomes - Issues and Options, (Umwelt, February 2004)
- Maintenance Dredging of Lake Cathie Review of Environmental Factors, (GHD, September 2004)
- Port Macquarie-Hastings Council Dredging Strategy, (Port Macquarie-Hastings Council, September 2007)
- Lake Cathie Lake Innes Estuary - Hydrodynamic Model Development & Investigation (BMT WBM, May 2011)
- Lake Innes Environmental Assessment (Hale, 2013)
- Lake Cathie and Lake Innes Acid Sulfate Soil Risk Assessment, (Soil Conservation Services, July 2019)

Water quality monitoring

PMHC undertakes water quality monitoring at Lake Cathie typically monthly and primarily from the Ocean Drive Bridge. As of June 2019, PMHC is also undertaking monitoring at three separate locations in the estuarine system. Water quality is broadly considered within acceptable limits although there have been some recent occurrences of high salinity. Water level data, salinity, electrical conductivity and water temperature data is recorded by the NSW Government from automatic recording equipment, managed by Manly Hydraulics Laboratory. Negotiations are underway with NPWS, Revive Lake Cathie and Southern Cross University to install a multi probe water quality logger in the Lake Innes.

Water quality declined slightly in Lake Cathie – Lake Innes from 2011 to 2014-15. Lake Innes (D+) in 2011 fell to a (D-) in 2014-15. Lake Cathie had a larger decline from (C) in 2011 to a score (D-) in 2014-15. Declines were driven by high persistent exceedances of TN, TP and especially NOx.

Connection of Lake Innes to Lake Cathie

Lake Cathie and Lake Innes are a connected system however this has not always been so. Before 1933, Lake Innes was a stand-alone freshwater lake. A channel was dug between both lakes in an attempt to drain Lake Innes to create farmland, this resulted in Lake Innes being converted to an estuarine system with permanent connection to Lake Cathie. This gauging station has recently been upgraded by Manly Hydraulics Laboratory and now provides information on Salinity, Electrical Conductivity and Water Temperature.

Opening of Lake Cathie

The Intermittently Closed and Open Lake or Lagoon (ICOLL), from which the town of Lake Cathie takes its name, is part of a wider system that includes Cathie Creek and Lake Innes to the north.

PMHC (and its earlier counterpart i.e. Hastings Shire Council) has been artificially opening Lake Cathie since the 1960s. This is typically done by excavating a small starter channel through the beach dune when water levels exceed 1.6m AHD, however this level has formerly been 1.5m AHD and 1.8m AHD.

PMHC in consultation with the community established the Lake Cathie Opening Strategy in 1995. The strategy was reviewed in 2001, 2004/2005 and 2011. Artificial openings, to alleviate flooding have occurred on average once every 12 months. The Strategy aimed to minimise adverse effects on the ecology of the area, minimise build-up of sand in the lake entrance, and reduce impacts of flooding, while providing residents and visitors with opportunities for recreational activities. The former Opening Strategy flowchart is shown in *[see Figure 56 over page]*.

A hydrodynamic model was developed by BMT WBM in 2011 to assist in management of the Lake Cathie

ICOLL. This report did not recommend any changes be made to the opening strategy.

Lake Cathie continues to be a contentious area in regard to its existing and ongoing management from the perspective of the community and environmental groups. The health of the estuary is questioned constantly with community members quite often requesting that PMHC open the lake regardless of whether opening triggers have been met or not. Extensive consultation and education work have been undertaken in the last two years however there appears to be an ever-growing demand for a change in management strategy. Considering this community interest and the length of time since the latest review, (2011) a review of the existing Opening Strategy will be prioritised in the Lake Cathie/Bonny Hills chapter.

Further impetus to update the Opening Strategy comes from recent Crown Land advice where it was determined that as the environmental approval (Review of Environmental Factors - REF) was greater than 5 years old, a new REF would be required before lake openings could be undertaken. As Council does not own the land (i.e. the lower estuary, downstream of Ocean Drive bridge is Crown Land) works cannot be undertaken until a licence is issued, this will not be issued by Crown Land unless it is supported by an up to date REF.

Lake System Acid Sulphate Soils

The latest artificial opening of Lake Cathie occurred in mid-July 2018 as water levels reached the upper threshold of 1.6m AHD under the opening strategy. The draining of the lake system followed a similar pattern to other opening events whereby the initial discharge of lake water scours the beach berm down to meet the prevailing low tide mark. However ongoing drought conditions on the east coast of Australia during 2019 resulted in the lowest annual rainfall total for Port Macquarie ever recorded. After the lake entrance closed the water levels continued to decline and expose extensive foreshore areas comprising Acid Sulfate Soils. Ongoing evaporation, dry and hot conditions and bushfires resulted in the lake water levels dropping further causing high water temperatures, low dissolved oxygen, hypersalinity and fish kills.

In order to better understand the ASS risk within the lake system, Soil Conservation Services (SCS) were engaged By PMHC & NPWS to undertake a risk assessment. This report confirmed that a significant ASS storage and high risk contamination exists and needs further investigation. Accordingly, it was agreed between managing stakeholders that additional ASS studies were required. Council set aside $147,500 to fund this work in 2019 and applied for grant funding to cover the additional $147,500. This application has lapsed and a new application will be submitted to the coastal program upon completion of this scoping study.

The lake filled in early 2020 following sustained rainfall, which submerged the ASS. However due to sustained community and political pressure to open the lake, Council resolved to provide a shallow flood relief starter channel in the beach berm. This was against the advice of the NSW State Government agencies who recommended a scraping to 1.6m AHD. Ultimately the shallow channel which was dug on 22 May 2020 resulted in a full opening of the lake system, which drained the lakes and has resulted in tidal waters pumping the ASS and has generated acidic discharge and a substantial Iron Floc. This has resulted in visually poor water quality upstream from the Ocean Drive Bridge, and Council has had to erect signage to advise against swimming and eating fish caught within the lakes. This highlights the need to undertake a substantial review of the Entrance Opening Strategy in order to avoid similar situations happening again.

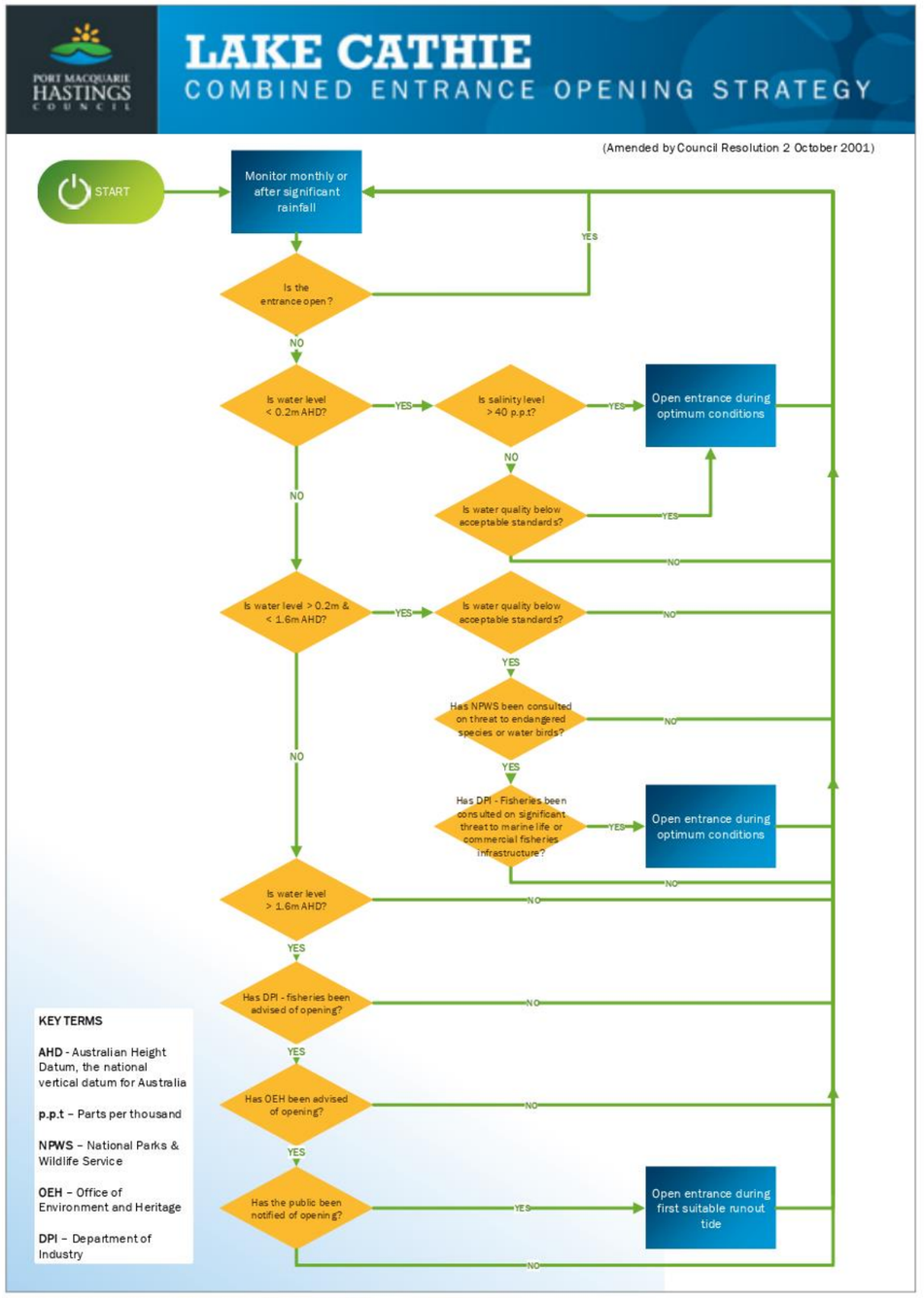


Figure 56. *Former Lake Cathie Opening Strategy Flowchart*

16.2.4 SALTWATER CREEK MANAGEMENT PLAN

Saltwater Creek is a small creek that flows through the northern section of Bonny Hills and drains a catchment of 2.5km2. The creek flows intermittently into the ocean at Rainbow beach immediately north of the Bonny Hills Surf Life Saving Club.

The Management Plan was developed in 2005 to identify issues associated with Saltwater Creek and its catchment, and proposes a strategy and action plan to address these issues.

The impetus of the plan came from the local community and the former Hastings Coast and Estuaries Committee who highlighted the deteriorating visual and environmental aspects of the creek and its surrounds.

Saltwater Creek had not received formal management or maintenance for some years prior to this management plan. One of the reasons for this has been multiple ownerships (i.e. private landowners, Crown Lands and PMHC).

Key Issues

Key issues explored and addressed by the plan are:

- Aesthetics
- Flooding
- Creek Water Quality
- Stormwater Quality
- Maintenance of Stormwater Infrastructure and derelict structures
- Sedimentation
- Debris Build up and rubbish dumping
- Erosion
- Vegetation Management

Management Actions

The management plan identified issues and prioritised them according to their environmental impacts and importance placed by community. A range of strategies and actions were then recommended to manage specific issues.

Management actions contained in the plan will be reviewed and if appropriate, included in the CMP.

16.2.5 OTHER PLANS AND REPORTS

There are many other documents that fall within all coastal management areas and are managed by different Council sections, other government agencies and some in partnership with community groups. Some of these documents are listed below:

- Hastings Regional Crown Reserve - Precinct A - Plan of Management, December 2014
- Westport Park - Plan of Management, January 2012
- Bonny Hills Reserves Master Plan 2012
- Lake Cathie Foreshore Master Plan 2018
- Bruce Porter Reserve Master Plan 2011
- (Draft) Flynns Beach Master Plan 2019
- Town Beach Master Plan 2013
- Coastal Walk Master Plan 2017
- Port Macquarie Foreshore Walkway Master Plan (Concept) 2019

Figure 57. *Town Beach, Port Macquarie*

17. WHERE ACTION IS REQUIRED

17.1 KEY ISSUES AND THREATS

Key issues/threats to Coastal Management Areas have been previously determined through the EMPs and CZMPs. These threats have been reviewed and most are considered to still be relevant *[see Table 7 below]*.

Issue Description	Hastings River	Camden Haven	Lake Cathie & Bonny Hills	Open Coastline	Coastal Wetlands & Littoral Rainforests (CWLRA)	Coastal Vulnerability Area (CVA)	Coastal Environmental Area (CEA)	Coastal Use Area (CU)
Open coast erosion places natural and built assets at risk	Y		Y	Y	Y	Y	Y	Y
Estuary / river bank erosion places natural and built assets at risk		Y	Y		Y		Y	Y
Coastal lake or watercourse entrance instability negatively impacting natural and built assets			Y		Y	Y	Y	Y
Coastal inundation places natural and built assets at risk	Y		Y	Y	Y	Y	Y	Y
Coastal cliff or slope instability places natural and built assets at risk	Y			Y	Y	Y	Y	Y
Estuary / river flooding and inundation places natural and built assets at risk		Y	Y		Y	Y	Y	Y
Impacts of climate change and sea level rise on the coastal zone and estuaries		Y	Y	Y	Y	Y	Y	Y
Estuary sedimentation and/or shoaling negatively impacts navigation and recreational use		Y	Y		Y		Y	Y
Need for dredging strategy, plan and protocols to minimise conflict between recreational and commercial waterway users and coastal protection	Y	Y				Y	Y	Y
Need for sustainable ICOLL entrance opening strategy that considers flood risk as well as estuary processes	Y		Y		Y	Y	Y	Y
Need for conservation and promotion of scenic character/views, visual impacts have occurred	Y	Y	Y	Y		Y	Y	Y
Lack of appreciation of the value of native vegetation / clearing of native vegetation	Y	Y	Y	Y	Y		Y	
Inadequate / need for maintenance of public access and recreational infrastructure	Y	Y	Y	Y	Y	Y	Y	Y
Impacts of public access and recreational usage on the environment	Y	Y	Y	Y	Y	Y	Y	Y
Conflicts between recreational users of the foreshore and waterway areas / overcrowding	Y	Y	Y	Y		Y	Y	Y
Need for conservation and promotion of Indigenous and non-Indigenous cultural heritage	Y	Y	Y	Y	Y	Y	Y	Y
Declines in water quality	Y	Y	Y	Y	Y	Y	Y	Y
Acid sulfate soils have a range of impacts on built and natural assets		Y	Y		Y	Y	Y	Y
Need for sustainable management of commercial fisheries and oyster aquaculture that considers other waterway users		Y			Y	Y	Y	Y
Need for strategic land use planning and development controls to minimise impacts on the coastal zone	Y	Y	Y	Y	Y	Y	Y	Y
Impacts on estuarine macrophytes (e.g. seagrass) and wetlands		Y	Y		Y		Y	Y
Impacts on riparian zone due to recreational boating, agricultural practices and other land use practices		Y	Y		Y	Y	Y	Y
Terrestrial weeds and pests	Y	Y	Y	Y	Y		Y	Y
Impact of stormwater runoff from urban, rural, agricultural and industrial areas	Y	Y	Y	Y	Y		Y	Y
Need for compliance and regulatory enforcement (e.g. of antisocial behaviour, illegal dumping, fishing regulations, sewage disposal from vessels)	Y	Y	Y	Y	Y	Y	Y	Y
Need for sustainable management / development of tourism	Y	Y	Y	Y			Y	Y
Lack of community awareness of environmental issues and conservation values	Y	Y	Y	Y			Y	Y
Uncertainty around land tenure and management responsibilities, need for coordinated strategic management	Y	Y	Y	Y	Y		Y	Y
Equity in distribution of costs and benefits from coastal management activities to ensure sustainable management of the coastal zone	Y	Y	Y	Y	Y	Y	Y	Y

Table 7. *Key issue/threats to Coastal Management Areas*

17.2 FIRST-PASS RISK ASSESSMENT

A first-pass risk assessment was undertaken based on the issues identified in *[Section 16]*. This risk assessment was done in order to prioritise issues to determine when and where action needs to be taken.

The risk assessment methodology was sourced from the Manual Part B: Stage 1. *[Table 8]* shows the consequence scale and *[Table 9]* shows the likelihood scale and *[Table 10]* shows the risk assessment matrix. The success criteria in the consequence scale was chosen based on what was most applicable to each issue.

Each issue was assessed based on the likelihood of it occurring and the consequence of it occurring. This assessment was done for each catchment as issues vary in significance across the LGA *[see Tables 11.1 to 11.4]*.

Issues identified as high risk and above are considered to be priority risks and should be considered in Stage 2 of the CMP. Low or moderate risks will still be considered, however timeframes for completion may be longer than high priority issues.

SUCCESS CRITERIA						
Rating	**Public safety**	**Local Economy and Growth**	**Community and Lifestyle**	**Biodiversity**	**Natural Water Quality and Physical Processes**	**Score**
Catastrophic	Loss of life. Large number of injuries	Regional decline leading to widespread business failure, loss of employment and hardship.	Region seen as unattractive due to poor quality of life. Very high levels of conflict between users that receive attention across the region. Loss of several pieces of key recreational	Significant, widespread and ongoing decline in habitat and associated species, including loss of conservation significant species and/or communities. Little to no potential for recovery and restoration works unlikely to be successful. Irreversible change or significant deterioration in multiple water quality parameters over a large area. Little to no potential for recovery or restoration.	Significant and irreversible impact on natural processes as a result of human activities.	5
Major	Moderate to large number of injuries.	Regional stagnation such that businesses across multiple sectors of the economy are unable to thrive and employment does not keep pace with population growth.		Major decline in condition, and loss of some areas of habitat/species over large area. Long term impact. Limited potential for natural recovery. Restoration works likely required.	Major and/or widespread impact on natural processes as a result of human activities. Significant deterioration in several water and/ or sediment parameters over a large area. Limited potential for recovery and restoration. Some clean-up / remediation required.	4
Moderate	Small to moderate number of injuries	Several businesses within more than one sector of the economy experience declines in economic performance.	General, noticeable decline in services. Conflict between a small number of users, may occur regularly/ seasonally. Damage to, or decline in condition of, facilities. Widespread decline in services. Moderate to high levels of conflict between users. Loss of key recreational infrastructure, or damage to several pieces of infrastructure.	Major decline in condition of habitat/species in small area, or moderate decline over larger area. Medium term impact Moderate to good potential for natural recovery, some restoration works required.	Moderate impact on natural processes in a limited area as a result of human activities. Deterioration of a limited number of water quality parameters throughout study area, or for several parameters in specific location. Potential for recovery by restoration works or long-term natural processes.	3
Minor	Near misses, single or small number of injuries.	Some individuals within certain sectors of the economy experience declines in economic performance.	Some individuals within certain sectors of the economy experience declines in economic performance.	Minor impact on habitat/ species over a limited area. Short to medium term impact. Good potential for natural recovery, restoration works unlikely to be required.	Minor impact on natural processes in a limited area as a result of human activities. Deterioration of 1-2 water quality parameters in a particular location. Good potential for recovery by restoration works or short-term natural processes.	2
Insignificant	No injuries. Has appearance of harm but no actual harm.	Negligible to minor shortfall relative to current forecasts	Area supports generally good lifestyle for a wide sector of the community. Very few reports of conflict between users. Infrastructure only requires routine maintenance.	No or negligible impact over the short term to riparian and estuarine habitat or associated species. No restoration works required	No or negligible impact on natural physical or water quality processes as a result of human activities.	1

Table 8: *Consequence scale. Sourced from NSW Coastal Management Manual Part B: Stage 1 (OEH, 2018) and adapted from Climate Change Risk Management: A guide for business and government (AGO, 2006).*

SCORE	LIKELIHOOD	DESCRIPTOR
5	*Almost Certain*	*Very likely. The event is expected to occur in most years, could occur several times per year.*
4	*Likely*	*The event will probably occur in most circumstances. 20-50% chance of occurrence in any given year.*
3	*Possible*	*May occur at some time. 10-20% chance of occurrence in any given year.*
2	*Unlikely*	*Uncommon, the event could occur but is not expected. 2-10% chance of occurrence in any given year.*
1	*Rare*	*The event may occur in exceptional circumstances. Event unlikely to occur in an individual's lifetime. <2% chance of occurrence in any given year.*

Table 9. *Likelihood scale. Sourced from NSW Coastal Management Manual Part B: Stage 1 (OEH, 2018) and adapted from NSW Marine Estate TARA (MEMA, 2017).*

CONSEQENCE					
Likelihood	**Insignificant**	**Minor**	**Moderate**	**Major**	**Catastrophic**
Almost certain	Medium	High	High	Extreme	Extreme
Likely	Medium	Medium	High	High	Extreme
Possible	Low	Medium	High	High	High
Unlikely	Low	Low	Medium	Medium	High
Rare	Low	Low	Medium	Medium	High

Table 10. *Risk assessment matrix. Sourced from Sourced from NSW Coastal Management Manual Part B: Stage 1 (OEH, 2018) and adapted from Climate Change Risk Management: A guide for business and government (AGO, 2006).*

17.2.1 LAKE CATHIE AND BONNY HILLS

Issue Description	Existing Risk 2019			Future Risk - 20yrs (2050)			Future Risk - 50yrs (2070)			Future Risk - 100 yrs (2120)		
	Likelihood	Consequence	Risk	Likelihood	Consequence	Risk	Likelihood	Consequence	Risk	Likelihood	Consequence	Risk
Acid sulfate soils have a range of impacts on built and natural assets	L5 - Almost certain	C4 - Major	Extreme	L5 - Almost certain	C4 - Major	Extreme	L5 - Almost certain	C4 - Major	Extreme	L5 - Almost certain	C4 - Major	Extreme
Impacts on estuarine macrophytes (e.g. seagrass) and wetlands	L5 - Almost certain	C4 - Major	Extreme	L5 - Almost certain	C4 - Major	Extreme	L5 - Almost certain	C4 - Major	Extreme	L5 - Almost certain	C4 - Major	Extreme
Need for sustainable ICOLL entrance opening strategy that considers flood risk as well as estuary processes	L5 - Almost certain	C3 - Moderate	High	L5 - Almost certain	C4 - Major	Extreme	L5 - Almost certain	C4 - Major	Extreme	L5 - Almost certain	C4 - Major	Extreme
Declines in water quality	L4 - Likely	C3 - Moderate	High	L5 - Almost certain	C3 - Moderate	High	L5 - Almost certain	C3 - Moderate	High	L5 - Almost certain	C3 - Moderate	High
Estuary / river bank erosion places natural and built assets at risk	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L5 - Almost certain	C3 - Moderate	High	L5 - Almost certain	C4 - Major	Extreme
Estuary / river flooding and inundation places natural and built assets at risk	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C4 - Major	High	L5 - Almost certain	C4 - Major	Extreme
Estuary sedimentation and/or shoaling negatively impacts navigation and recreational use	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High
Inadequate / need for maintenance of public access and recreational infrastructure	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L5 - Almost certain	C3 - Moderate	High	L5 - Almost certain	C3 - Moderate	High
Impacts of public access and recreational usage on the environment	L4 - Likely	C3 - Moderate	High	L5 - Almost certain	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High
Need for strategic land use planning and development controls to minimise impacts on the coastal zone	L4 - Likely	C4 - Major	High	L4 - Likely	C4 - Major	High	L4 - Likely	C4 - Major	High	L4 - Likely	C4 - Major	High
Terrestrial weeds and pests	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High
Impact of stormwater runoff from urban, rural, agricultural and industrial areas	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High
Uncertainty around land tenure and management responsibilities, need for coordinated strategic management	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High
Equity in distribution of costs and benefits from coastal management activities to ensure sustainable management of the coastal zone	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High
Need for conservation and promotion of Indigenous and non-Indigenous cultural heritage	L3 - Possible	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High
Lack of understanding of and knowledge about natural environmental processes / aquatic ecological processes and productivity to ensure long term sustainability of the coastal zone	L3 - Possible	C2 - Minor	Medium	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High
Open coast erosion places natural and built assets at risk	L3 - Possible	C4 - Major	High	L3 - Possible	C4 - Major	High	L3 - Possible	C5 - Catastrophic	High	L4 - Likely	C5 - Catastrophic	Extreme
Impacts of climate change and sea level rise on the coastal zone and estuaries	L3 - Possible	C3 - Moderate	High	L3 - Possible	C3 - Moderate	High	L4 - Likely	C4 - Major	High	L5 - Almost certain	C4 - Major	Extreme
Coastal lake or watercourse entrance instability negatively impacting natural and built assets	L4 - Likely	C2 - Minor	Medium	L4 - Likely	C2 - Minor	Medium	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High
Coastal inundation places natural and built assets at risk	L1 - Rare	C3 - Moderate	Medium	L1 - Rare	C3 - Moderate	Medium	L2 - Unlikely	C3 - Moderate	Medium	L3 - Possible	C3 - Moderate	High
Coastal cliff or slope instability places natural and built assets at risk	Not applicable.											
Need for dredging strategy, plan and protocols to minimise conflict between recreational and commercial waterway users and coastal protection	L2 - Unlikely	C2 - Minor	Low	L2 - Unlikely	C2 - Minor	Low	L2 - Unlikely	C2 - Minor	Low	L2 - Unlikely	C2 - Minor	Low
Need for conservation and promotion of scenic character/views, visual impacts have occurred	L2 - Unlikely	C2 - Minor	Low	L2 - Unlikely	C3 - Moderate	Medium	L2 - Unlikely	C3 - Moderate	Medium	L2 - Unlikely	C3 - Moderate	Medium
Lack of appreciation of the value of native vegetation / clearing of native vegetation	L3 - Possible	C2 - Minor	Medium	L3 - Possible	C2 - Minor	Medium	L3 - Possible	C2 - Minor	Medium	L3 - Possible	C2 - Minor	Medium
Conflicts between recreational users of the foreshore and waterway areas / overcrowding	L3 - Possible	C2 - Minor	Medium	L3 - Possible	C2 - Minor	Medium	L3 - Possible	C2 - Minor	Medium	L3 - Possible	C2 - Minor	Medium
Need for sustainable management of commercial fisheries and aquaculture that considers other waterway users	Not applicable - no oyster aquaculture or commercial fishing.											
Impacts on riparian zone due to recreational boating, agricultural practices and other land use practices	L2 - Unlikely	C3 - Moderate	Medium	L2 - Unlikely	C3 - Moderate	Medium	L2 - Unlikely	C3 - Moderate	Medium	L2 - Unlikely	C3 - Moderate	Medium
Need for compliance and regulatory enforcement (e.g. of antisocial behaviour, illegal dumping, fishing regulations, sewage disposal from vessels)	L2 - Unlikely	C2 - Minor	Low	L2 - Unlikely	C2 - Minor	Low	L2 - Unlikely	C2 - Minor	Low	L2 - Unlikely	C2 - Minor	Low
Need for sustainable management / development of tourism	L3 - Possible	C3 - Moderate	High	L3 - Possible	C3 - Moderate	High	L3 - Possible	C3 - Moderate	High	L3 - Possible	C3 - Moderate	High
Lack of community awareness of environmental issues and conservation values	L3 - Possible	C1 - Insignificant	Low	L4 - Likely	C1 - Insignificant	Low	L3 - Possible	C1 - Insignificant	Low	L3 - Possible	C1 - Insignificant	Low

Table 11.1. *Lake Cathie & Bonny Hills Risk Assessment Outcomes (Ranked Highest to Lowest Risk)*

17.2.2 HASTINGS RIVER

Issue Description	Existing Risk 2019			Future Risk - 20yrs (2050)			Future Risk - 50yrs (2070)			Future Risk - 100 yrs (2120)		
	Likelihood	Consequence	Risk	Likelihood	Consequence	Risk	Likelihood	Consequence	Risk	Likelihood	Consequence	Risk
Estuary / river bank erosion places natural and built assets at risk	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L5 - Almost certain	C3 - Moderate	High	L5 - Almost certain	C4 - Major	Extreme
Impacts on estuarine macrophytes (e.g. seagrass) and wetlands	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L5 - Almost certain	C3 - Moderate	High	L5 - Almost certain	C4 - Major	Extreme
Impacts of public access and recreational usage on the environment	L4 - Likely	C3 - Moderate	High	L5 - Almost certain	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High
Acid sulfate soils have a range of impacts on built and natural assets	L4 - Likely	C4 - Major	High	L4 - Likely	C4 - Major	High	L4 - Likely	C4 - Major	High	L4 - Likely	C4 - Major	High
Need for strategic land use planning and development controls to minimise impacts on the coastal zone	L4 - Likely	C4 - Major	High	L4 - Likely	C4 - Major	High	L4 - Likely	C4 - Major	High	L4 - Likely	C4 - Major	High
Impacts on riparian zone due to recreational boating, agricultural practices and other land use practices	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High
Terrestrial weeds and pests	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High
Need for sustainable management / development of tourism	L5 - Almost certain	C3 - Moderate	High	L5 - Almost certain	C3 - Moderate	High	L5 - Almost certain	C3 - Moderate	High	L5 - Almost certain	C3 - Moderate	High
Need for conservation and promotion of scenic character/views, visual impacts have occurred	L3 - Possible	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High
Inadequate / need for maintenance of public access and recreational infrastructure	L3 - Possible	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High
Conflicts between recreational users of the foreshore and waterway areas / overcrowding	L3 - Possible	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High
Need for conservation and promotion of Indigenous and non-Indigenous cultural heritage	L3 - Possible	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High
Declines in water quality	L3 - Possible	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High
Impact of stormwater runoff from urban, rural, agricultural and industrial areas	L3 - Possible	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High
Lack of understanding of and knowledge about natural environmental processes / aquatic ecological processes and productivity to ensure long term sustainability of the coastal zone	L3 - Possible	C2 - Minor	Medium	L4 - Likely	C3 - Moderate	High	L5 - Almost certain	C3 - Moderate	High	L5 - Almost certain	C3 - Moderate	High
Equity in distribution of costs and benefits from coastal management activities to ensure sustainable management of the coastal zone	L3 - Possible	C2 - Minor	Medium	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L5 - Almost certain	C3 - Moderate	High
Estuary / river flooding and inundation places natural and built assets at risk	L3 - Possible	C3 - Moderate	High	L3 - Possible	C3 - Moderate	Medium	L4 - Likely	C4 - Major	High	L5 - Almost certain	C5 - Catastrophic	Extreme
Impacts of climate change and sea level rise on the coastal zone and estuaries	L2 - Unlikely	C3 - Moderate	Medium	L3 - Possible	C3 - Moderate	Medium	L4 - Likely	C4 - Major	High	L5 - Almost certain	C4 - Major	Extreme
Open coast erosion places natural and built assets at risk	Not applicable - estuary.											
Coastal lake or watercourse entrance instability negatively impacting natural and built assets	Not applicable - trained entrance.											
Coastal inundation places natural and built assets at risk	Not applicable - estuary.											
Coastal cliff or slope instability places natural and built assets at risk	Not applicable - no coastal cliffs.											
Estuary sedimentation and/or shoaling negatively impacts navigation and recreational use	L3 - Possible	C2 - Minor	Medium	L3 - Possible	C2 - Minor	Medium	L3 - Possible	C2 - Minor	Medium	L3 - Possible	C2 - Minor	Medium
Need for dredging strategy, plan and protocols to minimise conflict between recreational and commercial waterway users and coastal protection	L3 - Possible	C2 - Minor	Medium	L3 - Possible	C2 - Minor	Medium	L3 - Possible	C2 - Minor	Medium	L3 - Possible	C2 - Minor	Medium
Need for sustainable ICOLL entrance opening strategy that considers flood risk as well as estuary processes	Not applicable - not an ICOLL.											
Lack of appreciation of the value of native vegetation / clearing of native vegetation	L3 - Possible	C2 - Minor	Medium	L3 - Possible	C2 - Minor	Medium	L3 - Possible	C2 - Minor	Medium	L3 - Possible	C2 - Minor	Medium
Need for sustainable management of commercial fisheries and aquaculture that considers other waterway users	L3 - Possible	C3 - Moderate	High	L3 - Possible	C3 - Moderate	High	L3 - Possible	C3 - Moderate	High	L3 - Possible	C3 - Moderate	Extreme
Need for compliance and regulatory enforcement (e.g. of antisocial behaviour, illegal dumping, fishing regulations, sewage disposal from vessels)	L3 - Possible	C2 - Minor	Medium	L3 - Possible	C2 - Minor	Medium	L3 - Possible	C2 - Minor	Medium	L3 - Possible	C2 - Minor	Medium
Lack of community awareness of environmental issues and conservation values	L3 - Possible	C1 - Insignificant	Low	L4 - Likely	C1 - Insignificant	Low	L3 - Possible	C1 - Insignificant	Low	L3 - Possible	C1 - Insignificant	Low
Uncertainty around land tenure and management responsibilities, need for coordinated strategic management	L3 - Possible	C2 - Minor	Medium	L3 - Possible	C3 - Moderate	Medium	L3 - Possible	C3 - Moderate	Medium	L3 - Possible	C3 - Moderate	Medium

Table 11.2. *Hastings River Risk Assessment Outcomes (Ranked Highest to Lowest Risk)*

17.2.3 CAMDEN HAVEN

Issue Description	Existing Risk 2019			Future Risk - 20yrs (2050)			Future Risk - 50yrs (2070)			Future Risk - 100 yrs (2120)		
	Likelihood	Consequence	Risk	Likelihood	Consequence	Risk	Likelihood	Consequence	Risk	Likelihood	Consequence	Risk
Estuary / river bank erosion places natural and built assets at risk	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L5 - Almost certain	C3 - Moderate	High	L5 - Almost certain	C4 - Major	Extreme
Impacts on estuarine macrophytes (e.g. seagrass) and wetlands	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L5 - Almost certain	C3 - Moderate	High	L5 - Almost certain	C4 - Major	Extreme
Impacts of public access and recreational usage on the environment	L4 - Likely	C3 - Moderate	High	L5 - Almost certain	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High
Declines in water quality	L4 - Likely	C3 - Moderate	High	L5 - Almost certain	C3 - Moderate	High	L5 - Almost certain	C3 - Moderate	High	L5 - Almost certain	C3 - Moderate	High
Acid sulfate soils have a range of impacts on built and natural assets	L4 - Likely	C4 - Major	High	L4 - Likely	C4 - Major	High	L4 - Likely	C4 - Major	High	L4 - Likely	C4 - Major	High
Need for strategic land use planning and development controls to minimise impacts on the coastal zone	L3 - Possible	C4 - Major	High	L3 - Possible	C4 - Major	High	L3 - Possible	C4 - Major	High	L3 - Possible	C4 - Major	High
Impacts on riparian zone due to recreational boating, agricultural practices and other land use practices	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High
Terrestrial weeds and pests	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High
Need for conservation and promotion of scenic character/views, visual impacts have occurred	L2 - Unlikely	C3 - Moderate	Medium	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High
Inadequate / need for maintenance of public access and recreational infrastructure	L3 - Possible	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High
Conflicts between recreational users of the foreshore and waterway areas / overcrowding	L3 - Possible	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High
Need for conservation and promotion of Indigenous and non-Indigenous cultural heritage	L3 - Possible	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High
Impact of stormwater runoff from urban, rural, agricultural and industrial areas	L3 - Possible	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High
Lack of understanding of and knowledge about natural environmental processes / aquatic ecological processes and productivity to ensure long term sustainability of the coastal zone	L3 - Possible	C2 - Minor	Medium	L4 - Likely	C3 - Moderate	High	L5 - Almost certain	C3 - Moderate	High	L5 - Almost certain	C3 - Moderate	High
Equity in distribution of costs and benefits from coastal management activities to ensure sustainable management of the coastal zone	L3 - Possible	C2 - Minor	Medium	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L5 - Almost certain	C3 - Moderate	High
Estuary / river flooding and inundation places natural and built assets at risk	L3 - Possible	C3 - Moderate	High	L3 - Possible	C3 - Moderate	High	L4 - Likely	C4 - Major	High	L5 - Almost certain	C5 - Catastrophic	Extreme
Impacts of climate change and sea level rise on the coastal zone and estuaries	L2 - Unlikely	C3 - Moderate	Medium	L3 - Possible	C3 - Moderate	Medium	L4 - Likely	C4 - Major	High	L5 - Almost certain	C4 - Major	Extreme
Open coast erosion places natural and built assets at risk	Not applicable - estuary.											
Coastal lake or watercourse entrance instability negatively impacting natural and built assets - Jesse has this as an issue. Does it relate to one of the component waterways of Camden Haven, noting entrance is trained?	Not applicable - trained entrance.											
Coastal inundation places natural and built assets at risk	Not applicable - estuary.											
Coastal cliff or slope instability places natural and built assets at risk	Not applicable.											
Estuary sedimentation and/or shoaling negatively impacts navigation and recreational use	L3 - Possible	C2 - Minor	Medium	L3 - Possible	C2 - Minor	Medium	L3 - Possible	C2 - Minor	Medium	L3 - Possible	C2 - Minor	Medium
Need for dredging strategy, plan and protocols to minimise conflict between recreational and commercial waterway users and coastal protection	L3 - Possible	C2 - Minor	Medium	L3 - Possible	C2 - Minor	Medium	L3 - Possible	C2 - Minor	Medium	L3 - Possible	C2 - Minor	Medium
Need for sustainable ICOLL entrance opening strategy that considers flood risk as well as estuary processes	Not applicable - trained entrance.											
Lack of appreciation of the value of native vegetation / clearing of native vegetation	L3 - Possible	C2 - Minor	Medium	L3 - Possible	C2 - Minor	Medium	L3 - Possible	C2 - Minor	Medium	L3 - Possible	C2 - Minor	Medium
Need for sustainable management of commercial fisheries and aquaculture that considers other waterway users	L3 - Possible	C3 - Moderate	High	L3 - Possible	C3 - Moderate	High	L3 - Possible	C3 - Moderate	High	L3 - Possible	C3 - Moderate	High
Need for compliance and regulatory enforcement (e.g. of antisocial behaviour, illegal dumping, fishing regulations, sewage disposal from vessels)	L3 - Possible	C2 - Minor	Medium	L3 - Possible	C2 - Minor	Medium	L3 - Possible	C2 - Minor	Medium	L3 - Possible	C2 - Minor	Medium
Need for sustainable management / development of tourism	L3 - Possible	C3 - Moderate	High	L3 - Possible	C3 - Moderate	High	L3 - Possible	C3 - Moderate	High	L3 - Possible	C3 - Moderate	High
Lack of community awareness of environmental issues and conservation values	L3 - Possible	C1 - Insignificant	Low	L4 - Likely	C1 - Insignificant	Low	L3 - Possible	C1 - Insignificant	Low	L3 - Possible	C1 - Insignificant	Low
Uncertainty around land tenure and management responsibilities, need for coordinated strategic management	L3 - Possible	C2 - Minor	Medium	L3 - Possible	C3 - Moderate	High	L3 - Possible	C3 - Moderate	High	L3 - Possible	C3 - Moderate	High

Table 11.3. *Camden Haven Risk Assessment Outcomes (Ranked Highest to Lowest Risk)*

17.2.4 OPEN COAST

Issue Description	Existing Risk 2019			Future Risk - 20yrs (2050)			Future Risk - 50yrs (2070)			Future Risk - 100 yrs (2120)		
	Likelihood	Consequence	Risk	Likelihood	Consequence	Risk	Likelihood	Consequence	Risk	Likelihood	Consequence	Risk
Inadequate / need for maintenance of public access and recreational infrastructure	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L5 - Almost certain	C3 - Moderate	High	L5 - Almost certain	C3 - Moderate	High
Conflicts between recreational users of the foreshore and waterway areas / overcrowding	L4 - Likely	C3 - Moderate	High	L5 - Almost certain	C3 - Moderate	High	L5 - Almost certain	C3 - Moderate	High	L5 - Almost certain	C3 - Moderate	High
Need for strategic land use planning and development controls to minimise impacts on the coastal zone	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High
Need for sustainable management / development of tourism	L5 - Almost certain	C3 - Moderate	High	L5 - Almost certain	C3 - Moderate	High	L5 - Almost certain	C3 - Moderate	High	L5 - Almost certain	C3 - Moderate	High
Equity in distribution of costs and benefits from coastal management activities to ensure sustainable management of the coastal zone	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High
Need for conservation and promotion of scenic character/views, visual impacts have occurred	L3 - Possible	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High	L4 - Likely	C3 - Moderate	High
Open coast erosion places natural and built assets at risk - revetment extension - effect during storms?	L2 - Unlikely	C3 - Moderate	Medium	L2 - Unlikely	C3 - Moderate	Medium	L3 - Possible	C4 - Major	High	L4 - Likely	C4 - Major	High
Impacts of climate change and sea level rise on the coastal zone and estuaries	L2 - Unlikely	C3 - Moderate	Medium	L3 - Possible	C3 - Moderate	Medium	L4 - Likely	C3 - Moderate	High	L4 - Likely	C4 - Major	High
Estuary / river bank erosion places natural and built assets at risk	Not applicable - not an estuary.											
Coastal lake or watercourse entrance instability negatively impacting natural and built assets	Not applicable - not an estuary.											
Coastal inundation places natural and built assets at risk - revetment extension - effect during storms?	L1 - Rare	C3 - Moderate	Low	L1 - Rare	C3 - Moderate	Low	L2 - Unlikely	C3 - Moderate	Medium	L3 - Possible	C3 - Moderate	Medium
Coastal cliff or slope instability places natural and built assets at risk - how unstable are they?	L1 - Rare	C4 - Major	Low	L1 - Rare	C4 - Major	Low	L1 - Rare	C4 - Major	Low	L1 - Rare	C4 - Major	Low
Estuary / river flooding and inundation places natural and built assets at risk	Not applicable - not an estuary.											
Estuary sedimentation and/or shoaling negatively impacts navigation and recreational use	Not applicable - not an estuary / not focus of boating.											
Need for dredging strategy, plan and protocols to minimise conflict between recreational and commercial waterway users and coastal protection	Not applicable - not focus of boating.											
Need for sustainable ICOLL entrance opening strategy that considers flood risk as well as estuary processes	Not applicable - not an ICOLL.											
Lack of appreciation of the value of native vegetation / clearing of native vegetation	L3 - Possible	C2 - Minor	Medium	L3 - Possible	C2 - Minor	Medium	L3 - Possible	C2 - Minor	Medium	L3 - Possible	C2 - Minor	Medium
Impacts of public access and recreational usage on the environment	L4 - Likely	C2 - Minor	Medium	L5 - Almost certain	C2 - Minor	Medium	L5 - Almost certain	C2 - Minor	Medium	L5 - Almost certain	C2 - Minor	Medium
Need for conservation and promotion of Indigenous and non-Indigenous cultural heritage	L2 - Unlikely	C3 - Moderate	Medium	L2 - Unlikely	C3 - Moderate	Medium	L2 - Unlikely	C3 - Moderate	Medium	L2 - Unlikely	C3 - Moderate	Medium
Declines in water quality	L3 - Possible	C3 - Moderate	High	L3 - Possible	C3 - Moderate	High	L3 - Possible	C3 - Moderate	High	L3 - Possible	C3 - Moderate	High
Acid sulfate soils have a range of impacts on built and natural assets	Not applicable - not an estuary.											
Need for sustainable management of commercial fisheries and aquaculture that considers other waterway users	Not applicable - not an estuary / not focus of boating.											
Impacts on estuarine macrophytes (e.g. seagrass) and wetlands	Not applicable - not focus of boating.											
Impacts on riparian zone due to recreational boating, agricultural practices and other land use practices	Not applicable - not an ICOLL.											
Terrestrial weeds and pests	L4 - Likely	C2 - Minor	Medium	L4 - Likely	C2 - Minor	Medium	L4 - Likely	C2 - Minor	Medium	L4 - Likely	C2 - Minor	Medium
Impact of stormwater runoff from urban, rural, agricultural and industrial areas	L4 - Likely	C2 - Minor	Medium	L4 - Likely	C2 - Minor	Medium	L4 - Likely	C2 - Minor	Medium	L4 - Likely	C2 - Minor	Medium
Need for compliance and regulatory enforcement (e.g. of antisocial behaviour, illegal dumping, fishing regulations, sewage disposal from vessels)	L4 - Likely	C2 - Minor	Medium	L4 - Likely	C2 - Minor	Medium	L4 - Likely	C2 - Minor	Medium	L4 - Likely	C2 - Minor	Medium
Lack of community awareness of environmental issues and conservation values	L3 - Possible	C1 - Insignificant	Low	L3 - Possible	C1 - Insignificant	Low	L3 - Possible	C1 - Insignificant	Low	L3 - Possible	C1 - Insignificant	Low
Uncertainty around land tenure and management responsibilities, need for coordinated strategic management	L3 - Possible	C3 - Moderate	High	L3 - Possible	C3 - Moderate	High	L3 - Possible	C3 - Moderate	High	L3 - Possible	C3 - Moderate	High
Lack of understanding of and knowledge about natural environmental processes / aquatic ecological processes and productivity to ensure long term sustainability of the coastal zone	L3 - Possible	C2 - Minor	Medium	L3 - Possible	C2 - Minor	Medium	L3 - Possible	C2 - Minor	Medium	L3 - Possible	C2 - Minor	Medium

Table 11.4. *Open Coast Risk Assessment Outcomes (Ranked Highest to Lowest Risk)*

17.3 FORWARD WORKS PROGRAM

OVERVIEW

As outlined in the Coastal Management Manual, preparation of the CMP is to be completed following a staged process *[illustrated in Figure 1]*. Guidance for this process along with key requirements are outlined in Part A and Part B of the Manual. The subsequent stages in this process after this Stage 1 Scoping Study are:

- Stage 2: Determine risks, vulnerabilities and opportunities (through further detailed studies).
- Stage 3: Identify and evaluate options (through risk assessment and cost, benefit analysis).
- Stage 4: Prepare, exhibit, finalise, certify and adopt a CMP (leading to implementation).
- Stage 5: Implement, monitor, evaluate and report (to feedback to the cycle).

This section provides:

- CMP Implementation obligations for Councils and public authorities.
- A summary of the requirements, process and expected outcomes for Stages 2 to 4 outlined from the Manual (Part B).

A section with considerations, analysis of options and recommendations related to governance of the CMP project going forward.

STAGE 2: DETERMINE RISKS, VULNERABILITIES AND OPPORTUNITIES

Stage 2 of the CMP process involves undertaking detailed studies that will help PMHC to identify, analyse and evaluate risks, vulnerabilities and opportunities in the study area. The studies conducted during Stage 2 are to provide information to support decision-making in the later stages of the CMP planning process.

A summary of the Coastal Management Manual identifies Stage 2 as including the following:

- Engaging with the community and stakeholders.
- Refining the understanding of key management issues.
- Identifying areas exposed to coastal hazards and threats to coastal values.
- Analysing and evaluating current and future risks (detailed risk assessment). This will include the identification of areas not covered by existing plans of management such as Duchess Creek and Partridge Creek.
- Identifying scenarios for social and economic change and related opportunities for coastal communities.
- Preparing a planning proposal to amend maps of coastal management areas, to commence the Gateway process.
- Identifying timing and priorities for responses, thresholds and lead times.

STAGE 3: IDENTIFY AND EVALUATE OPTIONS

Stage 3 of the CMP process requires PMHC to identify and evaluate possible management options in order to select preferred coastal management actions to address the issues identified as affecting the CMP study area. The aim of Stage 3 is to develop strategies and management actions that reduce exposure to coastal hazards, address coastal management issues and take advantage of opportunities, consistent with provisions in Section 14 and 15 of the Coastal Management Act 2016.

A summary of the Coastal Management Manual identifies Stage 3 as including the following:

- Identifying and collating information on management options.
- Evaluating management actions, considering:
- Feasibility (is it an effective and sustainable way to treat the risks?).
- Viability (economic assessment).
- Acceptability to stakeholders.
- Engaging public authorities about implications for their assets and responsibilities.
- Evaluating mapping options and implications if a planning proposal is being prepared.
- Identifying pathways and timing of actions.
- Preparing a business plan for implementation.

STAGE 4: PREPARE, EXHIBIT, FINALISE, CERTIFY AND ADOPT A CMP.

Stage 4 of the CMP process involves a draft coastal management program being prepared, exhibited and then submitted to the Minister for certification.

It is a mandatory requirement of the Coastal Management Manual that a draft CMP be exhibited for a period of at least 28 calendar days. It is also a requirement under Section 16 of the CM Act that consultation is carried out during the preparation of the draft CMP.

Once the Minister certifies the CMP, PMHC must publish it in the Gazette. The CMP takes effect on the date on which it is published in the Gazette (or on a later date if specified in the CMP)

STAGE 5: IMPLEMENT, MONITOR, EVALUATE AND REPORT.

Stage 5 gives guidance to councils on how to implement and give effect to their CMP and the associated ongoing monitoring and reporting of the implementation of a CMP to meet the requirements of the Coastal Management Act 2016.

The Coastal Management Manual provides council with guidance on the following:

- Implementing actions in the published Coastal Management Program through the Integrated Planning and Reporting (IP&R) framework and Land Use Planning System.
- Implementing actions in partnership with adjoining councils and public authorities where relevant.
- Implementing an effective Monitoring, Evaluation and Reporting (MER) program.
- Monitoring indicators, trigger points and thresholds.
- Amending, reviewing and updating the CMP.
- Reporting to stakeholders and the community on progress and outcomes through the IP&R framework.

CMP Stage	Lake Cathie & Bonny Hills	Hastings River	Camden Haven	Open Coastline
Stage 2	*2021-2022*	*2022-2023*	*2023-2024*	*2023-2024*
Stages 3-4	*2023*	*2023-2024*	*2025*	*2025*
Stage 5	*2024+*	*2025+*	*2026+*	*2026+*

Table 12. *Forward plan stages and indicative timeframes*

17.3.1 LAKE CATHIE AND BONNY HILLS

An indicative forward plan for Lake Cathie and Bonny Hills is provided in *[Table 13.1]*. It provides a list of activities to be undertaken, and details responsibility for implementation, preliminary cost estimates, and indicative timeframes. It is estimated that Stage 2 would cost around $750,000 and take around 34 months to implement. Assuming the two stages are undertaken concurrently, it is estimated Stages 3-4 would cost around $100,000 and take around 16 months to complete.

Item	Activities	Estimated costs (excl. GST)	Approximate Duration
STAGE 2			
Community and stakeholder engagement	· Refer to Communication, Education and Engagement Plan in *[section 17.4]*	*$30,000-40,000 Consultancy fee Plus internal Council resources (e.g. Council to support all activities, but to also implement public exhibition)*	*Included in tasks below*
Further Study 1 - Digestion model of ASS study.	· *Quantify the ASS risk of the lake system using ASS digestion and hydrodynamic modelling.* · *Review the 2013 Lake Innes reversion study in light of the findings.* · *Provide management options to address the ASS risk and review the preferred option under 2030 and 2070 climate change projections.*	*$185,000 Consultancy fee*	*3-6 months*
Further Study 2 – Review of potential ASS containment options.	· *Based on the findings of Further Study 1, consider possible ASS containment options.* · *Recommend strategies.* · *Set up a comprehensive hydrodynamic model for the lake system*	*$50,000 Consultancy fee*	*2-3 months*
Further Study 3 – Ecological condition assessment of saltmarsh and seagrass communities.	· *Field survey of saltmarsh and seagrass by suitably qualified ecologist.* · *GIS mapping and data analysis.* · *Modelling of potential distribution for different water levels.* · *Report findings and recommendations.*	*$15,000 Consultancy fee*	*2 months*
Further Study 4 – Review of Lake Innes Environmental Assessment (2013) (Lake Innes Reversion Study).	· *Review legislative and management context.* · *Literature review of previous studies, including hydrodynamic and water quality investigations* · *Review relevant findings of Further Studies 1 and 3.* · *Consider engineering feasibility.* · *Evaluate potential costs and benefits.*	*$50,000 Consultancy fee*	*2-3 months*
Further Study 5 - Investigation into existing creek entrance behaviours for Lake Cathie and Bonny Hills	· *Survey audit and mapping of of existing private and public foreshore infrastructure* · *Establish infrastructure risk from natural berm outbreak heights and managed trigger water levels* · *Investigate infrastructure resilience options* · *Consider implications of ASS management* · *Recommend revised entrance strategies for consideration in CMP preparation*	*$20,000-$30,000*	*2 months*
Further Study 6 – LGA-wide Coastal Recreational User Needs Analysis	· *Assessment of recreational user groups and activities undertaken in the coastal zone of the LGA.* · *Review of assets that support both foreshore-based and water-based recreational activities.* · *The purpose of the study would be to identify key recreational activities undertaken in the coastal zone, patterns in usage and the suitability of existing infrastructure to support recreation.*	*$75,000-100,000 Consultancy fee*	*4 months*
Further Study 7 – LGA Wide Water Quality Study Model	· *Collate existing water quality data & pollutant sources* · *Develop sampling campaign to assess water quality in river/creek systems to assess pollutant links and recovery following a major storm event* · *Catchment modelling to develop pollutant export models (e.g. with Source).* · *Study to be undertaken with reference to data collected as part of the Estuary Processes Study (1999).*	*$150,000-250,000 Consultancy fee*	*6-12 months (depending on rainfall)*
Develop first draft CMP – Stage 2 for consultation with key stakeholders.	· *Synthesise outcomes of Stage 1 and further studies to better define risks, issues and opportunities.* · *Analyse and evaluate current and future risks (updated risk assessment).* · *Prepare planning proposal - if required* · *Prepare draft CMP – Stage 2.*	*$15,000 Consultancy fee*	*2 months*
Develop draft CMP – Stage 2 for public exhibition.	· *Prepare and final exhibit draft CMP*	*$10,000 Consultancy fee Plus internal Council resources for public exhibition*	*2 months*
Finalise CMP – Stage 2.	· *Prepare submissions report as discussed (and costed) above.* · *Finalise CMP.*	*$6,000 Consultancy fee Plus internal Council resources*	*2 months*
STAGES 3 AND 4			
Community and stakeholder engagement	· Refer to Communication, Education and Engagement Plan in *[section 17.4]*	*$45,000-55,000 Consultancy fee Plus internal Council resources (e.g. Council to support all activities, but to also implement public exhibition)*	*Included in tasks below*
Develop and assess management options	· *Review outcomes of Stages 1-2.* · *Undertake community and stakeholder engagement to confirm the management objectives for the CMP and identify management options as discussed (and costed) above.* · *Identify suite of management options to address identified risks.* · *Establish a semi-quantitative options assessment framework in consultation with key stakeholders and undertake an analysis of the relative costs and benefits of the options.* · *Investigate funding options and consider cost/resource sharing opportunities*	*$10,000 Consultancy fee Plus internal Council resources to support options development and assessment*	*8 months*
Develop first draft CMP for consultation with key stakeholders	· *Review outcomes of Stages 1-2.* · *Undertake community and stakeholder engagement to confirm the management objectives for the CMP and identify management options as discussed (and costed) above.* · *Identify suite of management options to address identified risks.* · *Establish a semi-quantitative options assessment framework in consultation with key stakeholders and undertake an analysis of the relative costs and benefits of the options.* · *Investigate funding options and consider cost/resource sharing opportunities.*	*$10,000 Consultancy fee Plus internal Council resources (e.g. to seek commitment from implementation partners)*	*2 months*
Develop draft CMP for public exhibition	· *Prepare business plan for preferred options to be adopted as actions in the Plan - clarify roles, responsibilities and financial commitments.* · *Seek commitment to the Plan from implementation partners.* · *Prepare a monitoring and evaluation plan that will enable tracking of implementation of the CMP and achievement of the management objectives.* · *Prepare draft CMP for initial consultation with key stakeholders.*	*$15,000 Consultancy fee Plus internal Council resources for public exhibition*	*2 months*
Finalise CMP	· *Prepare and final exhibit draft CMP* · *Prepare submissions report as discussed (and costed) above.* · *Finalise CMP.* · *Obtain certification of the CMP.*	*$12,500 Consultancy fee Plus internal Council resources for submissions collation and certification*	*3-4 months*
STAGE 5			
Implement CMP, monitor, valuate and report	· *Council to implement CMP for 5 to 10-year period through IP&R.* · *Other organisations to implement CMP through work programs.* · *Undertake monitoring and evaluation activities to measure success of implementation of the CMP.*	*Unknown*	*N/A – until update of the CMP is required, likely 5-10 years.*

Table 13.1. *Forward Plan for Lake Cathie and Bonny Hills*

17.3.2 HASTINGS RIVER

An indicative forward plan for the Hastings River is provided in *[Table 13.2]*. It provides a list of activities to be undertaken, and details responsibility for implementation, preliminary cost estimates, and indicative timeframes. It is estimated that Stage 2 would cost around $265,000 and take around 10 months to implement. Assuming the two stages are undertaken concurrently, it is estimated Stages 3-4 would cost around $105,000 and take around 16 months to complete.

Item	Activities	Estimated costs (excl. GST)	Approximate Duration
STAGE 2			
Community and stakeholder engagement	· Refer to Communication, Education and Engagement Plan in *[section 17.4]*	*$30,000-40,000 Consultancy fee Plus internal Council resources (e.g. Council to support all activities, but to also implement public exhibition)*	*Included in tasks below*
Further Study 1 – Bank condition assessment.	· *Field survey by suitably qualified individual (to include the main tributaries, budget permitting).* · *GIS mapping and data analysis.* · *Report findings and recommendations.*	*$100,000-200,000 Consultancy fee*	*3-4 months*
Further Study 2 – Assessment of estuarine flood/inundation hazard	· *Being undertaken by Council under NSW Government Floodplain Management Program.*	-	-
Develop first draft CMP – Stage 2 for consultation with key stakeholders.	· *Synthesise outcomes of Stage 1 and further studies to better define risks, issues and opportunities.* · *Analyse and evaluate current and future risks (updated risk assessment).* · *Prepare planning proposal if required* · *Prepare draft CMP – Stage 2*	*$10,000 Consultancy fee*	*2 months*
Develop draft CMP – Stage 2 for public exhibition.	· *Prepare and final exhibit draft CMP*	*$10,000 Consultancy fee Plus internal Council resources for public exhibition*	*2 months*
Finalise CMP – Stage 2.	· *Prepare submissions report as discussed (and costed) above.* · *Finalise CMP.*	*$5,000 Consultancy fee Plus internal Council resources*	*2 months*
STAGES 3 AND 4			
	· Refer to Communication, Education and Engagement Plan in *[section 17.4]*	*$45,000-60,000 Consultancy fee Plus internal Council resources (e.g. Council to support all activities, but to also implement public exhibition)*	*Included in tasks below*
	· *Review outcomes of Stages 1-2.* · *Undertake community and stakeholder engagement to confirm the management objectives for the CMP and identify management options as discussed (and costed) above.* · *Identify suite of management options to address identified risks.* · *Establish a semi-quantitative options assessment framework in consultation with key stakeholders and undertake an analysis of the relative costs and benefits of the options.* · *Investigate funding options and consider cost/resource sharing opportunities.*	*$10,000 Consultancy fee Plus internal Council resources to support options development and assessment*	*8 months*
	· *Prepare business plan for preferred options to be adopted as actions in the Plan - clarify roles, responsibilities and financial commitments.* · *Seek commitment to the Plan from implementation partners.* · *Prepare a monitoring and evaluation plan that will enable tracking of implementation of the CMP and achievement of the management objectives.* · *Prepare draft CMP for initial consultation with key stakeholders.*	*$10,000 Consultancy fee Plus internal Council resources (e.g. to seek commitment from implementation partners)*	*2 months*
	· *Prepare and final exhibit draft CMP*	*$15,000 Consultancy fee Plus internal Council resources for public exhibition*	*2 months*
	· *Prepare submissions report as discussed (and costed) above.* · *Finalise CMP.* · *Obtain certification of the CMP.*	*$12,500 Consultancy fee Plus internal Council resources for submissions collation and certification.*	*3-4 months*
STAGE 5			
Implement CMP, monitor, evaluate and report	· *Council to implement CMP for 5 to 10-year period through IP&R.* · *Other organisations to implement CMP through work programs.* · *Undertake monitoring and evaluation activities to measure success of implementation of the CMP.*	*Unknown*	*N/A – until update of the CMP is required, likely 5-10 years.*

Table 13.2. *Forward Plan for the Hastings River*

17.3.3 CAMDEN HAVEN

An indicative forward plan for the Camden Haven is provided in *[Table 13.3]*. It provides a list of activities to be undertaken, and details responsibility for implementation, preliminary cost estimates, and indicative timeframes. It is estimated that Stage 2 would cost around $70,000 and take around 6 months to implement. Assuming the two stages are undertaken concurrently, it is estimated Stages 3-4 would cost around $105,000 and take around 16 months to complete.

Item	Activities	Estimated costs (excl. GST)	Approximate Duration
STAGE 2			
Community and stakeholder engagement	· Refer to Communication, Education and Engagement Plan in *[section 17.4]*	*$30,000-40,000 Consultancy fee Plus internal Council resources (e.g. Council to support all activities, but to also implement public exhibition)*	*Included in tasks below*
Further Study 1 – Assessment of estuarine flood/inundation hazard	· *Being undertaken by Council under NSW Government Floodplain Management Program.*	-	-
Develop first draft CMP – Stage 2 for consultation with key stakeholders.	· *Synthesise outcomes of Stage 1 and further studies to better define risks, issues and opportunities.* · *Analyse and evaluate current and future risks (updated risk assessment).* · *Prepare planning proposal - if required* · *Prepare draft CMP – Stage 2.*	*$10,000 Consultancy fee*	*2 months*
Develop draft CMP – Stage 2 for public exhibition.	· *Prepare and final exhibit draft CMP*	*$10,000 Consultancy fee Plus internal Council resources for public exhibition*	*2 months*
Finalise CMP – Stage 2.	· *Prepare submissions report as discussed (and costed) above.* · *Finalise CMP.*	*$5,000 Consultancy fee Plus internal Council resources*	*2 months*
STAGES 3 AND 4			
Community and stakeholder engagement	· Refer to Communication, Education and Engagement Plan in *[section 17.4]*	*$45,000-60,000 Consultancy fee Plus internal Council resources (e.g. Council to support all activities, but to also implement public exhibition)*	*Included in tasks below*
Develop and assess management options	· *Review outcomes of Stages 1-2.* · *Undertake community and stakeholder engagement to confirm the management objectives for the CMP and identify management options as discussed (and costed) above.* · *Identify suite of management options to address identified risks.* · *Establish a semi-quantitative options assessment framework in consultation with key stakeholders and undertake an analysis of the relative costs and benefits of the options.* · *Investigate funding options and consider cost/resource sharing opportunities.*	*$10,000 Consultancy fee Plus internal Council resources to support options development and assessment*	*8 months*
Develop first draft CMP for consultation with key stakeholders	· *Prepare business plan for preferred options to be adopted as actions in the Plan - clarify roles, responsibilities and financial commitments.* · *Seek comm* · *itment to the Plan from implementation partners.* · *Prepare a monitoring and evaluation plan that will enable tracking of implementation of the CMP and achievement of the management objectives.* · *Prepare draft CMP for initial consultation with key stakeholders.*	*$10,000 Consultancy fee Plus internal Council resources (e.g. to seek commitment from implementation partners)*	*2 months*
Develop draft CMP for public exhibition	· *Prepare and final exhibit draft CMP*	*$15,000 Consultancy fee Plus internal Council resources for public exhibition*	*2 months*
Finalise CMP	· *Prepare submissions report as discussed (and costed) above.* · *Finalise CMP.* · *Obtain certification of the CMP.*	*$12,500 Consultancy fee Plus internal Council resources for submissions collation and certification.*	*3-4 months*
STAGE 5			
Implement CMP, monitor, evaluate and report	· *Council to implement CMP for 5 to 10-year period through IP&R.* · *Other organisations to implement CMP through work programs.*	*Unknown*	*N/A – until update of the CMP is required, likely 5-10 years.*

Table 13.3. *Forward Plan for the Camden Haven*

17.3.4 OPEN COASTLINE

An indicative forward plan for Open Coastline is provided in *[Table 13.4]*. It provides a list of activities to be undertaken, and details responsibility for implementation, preliminary cost estimates, and indicative timeframes. It is estimated that Stage 2 would cost around $390,000 and take around 26 months to implement. Assuming the two stages are undertaken concurrently, it is estimated Stages 3-4 would cost around $105,000 and take around 16 months to complete.

Item	Activities	Estimated costs (excl. GST)	Approximate Duration
STAGE 2			
Community and stakeholder engagement	• Refer to Communication, Education and Engagement Plan in *[section 17.4]*	*$30,000-40,000 Consultancy fee Plus internal Council resources (e.g. Council to support all activities, but to also implement public exhibition)*	*Included in tasks below*
Further Study 1 – Coastal Vulnerability Area (CVA) Mapping	• *Assessment of existing NSW Government Regional Coastal Erosion Hazard Dataset* • *Conduct Coastal hazard assessment for current, 50 and 100 year planning horizons* • *Use Coastal Hazard Mapping to identify key exposure sites* • *Update PMHC LEP as required*	*$150,000-250,000 Consultancy fee*	*12 months (depending on rainfall)*
Further Study 2 – Geotechnical Risk Assessment	• *Field survey by suitably qualified geotechnical engineer.* • *Identification of potential failure mechanisms and likely future behaviour of cliff lines.* • *Analysis of risk to life and property.* • *Report findings and recommendations.*	*$30,000 Consultancy fee*	*3-4 months*
Further Study 3 – Coastal Hazard Assessment	• *Undertake updated coastal hazard assessment that takes into account changes since the previous assessment(s) (e.g. construction of revetments at Town Beach and Flynns Beach) and in accordance with the current requirements.* • *To include all beach compartments with identified assets (including the northern extent of Lighthouse Beach where there is development).* *Coastal hazards to be considered include erosion (storm bite), shoreline recession, and wave runup and overtopping.* • *Prepare coastal hazard mapping.*	*$45,000 Consultancy fee*	*3-4 months*
Develop first draft CMP – Stage 2 for consultation with key stakeholders.	• *Synthesise outcomes of Stage 1 and further studies to better define risks, issues and opportunities.* • *Analyse and evaluate current and future risks (updated risk assessment).* • *Prepare planning proposal - if required* • *Prepare draft CMP – Stage 2.*	*$10,000 Consultancy fee*	*2 months*
Develop draft CMP – Stage 2 for public exhibition.	• *Prepare and final exhibit draft CMP*	*$10,000 Consultancy fee Plus internal Council resources for public exhibition*	*2 months*
Finalise CMP – Stage 2.	• *Prepare submissions report as discussed (and costed) above.* • *Finalise CMP.*	*$5,000 Consultancy fee Plus internal Council resources*	*2 months*
STAGES 3 AND 4			
Community and stakeholder engagement	• Refer to Communication, Education and Engagement Plan in *[section 17.4]*	*$45,000-60,000 Consultancy fee Plus internal Council resources (e.g. Council to support all activities, but to also implement public exhibition)*	*Included in tasks below*
Develop and assess management options	• *Review outcomes of Stages 1-2.* • *Undertake community and stakeholder engagement to confirm the management objectives for the CMP and identify management options as discussed (and costed) above.* • *Identify suite of management options to address identified risks.* • *Establish a semi-quantitative options assessment framework in consultation with key stakeholders and undertake an analysis of the relative costs and benefits of the options.* • *Investigate funding options and consider cost/resource sharing opportunities.*	*$10,000 Consultancy fee Plus internal Council resources to support options development and assessment*	*8 months*
Develop first draft CMP for consultation with key stakeholders	• *Prepare business plan for preferred options to be adopted as actions in the Plan - clarify roles, responsibilities and financial commitments.* • *Seek comm* • *itment to the Plan from implementation partners.* • *Prepare a monitoring and evaluation plan that will enable tracking of implementation of the CMP and achievement of the management objectives.* • *Prepare draft CMP for initial consultation with key stakeholders.*	*$10,000 Consultancy fee Plus internal Council resources (e.g. to seek commitment from implementation partners)*	*2 months*
Develop draft CMP for public exhibition	• *Prepare and final exhibit draft CMP*	*$15,000 Consultancy fee Plus internal Council resources for public exhibition*	*2 months*
Finalise CMP	• *Prepare submissions report as discussed (and costed) above.* • *Finalise CMP.* • *Obtain certification of the CMP.*	*$12,500 Consultancy fee Plus internal Council resources for submissions collation and certification.*	*3-4 months*
STAGE 5			
Implement CMP, monitor, evaluate and report	• *Council to implement CMP for 5 to 10-year period through IP&R.* • *Other organisations to implement CMP through work programs.*	*Unknown*	*N/A – until update of the CMP is required, likely 5-10 years.*

Table 13.4. *Forward Plan for Open Coastline*

FUNDING FOR THE CMP

It is Council's responsibility to lead the development of the four CMPs. The estimated costs of preparing the CMPs are estimated above. This cost may change if some stages of the CMP are combined, or if some further studies identified for different locations are combined into one larger study that would inform multiple CMPs (e.g. the recreational user needs studies). However, regardless of the approach adopted opportunities for receiving partial funding under the NSW Government Coastal Management Program are available.

The significant funding boost to both coastal management and marine estate management by the NSW Government (and the supporting State agencies who administer these programs) is expected to ease this financial and resource burden. Section 23 of the CM Act states, "Other public authorities to have regard to coastal management programs and coastal management manual". This also serves to improve collaboration between and ownership by local and state agencies for coastal management.

The NSW Government is committed to managing the coastal environment and marine estate of NSW. CMPs provide the framework for local councils to implement the government agenda and as such can apply for funding support. Council will be eligible to apply for 'dollar for dollar' funding to prepare each of the CMPs. Therefore, Council should budget for 50% of the CMP estimates provided in the forward plans to progress with CMP Stages 2 to 4 for each location. In addition, it may be prudent to allocate a contingency budget (say 20%).

CMP STRUCTURE AND PROJECT GOVERNANCE

The NSW Coastal Management Framework provides flexibility around the scope, structure and governance arrangements of a CMP.

A CMP provides a unique opportunity for Council, state government agencies and their communities to achieve a strategic and coordinated approach to manage coastal risks and improve coastal habitats and environments, for both environmental and social (community) benefit within the PMH LGA.

PMHC will manage the CMP development, implementation and reporting processes. This includes the preparation, development and review of, and the contents of, the plans, strategies, programs and reports to which Part 2 of Chapter 13 of the Local Government Act 1993 applies, and the preparation of planning proposals (if required) and development control plans under the Environmental Planning and Assessment Act 1979.

Potential governance and management arrangement for the CMP are outlined in *[Table 14]*.

Entity	Responsibility
Port Macquarie-Hastings Council	*Lead agency, coordination and implementation.*
State Agencies: - *Department of Planning Industry and Environment* - *Department of Industry - Crown Lands and Water* - *Department of Primary Industries - Fisheries* - *National Parks and Wildlife Services* - *NSW Environment Protection Authority* - *Roads and Maritime Services* - *Transport for NSW*	*Sign off on CMP, collaboration, action(s) and implementation (as defined).*
Coast, Estuary & Floodplain Advisory Sub-Committee - *Port Macquarie-Hastings Council* - *State Agencies* - *Industry Representatives* - *Community Representatives*	*Council adopted Sub-Committee, to assist Council in undertaking management and planning. To assist reviewing studies, plans and policies and to provide and receive feedback from the community.*

Table 14. *Potential CMP Governance and Management*

17.4 PRELIMINARY BUSINESS CASE

OVERVIEW

A preliminary business case is provided herein to outline the benefits of and recommendation for, progressing with a CMP for the four main areas in the LGA: The Hastings River, Lake Cathie/Bonny Hills (including adjoining open coastline), Camden Haven River as well as the coastline from Point Plomer to Diamond Head (excluding coastline around Lake Cathie township).

Reforms to the NSW coastal management legislative and regulatory framework present a unique opportunity to build on the existing coastal management work considering lessons learnt, and improved engagement and collaboration with relevant stakeholders and agencies, preparing a holistic, inclusive CMP.

This business case demonstrates the benefit of preparing a CMP to the economic, social and ecological values of the Port Macquarie-Hastings region. The business case aims to demonstrate the need to take a long-term, risk based approach to coastal management, which can be facilitated through the preparation of a CMP. There is a wealth of existing information and suitable management actions in former EMP's and CZMP's, and the CMP will provide an opportunity to build on these past studies and planning.

Considerations and context for collaboration and cost sharing arrangements are also provided. A preliminary business case is a requirement of the Stage 1 CMP Scoping Study.

Under the Coastal Management Act, Council may prepare a Coastal Management Program that covers its entire coastal zone. The current timeframe for transitioning older style plans to CMPs is the 31st December 2021. Additionally, the grants funding package which accompanied the coastal management reforms in NSW will only extend to the 2020-21 financial year. State government funding under the Coast & Estuary Grants program is not confirmed nor guaranteed after this time.

ECONOMIC, ENVIRONMENTAL AND SOCIAL BASIS

The Port Macquarie-Hastings area is a wonderfully biodiverse region and its natural environment is highly valued by the community. The biological and natural assets contribute to the cultural, lifestyle, aesthetic and recreational identity of the area.

The natural environment is also locally enriched by a long history and ongoing connection of Aboriginal people with the coast, post-European settlement heritage and a wide range of passive and recreational activities.

The waterways and coastline in the study area are highly utilised by the public for swimming, fishing, surfing and a variety of other recreational activities. The area also supports valuable aquaculture and commercial fishing industries.

As such the coastline supports many significant and important environmental, economic, sociocultural values and community benefits. These values and benefits are threatened by increasing pressures including coastal hazards, climate change, sea level rise, population and tourism growth and coastal development.

A CMP will provide a comprehensive strategic vision and action plan that is locally contextualised and enabled through a government supported process, for managing the priority issues affecting the study area.

PROGRAM RISKS AND RESPONSIBILITIES

Some key risks and challenges associated with the development of a CMP are:

Resourcing

- Ongoing allocation of resources. The preparation of a CMP could potentially result in conflict within Council and with other contributing stakeholders, in terms of competing needs for scarce resources (including but not limited to funding and staff).

Responsibility

- Co-ordination, ongoing involvement and meaningful commitment of multiple agencies during both the development and implementation of the CMP.

Funding

- Grant funding is only available for existing certified CZMP's, developing a CMP or for action items contained within CMP's. For existing CZMP's only 1:1 funding is available. For development of CMPs' and adopted items, only 2:1 funding is available.
- Council has limited funding, therefore its ability to development and implement actions for management of the coastline and estuaries is limited.
- Coastal & Estuary grant funding applications are not always successful.
- Coastal and Estuary grant program funding is not guaranteed after 20-21 FY.
- For projects with significant costs they need to be accompanied by a CBA (it should be noted that the role CBAs play and how they are used is currently under review by the NSW Government).

Expectations

- Expectations of key stakeholders (agencies, authorities and community) not aligning with priorities. Preparation of the CMP is likely to create (or exacerbate) community expectations for the implementation of actions for coastal management. An inherent risk exists if the CMP process fails to deliver the actions, or if these actions fail to achieve the vision and objectives of the CMP.
- Negative community opinion of "yet another plan".
- Outcomes of coastal hazard assessment not being palatable to some members of the community (insurance and a perceived decline in property values).
- Expectation that the NSW Government will not change the program again and result the CMP process being redundant.

EXISTING MANAGEMENT ARRANGEMENTS

The estuaries have been the subject of previous management investigations and as such, each had an EMP prepared under the former NSW planning frameworks. The existing plans vary in age and in the extent to which management actions have been implemented. Similarly, certain areas of the coastline (Town Beach, Lake Cathie) were the subject of previous investigations with Lake Cathie still having an active CZMP. However this plan will lapse in December 2021 unless the actions from this plan are incorporated in a new CMP.

COMMUNICATION, EDUCATION AND ENGAGEMENT PLAN

Overview

The Coastal Management Program will seek to inform, educate and engage with the community around all aspects of the CMP for each coastal chapter within the LGA following the IAP2 framework *[See Figure 57]*.

These chapters include:

- Lake Cathie and Bonny Hills
- Hastings River Estuary
- Camden Haven Estuary
- Open coastline from Point Plomer to Diamond Head

The Communications, Education and Engagement processes will follow the below five stages of the CMP:

- **Stage 1:** Identify the scope of the CMP
- **Stage 2:** Determine risks, vulnerabilities and opportunities
- **Stage 3:** Identify and evaluate options
- **Stage 4:** Prepare, exhibit, finalise, certify and adopt the CMP
- **Stage 5:** Implement, monitor, evaluate and report

The strategy and tactical actions at each stage will be tailored to each audience segmentation within the geographic location outlined in the above four chapters.

Framework for CMP Communication, Education and Engagement

Purpose

The Communications, Education and Engagement Plan is to ensure our community is well informed, educated and provided the opportunity to be involved and engaged with throughout the CMP process.

Goal

The aim of the Plan is to provide a framework for the best ways to inform, educate and engage with our community to ensure outcomes are customer focused and customer driven.

Objectives

1. Continue to build trust with the community measure by participation in the CMP process.
2. Ensure there are effective and productive engagement and education opportunities with the community
3. Provide clear and consistent communications and messaging to the community on a regular and as required basis.

Stage 1 – Identify the scope of the CMP

Inform

To inform the community that Council is identifying the scope of the CMP, why Council is doing it, what this means, and what is involved. The community will be informed using a multi-channel approach, delivering tailored content to each segmented audience.

Consult

To inform and consult with the community in identifying the scope of the CMP and facilitating community awareness and involvement in the process.

Stage 2 – Determine risks, vulnerabilities and opportunities

Inform

To inform the community that Council has determined the scope of study and is now determining the risks, vulnerabilities, and opportunities. The community will be informed using a multi-channel approach, delivering tailored content to each segmented audience.

Educate

Our purpose will be to educate the community around the threats and issues we identify specific to each local chapter. Content will include:

a) How threats and vulnerabilities are identified

b) How each is ranked based on risk

c) How each is actioned and in what order of priority they will be actioned.

Stage 3 – Identify and Evaluate Options

Inform

To inform the community that Council is identifying and evaluating options to mitigate the risks and vulnerabilities that were further explored in stage 2 and to provide clarity to the community the proposed future plans management actions. The community will be informed using a multi-channel approach, delivering tailored content to each segmented audience.

Educate

Our purpose will be to educate the community around the solutions we have identified and why certain solutions / options have been chosen and prioritized.

Involve

We aim to consult and involve the community in encouraging their feedback on the proposed solutions and participation in identifying other appropriate options.

Stage 4 – Prepare, exhibit, finalise, certify and adopt the CMP

Inform

To inform the community of the process of finalizing and seeking certification of each chapter of the CMP. The community will be informed using a multi-channel approach, delivering tailored content to each segmented audience.

Consult

We consult with the community around the preferred solutions and priorities for implementing the actions of the CMP and seek feedback before certification of the CMP is sought.

Stage 5 – Implement, monitor, evaluate and report

Inform

To inform the community of the progress of the CMP and continue to update achievements, milestones, outcomes, and roadblocks accordingly. The community will be informed using a multi-channel approach, delivering tailored content to each segmented audience.

Educate

Our purpose will be to educate the community in regards to the preferred management actions, why they are being implemented and any changes or adjustments to actions based on feedback and data. The educational messages will be informed by the data that is gathered through monitoring and evaluating the management actions.

Consult

Our purpose is to inform the community about this stage of the process and to encourage open dialogue regarding community perspective on chosen solutions. Community feedback will be integrated into ongoing project delivery.

Delivery Mechanisms

Educational Methodology and Tools

Each stage of the education project will commence with collating existing assets then designing additional assets that are require for the desired outcomes of the project.

This may include - but is not limited to:

Digital

- Video interviews & vision from the area
- 360° Video
- Images / image slideshows
- Audio interviews
- Ambient audio recordings
- Fact sheets
- External links (e.g water testing results)
- PDF reports
- Narrated presentations (e.g PowerPoint)

Face to face

- Group presentations and pop-ups
- Interactive
- Virtualised
- One-on-one discussion

Printed Collateral

- Booklets and info / facts sheets
- Signage supported by digital assets

Community Engagement Methodology and Tools

The following list is examples of participation activities which may be undertaken by the engagement team as part of the CMP process relative to the chapter areas. This is not an exhaustive list.

Inform

- Webpage updates
- Letter box drop
- Factsheets
- Frequently Asked Questions
- Onsite visual information displays with dynamic QR codes
- Community Engagement E-newsletter
- Emails to databases
- Public notices
- EngagePMH Facebook Group

Consult

- Public Exhibition (28 days)
- 'Have Your Say' survey, interactive maps, ideas board
- On-site pop-up sessions
- Focus groups (face to face or online)
- Suggestion boxes
- Facebook survey

Involve

- Workshop sessions (face to face or online)
- Public meeting
- Live Q&A session
- User/Stakeholder Meetings (face to face or online)
- Community forum

Collaborate

- Ongoing advisory group
- Taskforce or working party
- Management Committees
- Co-Design/ Enquiry by Design
- Joint venture

SPECTRUM	PARTICIPATION GOAL	PARTICIPATION ACTIVITY*	LEVEL 1 High Impact on whole region	LEVEL 2 High Impact of local nature	LEVEL 3 Low Impact on whole region	LEVEL 4 Low Impact of local nature
INFORM	To provide the public with balanced and objective information to assist them in understanding the problem, alternatives, opportunities and/or solutions.	WEBSITE NOTIFICATION	■	■	■	■
		COMMUNITY NOW NOTICES	■	■	■	■
		SOCIAL MEDIA NOTIFICATION	■	■	■	■
		MEDIA RELEASE AND/OR ALERT	■	■	■	■
		COMMUNITY DISPLAYS / NOTICES	■	■	■	■
		FACTSHEET'S / FAQ'S	■	■	■	■
		HOTLINE / PHONE-IN	■	■	■	■
		LETTER BOX DROP	■	■	■	■
		ON-SITE VISUAL INFORMATION DISPLAY	■	■	■	■
		RATES NOTICES INCLUSION	■			
CONSULT	To obtain public feedback on analysis, alternatives and/or decisions.	PUBLIC EXHIBITION	■	■	■	■
		ENGAGEMENT POP-UP^	■	■	■	■
		FOCUS GROUPS ^	■	■	■	■
		PERSONAL PHONE CONTACT	■	■	■	■
		TELEPHONE SURVEY	■	■	■	■
		SUGGESTION BOX	■	■	■	■
INVOLVE	To work directly with the public throughout the process to ensure that public concerns and aspirations are consistently understood and considered.	USER/STAKEHOLDER GROUP MEETINGS^	■	■	■	■
		PUBLIC MEETING ^	■	■	■	■
		MEETING WITH EXISITING GROUP^	■	■	■	■
		WORKSHOP SESSIONS^	■	■	■	■
		COMMUNITY FORUM / DEBATE^	■	■	■	■
COLLABORATE	To partner with the public in each aspect of the decision including the development of alternatives and the identification of the preferred sol	ONGOING ADVISORY GROUPS^	■	■		
		JOINT VENTURE	■	■	■	
		TASKFORCE OR WORKING PARTY	■	■	■	■
		MANAGEMENT COMMITTEES	■	■		
		CO-DESIGN/ENQUIRY BE DESIGN	■	■		

Figure 58. *IAP² Spectrum of Public Participation Framework*

STAKEHOLDER MANAGEMENT

There are a broad spectrum of stakeholders involved in the CMP process given the complex and diverse nature of coastal management. These stakeholders range from State Government agencies to community groups. *[Table 15 below]* identifies known stakeholders. It is intended that the number of stakeholders will increase as well as the detail around their interests as the CMP process progresses. The exact timeframe of stakeholder has not yet been determined however it is likely to comprise of information sessions, surveys and meetings.

Consultation will be undertaken with both internal Council staff and key external stakeholders including the general community, and the Coast, Estuary & Floodplain Advisory Sub-Committee.

Table 15.1 *Proposed Engagement Activities for Stage 2 (all CMPs)*

Stakeholders	Activity	Timing
CE&F Sub-Committee	· *Workshop 1 – Scope of CMP & statutory requirements, review / discuss current & emerging management issues.* · *Workshop 2 – Present outcomes of Stage 2 (further studies & updated risk assessment).* · *Review of the draft Stage 2 CMP.*	*Start of Stage 2.* *Before public exhibition of the Stage 2 report.* *Before public exhibition of the Stage 2 report.*
DPIE – EES	· *Technical advice and support.* · *Technical review of CMP documents.*	*Ongoing*
Council / Councillors	· *Councillor briefing.*	*Before public exhibition of the Stage 2 report.*
Council Staff ***Other Councils*** ***Industry / Other Key Stakeholder Organisations***	· *Stakeholder meetings / briefings (assume 6) to discuss current management issues / risks, values and uses of the coastal zone / estuary.*	*Prior to updating risk assessment.*
Community	· *Press release & newsletter notifying commencement of Stage 2 & advising of upcoming consultation activities.* · *Community survey on management issues.* · *Newsletter on Stage 2 outcomes.*	*Start of Stage 2.* *Start of Stage 2.* *Before public exhibition of the Stage 2 report.*
NSW Coastal Council	· *Technical advice and support.*	*As required.*
Other	· *Public exhibition of the CMP Stage 2.* · *Preparation of a submissions report.*	

Table 15.2 *Proposed Engagement Activities for Stages 3-4 (all CMPs)*

Stakeholders	Activity	Timing
CE&F Sub-Committee	· *Workshop 1 – Scope of Stage 3, management objectives, options assessment methodology, review management actions in existing EMP/CZMP.* · *Survey on ongoing / proposed management actions by Committee members, funding sources, etc.* · *Workshop 2 – Present management options assessment & recommend actions for in the CMP. Discuss implementation, business plan & ME&R. Report back on community & stakeholder engagement outcomes.* · *Workshop 3 – Present draft CMP.* · *Letter confirming organisational commitments in the CMP.* · *Review of draft CMP.*	*Start of Stage 3-4.* *Following Workshop 1.* *Prior to commencing Stage 4 activities.* *Before public exhibition of the Stage 2 report.*
DPIE – EES	· *Technical advice and support.* · *Technical review of CMP documents.*	*Ongoing*
Council / Councillors	· *Councillor briefing.*	*Before public exhibition of the Stage 2 report.*
Council Staff	· *Workshop 1 – Purpose & scope of the CMP, implications for Council's day to day operations, identify activities that need to be included in the CMP. Review the options assessment framework.* · *Workshop 2 – Present options assessment outcomes / preferred management actions, discuss potential sources of funding, approach to business plan, & ME&R.*	*Start of Stage 3-4.* *Prior to commencing Stage 4 activities.*
Other Councils and Industry / Other Key Stakeholder Organisations	· *Stakeholder meetings / briefings (assume 6) to discuss management activities they currently undertake, potential management options, present options assessment framework.* · *Stakeholder briefing to present final CMP.*	*Start of Stage 3-4.* *Before public exhibition of the Stage 2 report.*
Community	· *Press release & newsletter notifying commencement of Stages 3 & 4 & advising of upcoming consultation activities.* · *Workshop – Review outcomes of Stage 2, discuss management options.* · *Survey / web-based mapping – potential management options.* · *Information session – draft CMP.*	*Start of Stage 3-4.* *Start of Stage 3-4.* *Start of Stage 3-4.* *Start of Stage 3-4.*
NSW Coastal Council	· *Technical advice and support.*	*As required.*
Other	· *Public exhibition of the CMP.* · *Preparation of a submissions report.*	

Engagement activities in Stage 5 may include:

- Ongoing regular meetings of the CE&F Sub-Committee;
- Meetings with key stakeholders or community organisations as required to facilitate implementation of the CMP;
- Notifications on outcomes under the CMP (e.g. an annual report card) and notification of opportunities to be involved in the CMP implementation.

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PORT MACQUARIE-HASTINGS COUNCIL

Coast, Estuary and Floodplain Management Plan Action Status

Specific Plan Action Number	Catchment/Management Area	Coast/Estuary/Flood	Key Issues	Management Action Required	Sub Tasks	Status Comment
5	Camden Haven	Floodplain Management		Emergency Management Measures		Complete.
6	Camden Haven	Floodplain Management		Improved Flood Access		Complete.
1	Camden Haven	Floodplain Management		Planning & Development Controls		Complete.
8	Camden Haven	Floodplain Management		Small Levee in Lakewood Village		Project is considered a low priority. Numerous unsuccessful grant applications have impacted the delivery of this project. Due to the low cost/benefit ratio this project is unlikely to be completed.
7	Camden Haven	Floodplain Management		Voluntary House Raising		Yet to commence - Audit undertake in 2007 showed project of high cost and mixed interest from owners. Pilot scheme was suggested to gauge likely issues. The pilot has not commenced at this time.
7	Hastings	Floodplain Management		Commission a Climate Change Assessment Study to investigate and quantify the implications of climate change on existing design flood predictions to Year 2100	1. Prepare Brief defining climate change scenarios to be investigated 2. Engage consultant to undertake associated modelling 3. Undertake Investigations and compare results to Design Levels adopted in Hastings FRMS (2011) 4. Adopt revised Design Flood Levels (as appropriate) 5. Determine and map Updated Flood Planning Area (as required)	Complete. Completed during 2018-19 FY.
8	Hastings	Floodplain Management		Commission a Hibbard Precinct Floodway Refinement Study to investigate potential options for the management of the designated floodway between Fernbank Creek and Hibbard, including potential options to modify the current floodway to accommodate existing development, while at the same time maintaining flow conveyance	1. Undertake "local scale" investigation to identify potential alternative floodway alignments through Hibbard Precinct 2. Consult with stakeholders including landowners to identify feasible floodway alternatives 3. Identify potential properties for buy back over time (potential may exist for voluntary purchase depending on funding availability). Funding opportunities to be determined in association with OEH. 4. Determine recommended alternate / refined floodway corridor 5. Identify potential properties for voluntary purchase 6. Develop Implementation Plan	Commenced. Flood Study phase is complete, however due to complexities in the adoption of the Hastings River Climate Change study the Hibbard Flooway Study was significantly delayed and grant funding requirements could not be met. Hence, the Floodplain Risk Management Study & Plan phase of the previous contract was not delivered. These stages will require a further grant funding application. Accordingly, the Floodplain Risk Management Study & Plan (FRMS/P) phase is yet to commence. Future grant application will be required to recommence the FRMS & FRMP phases of this project.
11	Hastings	Floodplain Management		Develop flood interpretation software package which incorporates flood warning data for use as a flood management tool	1. Identify flood interpretation software; e.g., waterRIDE or other software 2. Engage consultant to develop flood forecasting tool 3. Develop Flood Forecasting Tool 4. SES have obtained relevant software licenses and are currently working on producing inundation mapping and incident management plans for critical areas. A MOU is in place with MIDROC to provide a technical officer as part of the Incident management Team. 5. Undertake training of SES personnel in the use of the Flood Forecasting Tool	Yet to be scheduled - The NSW SES currently does not have the required resources and is not currently undertaking any work in relation to this matter.
5	Hastings	Floodplain Management		Prepare and Adopt LGA Wide Flood DCP/ Policy.	1. Prepare LGA Wide Flood DCP in line with Draft DCP recommendations to apply across the entire LGA, incorporating: - provision for climate change impacts on design flood levels and flood planning area - protocols for approvals on land within the Hibbard South Precinct 2. Exhibit draft Flood DCP in accordance with statutory	Yet to commence - updates to the Flood Policy were undertaken in 2018 to reflect new flood study information. Another review is required to incorporate new flood information and ensure that current deficiencies are addressed.
2	Hastings	Floodplain Management		Construct Settlement Point Flood Protection Levee	1. Review results of Supplementary Study into climate change impacts on Design Flood Characteristics and determine short, medium and long term implications for Settlement Point. Establish projected timescale for levee that acknowledges community based safety requirements. 2. Undertake local scale stakeholder consultation to educate local community on implications of climate change on design flood characteristics and associated risk to life. 3. Prepare REF/EIA for Settlement Point Levee. Develop preliminary concept design that recognises staggered impacts of climate change. 4. Apply for funding under the floodplain management grants program 5. Develop formal concept design incorporating additional stakeholder / community consultation 6. Undertake Detail Design 7. Undertake staged construction as per climate change impact	Yet to be scheduled - Project was reviewed in line with other priority projects and is now considered a low priority as a result. Mapping of the recently completed flood studies (Hastings River Climate Change Modelling, Hibbard Precinct Floodway Investigation, Wrights Creek Flood Study) is now the main focus area. Mapping works are underway.
4	Hastings	Floodplain Management		Update Port Macquarie-Hastings LEP 2011 to reflect latest standard clauses for the management of flood prone land	1. Develop recommended changes in wording for flood related clauses within Port Macquarie - Hastings LEP 2011 2. Submit recommended clause changes to Council's Planning Department for consideration 3. Workshop with Council's Dept of Planning (as required) 4. Submit final recommended clause changes to Council for acceptance 5. Following Council acceptance, forward to NSW Dept of Planning & Infrastructure for adoption and incorporation into LEP 2011 6. Public notification of changes & incorporation of community feedback.	Commenced & Ongoing - now that the Hastings River Climate Change Flood Study & Wrights Creek Flood Study Projects are completed, Council staff are working towards producing revised flood mapping. Additional work is required to finalise this flood mapping.
10	Hastings	Floodplain Management		Investigate options for properties / dwellings that fall within the floodway corridors for house raising	1. Identify relevant floodway areas: - Oaks Crescent - Blackmans Point - Fernbank Creek - sections along Hastings River Drive in Hibbard 2. Engage consultant to investigate feasibility and cost for house raising works 3. Consult with residents and landowners to gauge their support for house raising 4. OEH guidelines confirm that grant funding for house raising is not available where the development falls within a floodway. However it is dependent on the individual circumstances of the site and each proposal would be assessed on a case by case basis.	Yet to be scheduled
19	Hastings	Floodplain Management		Develop and initiate flood education and awareness program for vulnerable groups and flood affected communities	1. Vulnerable Groups to include: - Heritage Christian School at Hibbard - Wauchope High School - St Josephs Primary School and Regional High School 2. Priority flood affected communities to target: - Settlement Point - Hibbard - Fernbank - Blackmans Point	Yet to be scheduled - 2016-17 Grant funding application not successful - not proposed to submit grant funding application in 2017/18 due to volume of other flood projects underway.
9	Hastings	Floodplain Management		Commission a Climate Change Adaptation Study for the lower Hastings River Estuary that sets a strategy for protecting (or otherwise) existing infrastructure that will be exposed to more frequent fluvial and tidal flooding as climate change impacts manifest	1. Review results of Supplementary Climate Change Modelling Investigation (Item 7) and prepare Brief defining climate change adaptation investigation requirements 2. Engage consultant 3. Undertake Investigations and Develop Adaptation Strategy	Yet to be scheduled.

NOTE: YELLOW HIGHLIGHTING DENOTES CHANGE TO STATUS SINCE LAST COMMITTEE MEETING WAS HELD

Coast, Estuary and Floodplain Management Plan Action Status

Specific Plan Action Number	Catchment/Management Area	Coast/Estuary/Flood	Key Issues	Management Action Required	Sub Tasks	Status Comment
12	Hastings	Floodplain Management		Install additional rainfall and streamflow gauges, particularly at Dennis Bridge and Telegraph Point and identify any additional sites required	1. Engage with BoM/MHL to identify process for installation of streamflow gauges 2. Procure gauge and commission installation	Commenced - First round of additional gauges installed with the installation of a new gauge at Mundays Lane. River Level & Rainfall Gauge installed at this location by MHL. Additional gauges may be installed in future years pending grant funding and other competing priorities.
1	Hastings	Floodplain Management		Construct North Shore Flood Protection Levee	1. Review results of Supplementary Study into climate change impacts on Design Flood Characteristics and determine short, medium and long term implications for North Shore. Establish projected timescale for levee that acknowledges community based safety requirements. 2. Undertake local scale stakeholder consultation to educate local community on implications of climate change on design flood characteristics and associated risk to life. 3. Prepare REF/EIA for North Shore Levee. Develop preliminary concept design that recognises staggered impacts of climate change. 4. Apply for funding under the floodplain management grants program 5. Develop formal concept design incorporating additional stakeholder / community consultation 6. Undertake Detail Design 7. Undertake staged construction as per dimate change impact	Yet to be scheduled. Due to the inconclusive response from residents construction of a ring levee at North Shore may depend on community acceptance or a future change in flood policy.
13	Hastings	Floodplain Management		Raise Settlement Point Road between the ferry wharf and Park Street	1. Prepare REF/EIA for road raising 2. Apply for funding under the floodplain management grants program 3. Prepare concept & detail design 4. Undertake construction works	Yet to be scheduled - Project was reviewed in line with other priority projects, and is now considered a low priority as a result.
14	Hastings	Floodplain Management		Raise Hastings River Drive from west of Boundary Road to Tuffins Lane	1. Prepare REF/EIA for road raising 2. Apply for funding under the floodplain management grants program 3. Prepare concept & detail design 4. Undertake construction works	Yet to be scheduled - Road works to be progressively undertaken in conjunction with Council capital works program. Current priority is HRD from Port Home Zone (Hughes Place) to Boundary Street and Boundary Street from HRD Intersection to Airport.
15	Hastings	Floodplain Management		Raise Hastings River Drive between Fernbank Creek bridge and the existing Pacific Highway	1. Prepare REF/EIA for road raising 2. Apply for funding under the floodplain management grants program 3. Prepare concept & detail design	Yet to be scheduled - Road works to be progressively undertaken in conjunction with Council capital works program. Current priority is HRD from Port Home Zone (Hughes Place) to Boundary Street and Boundary Street from HRD Intersection to Airport.
16	Hastings	Floodplain Management		Raise Fernbank Creek Road	1. Prepare REF/EIA for road raising 2. Apply for funding under the floodplain management grants program 3. Prepare concept & detail design 4. Undertake construction works	Yet to be scheduled - Road works to be progressively undertaken in conjunction with Council capital works program. Current priority is HRD from Port Home Zone (Hughes Place) to Boundary Street and Boundary Street from HRD Intersection to Airport.
18	Hastings	Floodplain Management		Raise short section of Shoreline Drive (near Riverside Drive intersection) (interim emergency response measure)	1. Prepare REF/EIA for road raising 2. Apply for funding under the floodplain management grants program 3. Prepare concept & detail design 4. Undertake construction works	Yet to be scheduled - Road works to be progressively undertaken in conjunction with Council capital works program. Current priority is HRD from Port Home Zone (Hughes Place) to Boundary Street and Boundary Street from HRD Intersection to Airport.
17	Hastings	Floodplain Management		Raise Shoreline Drive and North Shore Drive (subject to construction of North Shore and Settlement Point Levees)	1. Prepare REF/EIA for road raising 2. Apply for funding under the floodplain management grants program 3. Prepare concept & detail design with consideration of existing stormwater drainage issues 4. Undertake construction works	Yet to be scheduled - Road works to be progressively undertaken in conjunction with Council capital works program. Current priority is HRD from Port Home Zone (Hughes Place) to Boundary Street and Boundary Street from HRD Intersection to Airport.
2.1	Lake Cathie	Coastal Management	Development Controls	Review interim development controls with reference to the NSW Coastal Planning Guideline: Adapting to Sea Level Rise (DoP 2010) to provide more guidance including a definition of relocatable structures, triggers for relocation and requirements for geotechnical/ coastal engineer's reports for foundation design.		Complete - coastal management planning guidelines updated and inserted into the DCP.
3.2	Lake Cathie	Coastal Management	Stormwater Management	Redirect Illaroo Rd stormwater to minimise the direct outflow of stormwater onto the beach. Illaroo Road only included as a contingency pending confirmation of the timing of the construction of the Revetment.		Commenced & ongoing - Detailed design plans completed. Grant application successful. Dumped asbestos has been uncovered as has Aboriginal archaeology. Aboriginal archaeology investigation works are now complete. Asbestos remediation works anticipated to commence in late 2021. Stormwater works anticipated to commence in 2022.
3.1	Lake Cathie	Coastal Management	Stormwater Management	Continue to upgrade the stormwater outlets to the beach e.g: placement of rock at outlets to reduce beach scour.		Commenced - numerous beach outlets upgraded within past 10 years. Grant funding application successful for Middle Rock & Chepana Street outlet works. Construction works completed for 2x outlets during 2018-19 FY.
5	Lake Cathie	Coastal Management	Ongoing Beach Nourishment	Any sand dredged/ excavated from the Lake Cathie entrance to be placed on the beach adjacent to Illaroo Road.		Nourishment efforts completed in 2015 & 2018.
7.4	Lake Cathie	Coastal Management	Foreshore Management	Batter back any storm erosion escarpment that forms at Foreshore Reserve (or in other locations) to ensure public safety and maintain park amenity.		Ongoing
9.2	Lake Cathie	Coastal Management	Public Access	Continue to monitor and rehabilitate informal beach access tracks		Ongoing
9.3	Lake Cathie	Coastal Management	Public Access	Reduce erosion escarpments at the base of beach accessways and carry out any necessary repairs following storm erosion		Ongoing
7.1	Lake Cathie	Coastal Management	Foreshore Management	Continue to control/ remove bitou bush along with regeneration/ revegetation with locally indigenous vegetation species.		Ongoing, subject to funding availability. Active Landcare site.
8.1	Lake Cathie	Coastal Management	Reserve Improvements	Prepare masterplan for foreshore reserves (Aqua Reserve, Foreshore Reserve and Johnathon Dixon Reserve), incorporating the following improvements: - additional lighting at Johnathon Dixon Reserve and in the vicinity of the Foreshore Reserve barbeque facilities - upgrade Johnathon Dixon Reserve to relieve pressure on Foreshore Reserve by providing shade, shelter and play areas. Upgrades should allow for revetment end effects.		Completed. Foreshore reserve masterplan developed and adopted by Council. Ongoing implementation will be undertaken over coming years.
2.2	Lake Cathie	Coastal Management	Development Controls	Review area subject to controls following construction of the revetment and when the hazard lines are reviewed. Note that the 50 year impact line would move over time due to shoreline recession (and possibly affect additional properties, e.g. along Chepana Street).		Yet to be scheduled
3.5	Lake Cathie	Coastal Management	Revetment	Call tenders and construct revetment.		Yet to be scheduled
3.6	Lake Cathie	Coastal Management	Revetment	Finalise private/ public cost-sharing arrangements including private payment plans.		Ongoing - Consultant has completed CBA & Funding Model. Community engagement commenced during Feb 2021 via direct consultation with affected properties, stakeholders and broader Lake Cathie community.
3.7	Lake Cathie	Coastal Management	Revetment	Carry out post-storm assessments to identify revetment maintenance requirements and actions to address exacerbated erosion in front of, and at the ends of, the revetment.		Yet to be scheduled
4.1	Lake Cathie	Coastal Management	Contingency Measures	Develop a Servicing Strategy in consultation with other service providers in the event that access and services to Illaroo Road properties are threatened by coastal erosion, prior to construction of a revetment.		Yet to be scheduled

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Coast, Estuary and Floodplain Management Plan Action Status

Specific Plan Action Number	Catchment/Management Area	Coast/Estuary/Flood	Key Issues	Management Action Required	Sub Tasks	Status Comment
4.2	Lake Cathie	Coastal Management	Contingency Measures	Designate Aqua Crescent/ Bundella Avenue and Illaroo as a one-way loop in a Local Area Traffic Management Plan in the event that damage to the road reserve occurs as a result of erosion events and the road pavement width needs to be reduced to maintain safe access, prior to the construction of a revetment.		Yet to be scheduled
26	Town Beach	Coastal Management		Maintain relatively natural pathway surfaces around southern headland (Flagstaff Hill)		Complete. Footpath surfaces determined as part of detailed design for upgrades having regard for access requirements and asset durability. Coastal Walk Upgrade between Kiosk and Flagstaff Hill complete.
24	Town Beach	Coastal Management		Design and install stormwater gross pollutant traps in car park at southern kiosk and car parks east and north of Gaol Point		Commenced - GPT installed adjacent to kiosk. Gaol Point GPT subject to review.
14	Town Beach	Coastal Management		Provide formalised stairway access from Gaol Point to the back beach area, on north and south faces of Gaol Point		Commenced - Stairs on southern face complete. Northern stairs yet to be scheduled.
8	Town Beach	Coastal Management		Construct new amenities building to service the northern reserve area		Complete.
10	Town Beach	Coastal Management		Install additional seating, tables and lighting in the northern reserve, in the same general style as that in the southern reserve		Complete.
16	Town Beach	Coastal Management		Upgrade pathways in Rotary Park and enhance landscaping to improve connectivity between the park, beach and adjacent accommodation		Complete.
20	Town Beach	Coastal Management		Install shade structures in the back beach reserve at the southern end of Town Beach, to complement planting of shade trees		Complete.
21	Town Beach	Coastal Management		Continue to use local flowering small trees for shade and to provide local habitat for foraging native species		Ongoing
1A	Town Beach	Coastal Management		Maintain Southern Breakwall of the Hastings River entrance, to replace dislodged rock and protect the wall core and raise crest height to 4.6 mAHD		Complete. Works completed on Southern Breakwall by NSW Government in 2014.
1B	Town Beach	Coastal Management		Ongoing maintenance of Southern Breakwall		Complete. Works completed on Southern Breakwall by NSW Government in 2014.
2	Town Beach	Coastal Management		Remove displaced rock from the surf zone to reduce safety hazards to swimmers and surfers		Complete. Works completed on Southern Breakwall by NSW Government in 2014.
22	Town Beach	Coastal Management		Continue to remove weeds from coastal bluff grassland vegetation communities, replacing weeds with local coastal shrub and ground cover species		Ongoing
25	Town Beach	Coastal Management		Highlight pedestrian linkages from Town Green to Town Beach and beyond in tourist information and in sign posting/maps all key junctions along the walking paths. Develop major theme to integrate the walking track system. Sign posting to also be provided at Flagstaff Hill to highlight special visual features such as whale watching.		Commenced and ongoing - Port Macquarie Coastal Walk master planning phase complete, public consultation undertaken. Initial construction works commenced earlier this year withnumerous stages completed. State Govt grant for the breakwall footpath upgrade was announced in late 2020. $5M allocated. Crown Lands to project manage.
27	Town Beach	Coastal Management		Review safety of all pathways, stairways, elevated walkways and lookout fencing around Flagstaff Hill.		Ongoing
28	Town Beach	Coastal Management		Ensure that any further development of facilities in the woodland areas at Flagstaff Hill and beyond does not detract from the natural landscape character of this area.		Ongoing
11	Town Beach	Coastal Management		Upgrade and install pathways in the northern reserve, two metres wide and including art work or natural/cultural heritage information in the surface		Complete.
15	Town Beach	Coastal Management		Provide interpretative signage at Gaol Point about the history of the site, the harbour entrance, surf conditions, passing whales and dolphins, walking trails etc.		Complete.
7	Town Beach	Coastal Management		Construct a rotunda adjacent to the children's playground area		Yet to be scheduled
17	Town Beach	Coastal Management		Prepare Traffic Management Plan that includes investigation of the closure of the southern end of Stewart Street and installation of traffic calming devices to minimise potential conflicts with pedestrians		Yet to be scheduled
18	Town Beach	Coastal Management		Implement Traffic Management Plan		Yet to be scheduled
19	Town Beach	Coastal Management		Improve lighting along all pathways, using efficient lighting fixtures		Ongoing
23	Town Beach	Coastal Management		Wherever possible, introduce shade trees into car parking areas		Ongoing

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