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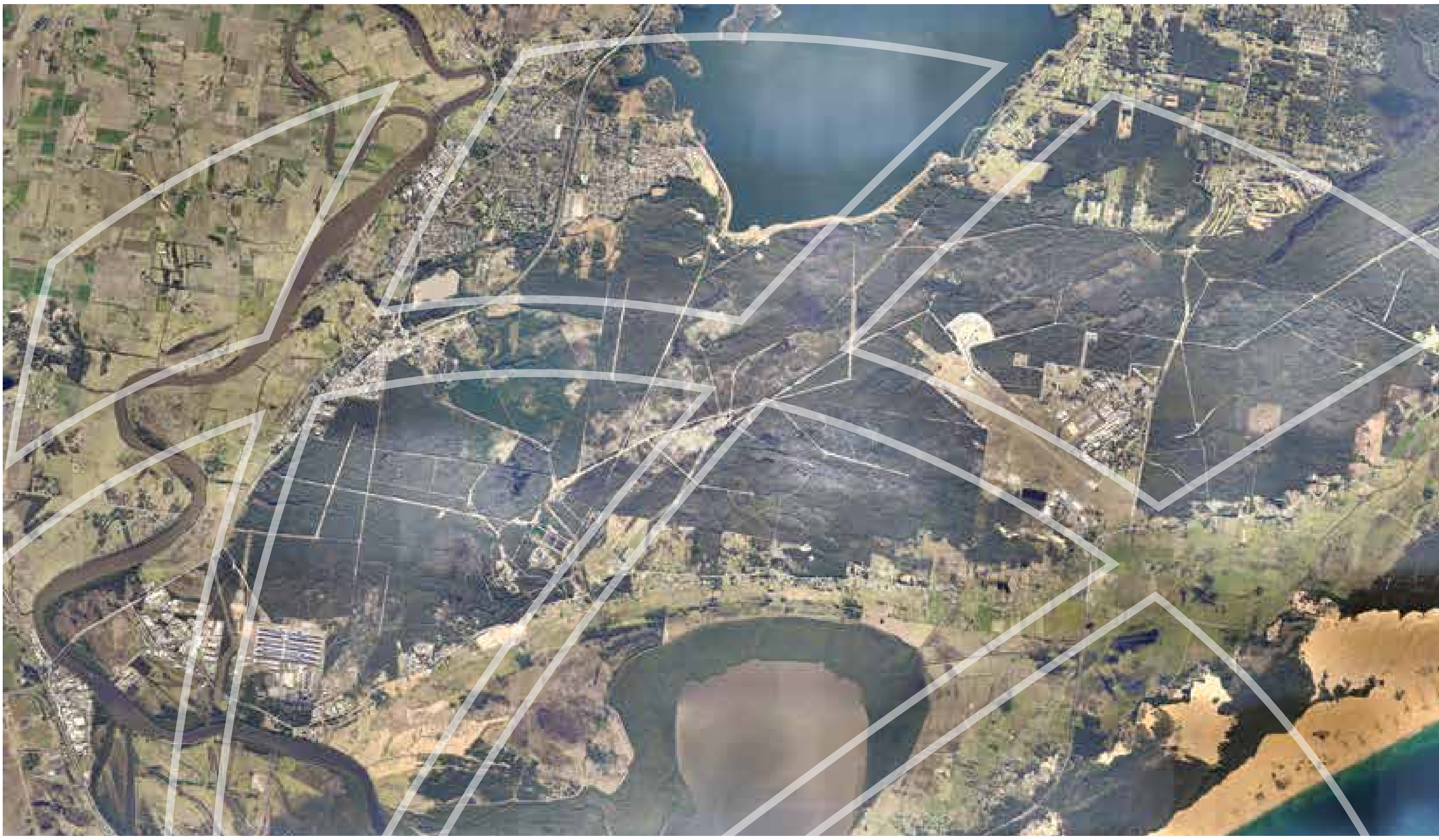

Williamtown - Salt Ash Floodplain Risk Management Study & Plan

Final Report

September 2017

Port Stephens COUNCIL

Williamtown Salt Ash Floodplain Risk Management Study and Plan

Prepared for:	Port Stephens Council
Prepared by:	BMT WBM Pty Ltd (Member of the BMT group of companies)

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Synopsis: **This report documents the Williamtown Salt Ash Floodplain Risk Management Study and Plan which investigates and presents a flood risk management strategy for the Williamtown / Salt Ash area. The study identifies the existing flooding characteristics and canvasses various measures to mitigate the effects of flooding. The end product is the Floodplain Risk Management Plan, which describes how flood liable lands within the Williamtown / Salt Ash area are to be managed in the future.**

REVISION/CHECKING HISTORY

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Executive Summary

Introduction

The Williamtown Salt Ash Flood Study and Williamtown Salt Ash Flood Study Review were prepared for Port Stephens Council (Council) by BMT WBM in 2005 and 2012 respectively, to define the flood behaviour of the Williamtown / Salt Ash area. Through the establishment of appropriate numerical models, the study produced information on flood flows, velocities, levels and extents for a range of flood event magnitudes under existing catchment and floodplain conditions.

The outcomes of the Williamtown Salt Ash Flood Study Review (BMT WBM, 2012) established the basis for subsequent floodplain management activities in the catchment. This Floodplain Risk Management Study (FRMS) aims to derive an appropriate mix of management measures and strategies to effectively manage flood risk in accordance with the Floodplain Development Manual. The findings of this study will be incorporated in a Plan of recommended works and measures and program for implementation.

The objectives of the Williamtown Salt Ash Floodplain Risk Management Study and Plan are to:

- Identify and assess measures for the mitigation of existing flood risk;
- Identify and assess planning and development controls to reduce future flood risks; and
- Present a recommended floodplain management plan that outlines the best possible measures to reduce flood damages in the Williamtown / Salt Ash locality.

This report documents the FRMS and presents a recommended Floodplain Risk Management Plan (FRMP) for the Williamtown / Salt Ash area.

The following provides an overview of the key findings and outcomes of the study, incorporating a review of design flood conditions within the catchment, assessment of potential floodplain management measures and a recommended Floodplain Management Plan.

This project has been conducted under the State Assisted Floodplain Management Program and received State financial support.

Flooding Behaviour

The Williamtown / Salt Ash district is located adjacent to the lower reaches of the Hunter River. The Hunter River drains a catchment area of approximately 21,000 km^2, nearly all of which lies upstream of Raymond Terrace. The study area lies partly within the Hunter River floodplain, but also includes the floodplains of a number of local catchments including:

- Windeyers Creek located south and east of Raymond Terrace;
- The Moors Drain flowing between the Williamtown RAAF base and Salt Ash into Tilligerry Creek;
- Tilligerry Creek between Fullerton Cove and Nelson Bay Road, Salt Ash; and
- Minor drainage channels draining to Tilligerry Creek or directly to Fullerton Cove.

Much of the study area floodplain is located between Fullerton Cove to the west and Port Stephens to the east. Nelson Bay Road limits the transfer of flood waters from Fullerton Cove into the Williamtown floodplain. Tilligerry Creek, which flows to Port Stephens, has a set of flood gates and levee located at Salt Ash. These structures typically prevent elevated water levels in Port Stephens from flooding the Salt Ash floodplain.

Flooding in the Williamtown / Salt Ash study area is primarily caused by three mechanisms:

- Flooding due to local runoff;
- Flooding due to backwater effects of flooding in the Hunter River or elevated ocean tide, which may include overtopping of the levee system surrounding Fullerton Cove; and
- Flooding due to backwater effects of flooding in Port Stephens, which may include overtopping of the levee system at Salt Ash.

The dominant flooding mechanism (in terms of peak design water levels) for the Williamtown / Salt Ash locality is mainstream Hunter River flooding. Under these conditions, Hunter River flooding results in Fullerton Cove filling and discharging into the Tilligerry Creek floodplain, under cross-drainage structures and through overtopping of Nelson Bay Road.

The Williamtown / Salt Ash Flood Study (BMT WBM, 2005) included the development of a hydraulic model for the study area. Subsequent to completion of the Flood Study, further modelling of the Lower Hunter River system has been undertaken for the Williams River Flood Study (BMT WBM, 2009) and Williamtown Salt Ash Flood Study Review (BMT WBM, 2012). Further refinement of the existing models has been undertaken as part of the Floodplain Risk Management Study following detailed review of the previous modelling.

The key updates for the revised modelling include:

- Updated topographical data using the 2013 LiDAR data set acquired by NSW Land and Property Information. Previous modelling utilised the 2007 LiDAR data set acquired by NSW Department of Planning.
- Update of Hunter River design flood flows through revised flood frequency analysis (FFA) at Raymond Terrace. An FFA from a 1994 study has been used as the basis for design flood estimation in the Hunter Estuary for subsequent studies and has now been revised as part of the current study; and
- Additional climate change scenario modelling. This included establishment of design flood conditions consistent with definition of design flood planning levels in current Council planning policy.

The 2007 LiDAR data has been retained for representing the general floodplain topography across the broader model area. Comparison of the 2007 and 2013 LiDAR provides for some differences in floodplain levels, typically of the order of 0.2-0.3 m but greater in some locations. This could be due to a number of factors, such as filtering algorithms, the nature of vegetation at the time of the data capture and the accuracy of the ground control points. Typically, the areas of greatest difference coincide with heavily vegetated parts of the floodplain. Ground survey data in the Fullerton Cove and Tomago localities held by BMT WBM from other projects confirmed the 2007 LiDAR data set to be a better match to the ground survey levels. Accordingly, the 2007 LiDAR was retained for representation of the general floodplain.

The 2013 LiDAR data provided for the best representation of current floodplain development conditions incorporating modified landforms for major development completed subsequent to the previous studies and 2007 LiDAR data acquisition (e.g. WesTrac facility, Tomago). The data was also used to reinforce some of the key hydraulic controls such as road crest levels where data is typically unaffected by vegetation conditions.

As part of ongoing studies in the Lower Hunter, BMT WBM has undertaken an updated FFA at Raymond Terrace incorporating an additional 23 years of complete annual maxima data and more advanced analysis of gauge data. A comparison of the design flood levels at Raymond Terrace from the revised FFA with those from the 1994 study is presented in Table E-1. Significantly, the 1% Annual Exceedance Probability (AEP) event, which is the principal flood planning event, is consistent between the analyses.

Table E-1 Comparison of Design Flood Levels from the 1994 and Revised FFAs

Design Event	Flood Level (m AHD)	
	1994 FFA	Revised FFA
20% AEP	2.1	2.4
10% AEP	2.7	2.9
5% AEP	3.1	3.2
2% AEP	3.7	4.1
1% AEP	4.8	4.8
0.5% AEP	(not estimated)	5.2

Existing and Future Flood Risk

Current practice in floodplain management generally requires consideration of the impact of potential climate change scenarios on design flood conditions. For the Williamtown / Salt Ash area this includes both increases in design rainfall intensities and sea level rise scenarios impacting on ocean boundary conditions. Accordingly, these potential changes will translate into increased design flood inundation, such that future planning and floodplain management in the catchment will need to take due consideration of this increased flood risk.

Low-lying coastal areas, such as those surrounding Fullerton Cove and Tilligerry Creek are at particularly high risk to climate change. The potential for future sea level rise is now expected to be the biggest driver for floodplain management around coastal and estuarine systems such as the Hunter Estuary and Port Stephens. The issue of future sea level rise presents particular challenges to future development, as the risks associated with flooding will progressively increase during the lifetime of the development. It may be such that risks do not manifest until the development is nearing the end of its design life.

A flood damages database has been developed to identify potentially flood affected properties and to quantify the extent of damages in economic terms for existing flood conditions. In developing the damages database, a floor level survey of all existing properties identified within the 1% AEP extent was undertaken. Key results from the flood damages database indicate:

- 14 residential homes, 4 commercial buildings and 1 community building have floor levels below the existing 1% AEP flood level
- 192 residential homes, 25 commercial buildings and 4 community building /public infrastructure have floor levels below the future 1% AEP flood level (incorporating 0.4 m sea level rise allowance and 20% increase in flow) used to establish current flood planning levels

The property inundation statistics confirms the relatively low flood risk exposure under existing floodplain conditions. However, the results also clearly demonstrate the increasing flood risk across the study area and relative vulnerability of the existing community to potential climate change influence. Accordingly, the floodplain risk management for the catchment is likely to have a focus on climate change adaptation rather than immediate flood protection works.

Community Consultation

Community consultation is aimed at informing the community about the development of the Floodplain Risk Management Study and its likely outcome as well as improving the community's awareness and readiness for flooding. The consultation process provides an opportunity to collect information on the community's flood experience, their concern on flooding issues and to collect feedback and ideas on potential floodplain management measures and other related issues. The key elements of the consultation program involved:

- Consultation with the Floodplain Management Committee through meetings and presentations;
- Public exhibition of the Draft Floodplain Risk Management Study and Plan; and
- Community information session undertaken during the public exhibition period to present and discuss the outcomes of the study and recommended floodplain risk management options.

Floodplain Management Options Considered

The principal flooding mechanism in the study area is major Hunter River flooding. Accordingly, there is limited opportunity for flood modification options to mitigate flooding on a catchment scale. Moreover, in the context of the study area, the existing flood risk exposure to existing property is relatively limited such that expensive, broad scale catchment flood management measures are not required at this stage.

Under climate change scenarios, existing flooding conditions are expected to gradually exacerbate in the study area. With increasing flood risk, the floodplain risk management options provide a focus on progressive climate change adaptation.

The Williamtown / Salt Ash Floodplain Risk Management Study considered and assessed a number of floodplain management measures, summarised below.

- *Nelson Bay Road Upgrades* – Nelson Bay Road is the principal flood access route through the study area. It is presently elevated well above the floodplain and typically provides for existing 1% AEP flood access. The existing flood immunity of the road will gradually decrease with progressive climate change impacts increasing design peak flood level conditions. Whilst not specifically requiring immediate works, road upgrades may be undertaken in association with regular maintenance programs (e.g. resurfacing) to provide progressive lifting of the existing road surface profile and maintain appropriate flood immunity.

- *Salt Ash Flood Gate Modification* – the existing flood gate and levee arrangement limits tidal water ingress to the floodplain upstream. The existing arrangement has limited control on peak flood level conditions, particularly in relation to Hunter River derived flooding. No modification works are therefore recommended to address existing flood risk. However, the floodplain management study notes the potential change in flood gate performance associated with progressive sea level rise. Accordingly, future modification of the existing structures will need to be considered in climate change adaptation programs.
- *Preparation of Local Drainage Strategies* – Acknowledging the principal concerns of the community that were raised during the consultation process, recommendation is made to prepare a Management Plan for the local drainage systems. From the floodplain risk management perspective, this is driven by the need for appropriate adaptation plans to be prepared to address increasing flooding under future climate change conditions. There are associated issues relating to local low flow drainage regimes including limited existing capacity, incidence of waterlogging and extended flooding durations, and impact of development on increased runoff. A more holistic Plan of Management would also consider other issues related to water quality and environmental issues.
- *Hunter River Levee Review* – the existing Hunter River flood levees provide existing protection for lower order flood events (<5% AEP) for the floodplain areas in the vicinity of Tomago and Fullerton Cove. Existing and future design flood conditions established in the current study are based on the current levee configurations. Ongoing floodplain risk management for Williamtown and Salt Ash needs to consider potential changes in the configuration or maintenance of these levees that may have a significant influence on design flood conditions in the study area. Future climate change conditions may warrant reassessment of the levee function, not just from a flood management perspective, but also ecological response in the broader Fullerton Cove/Lower Hunter River system which includes significant wetland areas. An initial review from a Williamtown – Salt Ash floodplain risk management perspective may be considered as an initial phase to a broader Plan of Management for the levee system.
- *Voluntary Purchase Schemes* – are generally applicable only to areas where flood mitigation is impractical and the existing flood risk is unacceptable. No property has been identified as suitable for voluntary purchase within the study area and therefore there is no recommendation for such a scheme in the Floodplain Risk Management Plan. However, the current predictions for sea level rise may improve the viability of such a scheme in the future.
- *Voluntary House Raising* – raising floor levels where practical to elevate habitable floor levels to required levels above the flood planning level. Not all houses are suitable for raising. Houses of brick construction or slab on ground construction are generally not suitable for house raising due to expense and construction difficulty. Generally this technique is limited to structures constructed on piers. This scheme has been recommended for further investigation within the Plan to identify suitable properties and funding. The current predictions for sea level rise may further improve the

viability of such a scheme in the future. A house raising program may form part of a broader climate change adaptation strategy for the study area.

- *Flood Proofing* – Flood proofing is proposed as part of the Plan for those properties that are below the 1% AEP flood level. A detailed list of individual property levels relative to predicted flood levels has been established. For those properties identified within the 1% AEP flood envelope, advice may be provided to individual landowners on available opportunities to reduce on-site flood damages.
- *Planning and Development Controls* – Land use planning and development controls are the key mechanisms by which Council can manage flood-affected areas within Williamtown-Salt Ash. This will ensure that new development is compatible with the flood risk, and allows for existing problems to be gradually reduced over time through sensible redevelopment. The Plan has recommended the adoption of the established 1% AEP flood level plus 0.5m freeboard as the flood planning level (maintains the existing design flood standard) and a review of current land-use zoning with respect to Floodway areas. It is noted the adopted FPL includes climate change allowance as per current Council policy. The recommendation also provides for adoption of the updated flood risk mapping including flood planning areas and hydraulic and hazard classifications.
- *Flood Warning* –The issuing of flood warnings in the region is the responsibility of the Lower Hunter Division of the State Emergency Services (*SES*). At present flood warnings and estimates of the time of arrival of the flood peak are based on floodwater levels at gauges located upstream including Singleton, Greta, Maitland and Raymond Terrace. The current study has established specific flood warning trigger levels and timings for Williamtown-Salt Ash linked to the existing Raymond Terrace, Hexham Bridge and Stockton Bridge water level gauges. The additional data in concert with the official Hunter River flood warning system should be used to establish appropriate flood warning and response triggers for the study area and update of Local Flood Plans accordingly.
- *Flood Response* –. The key improvements to emergency response considered in the current study is the update of Local Flood Plans to incorporate the flood intelligence data borne out of the revised understanding of catchment flooding conditions. This data includes the updated flood modelling, property inundation and flood damages analysis. It is recognised that a major event throughout the Lower Hunter River would provide for coincident flooding of numerous localities stretching already limited emergency response resources. Accordingly, it may unrealistic for the Williamtown-Salt Ash community to rely on external support for flood response. The concept of a "Community Flood Emergency Response Plan" should be explored. The Plan would provide information regarding evacuation routes, refuge areas, what to do/not to do during a flood event etc. If such a plan is developed and embraced at a community level, the self-sufficiency in terms of flood response would maximise potential for effective emergency response and a non-reliance on formal emergency services. Council and the SES would be expected to have a key role in developing the CFERP for the vulnerable areas.
- *Improved Flood Awareness* – raising and maintaining flood awareness will provide the community with an appreciation of the flood problem and what can be expected during flood events. An

ongoing flood awareness program should be pursued through collaboration of the SES and Council (e.g. FloodSafe program specific for the study area). The focus of this program should encourage landowners to develop their own Flood Plan for appropriate emergency response in lieu of reliance on Emergency Services as noted above.

- *Strategic Planning for Hunter River (Cumulative Development)* – the study investigated a number of potential large scale redevelopment areas within the Port Stephens LGA. Investigated in isolation, a number of these areas show potential for future redevelopment (including large scale filling/earthworks) with limited impact on existing flood conditions. However, a more coordinated flood impact assessment is recommended comprising a full cumulative development assessment with consideration of regional development opportunities across the Lower Hunter River floodplain incorporating the Port Stephens and Newcastle LGAs. Such an investigation is likely to consider broader regional land use planning and identify future development areas within the floodplain that duly consider overall flood risk and potential impacts under an ultimate development scenario. The outcomes of this cumulative impact assessment would further inform future LEP and DCP amendments (e.g. rezoning, development controls such as fill limitations).
- *Strategic Planning for Williamtown-Salt Ash (Climate Change Adaptation)* – the extent and severity of flooding in the Tilligerry Creek floodplain is controlled by the transfer of Hunter River floodwater across Nelson Bay Road. In raising Nelson Bay Road to combat climate change influence and maintain road flood immunity as a potential flood management measure, there is an opportunity to modify the flood behaviour to provide significant flood risk reductions in the Williamtown-Salt Ash localities under future climate conditions. Strategic planning studies in both a local and regional planning context are recommended to identify a long-term position on the future landscape of the Williamtown-Salt Ash locality under future climate change scenarios. Flood risk management options considered in the current study would be considered as part of local adaptation plans and updated accordingly

The Recommended Floodplain Management Plan and Implementation

A recommended floodplain management plan showing preferred floodplain management measures for Williamtown-Salt Ash is presented in Section 8 in the main body of the report. The key features of the plan are tabulated below with indicative costs, priorities and responsibilities for implementation.

ID	Action	Estimated Cost	Responsibility	Priority
1	Undertake Nelson Bay Road upgrade works road raising and culvert upgrades (note this may be progressive works in response to incremental climate change impacts)	t.b.c. (future works program)	RMS	Low
2	Investigation of consistent flood immunity for roads based on the adopted hierarchy and install flood indicator signs as appropriate	$50k	Council	Low
3	Upgrade Salt Ash flood gate and levee as required (note this may be progressive works in response to incremental climate change impacts)	t.b.c. (future works program)	Council	Low
4	Review of Hunter River Levee Scheme in providing ongoing function for Williamtown-Salt Ash flood control	$30k	Council / OEH	Medium
5	Update planning and development controls including flood risk mapping	Staff costs	Council	High
6	Investigate voluntary house raising program (limited properties)	$20k	Council / Landowner	Medium
7	Improved flood awareness through issue of flood information and community flood emergency response planning	$20k	Council / SES	High
8	Update of Local Flood Plans with current design flood information and intelligence	Staff costs	Council / SES	High
9	Implement a real-time flood forecasting tool based on BoM flood warnings at river gauges system	$50k	Council / SES	High
10	Preparation of a Regional Floodplain Development Strategy incorporating cumulative development flood impact assessment	$50k	NSW Planning / Port Stephens / Newcastle Councils	High
11	Preparation of a local drainage studies including climate change considerations	$50 - $100k	Council	High
12	Preparation of a Climate Change Adaptation Strategy for Williamtown-Salt Ash to define long term development directions	$100 - $200k	Council	High

The steps in progressing the floodplain management process from this point forward are as follows:

1. Council allocates priorities to components of the Plan, based on available sources of funding and budgetary constraints;

2. Council negotiates other sources of funding as required such as through OEH and the “Natural Disaster Mitigation Package” (NDMP); and

3. as funds become available, implementation of the Plan proceeds in accordance with established priorities.

The Plan should be regarded as a dynamic instrument requiring review and modification over time. The catalyst for change could include new flood events and experiences, legislative change, alterations in the availability of funding or changes to the area’s planning strategies. In any event, a thorough review every five years is warranted to ensure the ongoing relevance of the Plan. Flood risk in the study area is intrinsically linked to climate change response and the Flood Plan is expected to evolve with the underlying climate change science and policy at the various tiers of government.

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Glossary

annual exceedance probability (AEP)	The chance of a flood of a given size (or larger) occurring in any one year, usually expressed as a percentage. For example, if a peak flood discharge of 500 m^3/s has an AEP of 5%, it means that there is a 5% chance (i.e. a 1 in 20 chance) of a peak discharge of 500 m^3/s (or larger) occurring in any one year. (see also average recurrence interval (ARI)) Relationship between AEP and ARI is described by: $AEP = 1 - \exp\left(\frac{-1}{ARI}\right)$
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
attenuation	Weakening in force or intensity
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 occurrence 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 20yr ARI design flood will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event. (see also annual exceedance probability)
catchment	The catchment at a particular point is the area of land that drains to that point.
design flood	A hypothetical flood representing a specific likelihood of occurrence (for example the 100yr ARI or 1% AEP flood).
development	Existing or proposed works that may or may not impact upon flooding. Typical works are filling of land, and the construction of roads, floodways and buildings.
discharge	The rate of flow of water measured in tems of vollume per unit time, for example, cubic metres per second (m^3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving for example, metres per second (m/s).
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
flood	Relatively high river or creek flows, which overtop the natural or artificial banks, and inundate floodplains and/or coastal inundation resulting from super elevated sea levels and/or waves overtopping coastline defences.

flood behaviour	The pattern / characteristics / nature of a flood.
flood fringe	Land that may be affected by flooding but is not designated as floodway or flood storage.
flood hazard	The potential risk to life and limb and potential damage to property resulting from flooding. The degree of flood hazard varies with circumstances across the full range of floods.
flood level	The height or elevation of floodwaters relative to a datum (typically the Australian Height Datum). Also referred to as “stage”.
flood liable land	see flood prone land
floodplain	Land adjacent to a river or creek that is periodically inundated due to floods. The floodplain includes all land that is susceptible to inundation by the probable maximum flood (PMF) event.
floodplain management	The co-ordinated management of activities that occur on the floodplain.
floodplain risk management plan	A document outlining a range of actions aimed at improving floodplain management. The plan is the principal means of managing the risks associated with the use of the floodplain. A floodplain risk management plan needs to be developed in accordance with the principles and guidelines contained in the NSW Floodplain Management Manual. The plan usually contains both written and diagrammatic information describing how particular areas of the floodplain are to be used and managed to achieve defined objectives.
Flood planning levels (FPL)	Flood planning levels selected for planning purposes are derived from a combination of the adopted flood level plus freeboard, as determined in floodplain management studies and incorporated in floodplain risk management plans. Selection should be based on an understanding of the full range of flood behaviour and the associated flood risk. It should also take into account the social, economic and ecological consequences associated with floods of different severities. Different FPLs may be appropriate for different categories of landuse and for different flood plans. The concept of FPLs supersedes the “standard flood event”. As FPLs do not necessarily extend to the limits of flood prone land, floodplain risk management plans may apply to flood prone land beyond that defined by the FPLs.
flood prone land	Land susceptible to inundation by the probable maximum flood (PMF) event. Under the merit policy, the flood prone definition should not be seen as necessarily precluding development. Floodplain Risk Management Plans should encompass all flood prone land (i.e. the entire floodplain).
flood source	The source of the floodwaters. In this study, Hunter River flooding is the primary source of floodwaters.
flood storage	Floodplain area that is important for the temporary storage of floodwaters during a flood.

floodway	A flow path (sometimes artificial) that carries significant volumes of floodwaters during a flood.
freeboard	A factor of safety usually expressed as a height above the adopted flood level thus determing the flood planning level. Freeboard tends to compensate for factors such as wave action, localised hydraulic effects and uncertainties in the design flood levels.
geomorphology	The study of the origin, characteristics and development of land forms.
gauging (tidal and flood)	Measurement of flows and water levels during tides or flood events.
historical flood	A flood that has actually occurred.
hydraulic	The term given to the study of water flow in rivers, estuaries and coastal systems.
hydrodynamic	Pertaining to the movement of water
hydrograph	A graph showing how a river or creek's discharge changes with time.
hydrographic survey	Survey of the bed levels of a waterway.
hydrologic	Pertaining to rainfall-runoff processes in catchments
hydrology	The term given to the study of the rainfall-runoff process in catchments.
isohyet	Equal rainfall contour
m/s (metres per second)	Unit used to describe the velocity of floodwaters.
m^3/s (cubic metres per second)	Also referred as 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.
morphological	Pertaining to geomorphology
peak flood level, flow or velocity	The maximum flood level, flow or velocity that occurs during a flood event.
pluviometer	A rainfall gauge capable of continously measuring rainfall intensity
probable maximum flood (PMF)	An extreme flood deemed to be the maximum flood likely to occur.
probability	A statistical measure of the likely frequency or occurrence of flooding.
riparian	The interface between land and waterway. Literally means "along the river margins"
runoff	The amount of rainfall from a catchment that actually ends up as flowing water in the river or creek.

stage	equivalent to water level (both measured with reference to a specified datum - see flood level.
stage hydrograph	A graph of water level over time.
sub-critical	Refers to flow in a channel that is relatively slow and deep
topography	The shape of the surface features of land
velocity	The speed at which the floodwaters are moving. A flood velocity predicted by a 2D computer flood model is quoted as the depth averaged velocity, i.e. the average velocity throughout the depth of the water column. A flood velocity predicted by a 1D or quasi-2D computer flood model is quoted as the depth and width averaged velocity, i.e. the average velocity across the whole river or creek section.
water level	See flood level.

PART A – FLOODPLAIN RISK MANAGEMENT STUDY

1 Introduction

The Williamtown Salt Ash Flood Study and Williamtown Salt Ash Flood Study Review were prepared for Port Stephens Council (Council) by BMT WBM in 2005 and 2012 respectively, to define the flood behaviour of the Williamtown / Salt Ash area. Through the establishment of appropriate numerical models, the study produced information on flood flows, velocities, levels and extents for a range of flood event magnitudes under existing catchment and floodplain conditions.

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- Identify and assess measures for the mitigation of existing flood risk;
- Identify and assess planning and development controls to reduce future flood risks; and
- Present a recommended floodplain management plan that outlines the best possible measures to reduce flood damages in the Williamtown / Salt Ash locality.

This report documents the FRMS and presents a recommended Floodplain Risk Management Plan (FRMP) for the Williamtown / Salt Ash area.

This project has been conducted under the State Assisted Floodplain Management Program and received State financial support.

1.1 Study Location

The Williamtown / Salt Ash district is located adjacent to the lower reaches of the Hunter River, on the mid-north coast of NSW as shown in Figure 1-1. The Hunter River drains a catchment area of approximately 21,000 km^2, nearly all of which lies upstream of Raymond Terrace. Much of the study area floodplain is located between Fullerton Cove to the west and Port Stephens to the east. Nelson Bay Road limits the transfer of flood waters from Fullerton Cove into the Williamtown floodplain. Tilligerry Creek, which flows to Port Stephens, has a set of flood gates and levee located at Salt Ash. These structures typically prevent elevated water levels in Port Stephens from flooding the Salt Ash floodplain.

Title:

Study Locality

Figure: **1-1**

Rev: **A**

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 3.75 7.5km

Approx. Scale

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The study area lies partly within the Hunter River floodplain, but also includes the floodplains of a number of local catchments including:

- Windeyers Creek located south and east of Raymond Terrace;
- The Moors Drain flowing between the Williamtown RAAF base and Salt Ash into Tilligerry Creek;
- Tilligerry Creek between Fullerton Cove and Nelson Bay Road, Salt Ash; and
- Minor drainage channels draining to Tilligerry Creek or directly to Fullerton Cove.

The total study area covers over 130 km^2, comprising a combination of forested areas, pastures and urban lands. The main urban communities within the study area include Tomago and Raymond Terrace, however as these are situated on higher ground they are unlikely to be affected by flooding. Properties situated within the lower-lying parts of the study area are situated along Cabbage Tree Road, Nelson Bay Road and Lemon Tree Passage Road, with higher concentrations of urbanisation at both Williamtown and Salt Ash.

1.2 The Need for Floodplain Management in Williamtown-Salt Ash

The townships located within the study area (parts of Raymond Terrace, Williamtown, Salt Ash) have experienced a range of floods over the years. Flooding results from a combination of three mechanisms: rainfall on the local catchments, inundation from the Hunter River floods and tides in Fullerton Cove and Port Stephens. Coincident flooding from all three mechanisms may occur, however, given the differences in driving meteorological conditions and flooding response within the catchments, the coincidence of peak conditions occurring in the study area are unlikely. Nevertheless, consideration is given to combinations of flooding mechanisms in determining design flood conditions in the study area.

Flooding in the study area occurred in 1990 following heavy rainfall over the local catchments. Runoff from the upper catchment areas accumulated in the lower floodplains where drainage was then inhibited by relatively high tidal levels on the downstream side of the floodgates on Tilligerry Creek.

Notable flooding also occurred in 1955, when the major Hunter River flood overtopped Fullerton Cove and inundated the Tilligerry Creek floodplain.

Current practice in floodplain management generally requires consideration of the impact of potential climate change scenarios on design flood conditions. For the Williamtown / Salt Ash area this includes both increases in design rainfall intensities and sea level rise scenarios impacting on ocean boundary conditions. Accordingly, these potential changes will translate into increased design flood inundation, such that future planning and floodplain management in the catchment will need to take due consideration of this increased flood risk.

Low-lying coastal areas, such as those surrounding Fullerton Cove and Tilligerry Creek are at particularly high risk to climate change. The potential for future sea level rise is now expected to be the biggest driver for floodplain management around coastal and estuarine systems such as the Hunter Estuary and Port Stephens. The issue of future sea level rise presents particular challenges to future development, as the risks associated with flooding will progressively increase during the lifetime of the development. It may be such that risks do not manifest until the development is nearing the end of its design life.

There also remains inherent uncertainty regarding the projected extents of sea level rise in the future. The NSW Government has previously adopted a policy that advocates consideration of increased sea levels by 0.4 m by 2050, and 0.9 m by 2100. However, there is potential for sea level rise to occur slower, or indeed faster, than these rates.

Floodplain risk management considers the consequences of flooding on the community and aims to develop appropriate floodplain management measures to minimise and mitigate the impact of flooding. This incorporates the existing flood risk associated with current development, and future flood risk associated with future development and changes in land use.

Accordingly, Council desires to approach local floodplain management in a considered and systematic manner. This study comprises the intermediate stages of that systematic approach, as outlined in the Floodplain Development Manual (NSW Government, 2005).

1.3 The Floodplain Management Process

The State Government's Flood Prone Land Policy is directed towards providing solutions to existing flooding problems in developed areas and ensuring that new development is compatible with the flood hazard and does not create additional flooding problems in other areas. Policy and practice are defined in the Government's Floodplain Development Manual (2005).

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 and provides specialist technical advice to assist Councils in the discharge of their floodplain management responsibilities.

The Policy provides for technical and financial support by the State Government through the following six sequential stages:

Table 1-1 Stages of Floodplain Management

	Stage	Description
1	Formation of a Committee	Established by Council and includes community group representatives and State agency specialists.
2	Data Collection	Past data such as flood levels, rainfall records, land use, soil types etc.
3	Flood Study	Determines the nature and extent of the flood problem.
4	**Floodplain Risk Management Study**	**Evaluates management options for the floodplain in respect of both existing and proposed developments.**
5	**Floodplain Risk Management Plan**	**Involves formal adoption by Council of a plan of management for the floodplain.**
6	Implementation of the Floodplain Risk Management Plan	Construction of flood mitigation works to protect existing development. Use of local environmental plans to ensure new development is compatible with the flood hazard.

The Williamtown Salt Ash Flood Study (2005) and Williamtown Salt Ash Flood Study Review (2012) defined the existing flood behaviour and established the basis for future floodplain management activities.

The Williamtown Salt Ash Floodplain Risk Management Study and Plan (this document) constitutes the fourth and fifth stages of the management process. It has been prepared for Council to provide the basis for future management of flood liable land within the Williamtown / Salt Ash area.

1.4 Structure of Report

This report documents the Study's objectives, results and recommendations.

Section 1 introduces the study.

Section 2 provides background information including a catchment description, history of flooding and previous investigations.

Section 3 outlines the community consultation program undertaken.

Section 4 describes the flooding behaviour in the catchment including climate change analysis.

Section 5 provides a summary of the flood damages assessment including identification of property potentially affected by flooding.

Section 6 provides a review of relevant existing planning measures and controls.

Section 7 provides an overview of potential floodplain risk management measures.

Section 8 presents the recommended measures and an implementation plan.

2 Background Information

2.1 Catchment Description

The Williamtown / Salt Ash district is located adjacent to the lower reaches of the Hunter River, on the mid-north coast of NSW. The Hunter River drains a catchment area of approximately 21,000 km^2, nearly all of which lies upstream of Raymond Terrace and Williamtown.

The topography of the catchment is shown in Figure 2-1. The study area is low-lying, with most locations at an elevation of below RL 10 m AHD and a significant proportion below RL 2 m AHD. Much of the higher land is located within the north and west of the area, between Raymond Terrace, Williamtown and Tomago. The eastern boundary of the area is characterised by a large, elevated dune system, which separates the Tilligerry Creek floodplain from the Tasman Sea. Local catchment runoff predominantly drains to the floodplain areas located around Fullerton Cove and Tilligerry Creek. Tilligerry Creek can drain westwards to the Hunter River, via Fullerton Cove, or eastwards to Port Stephens.

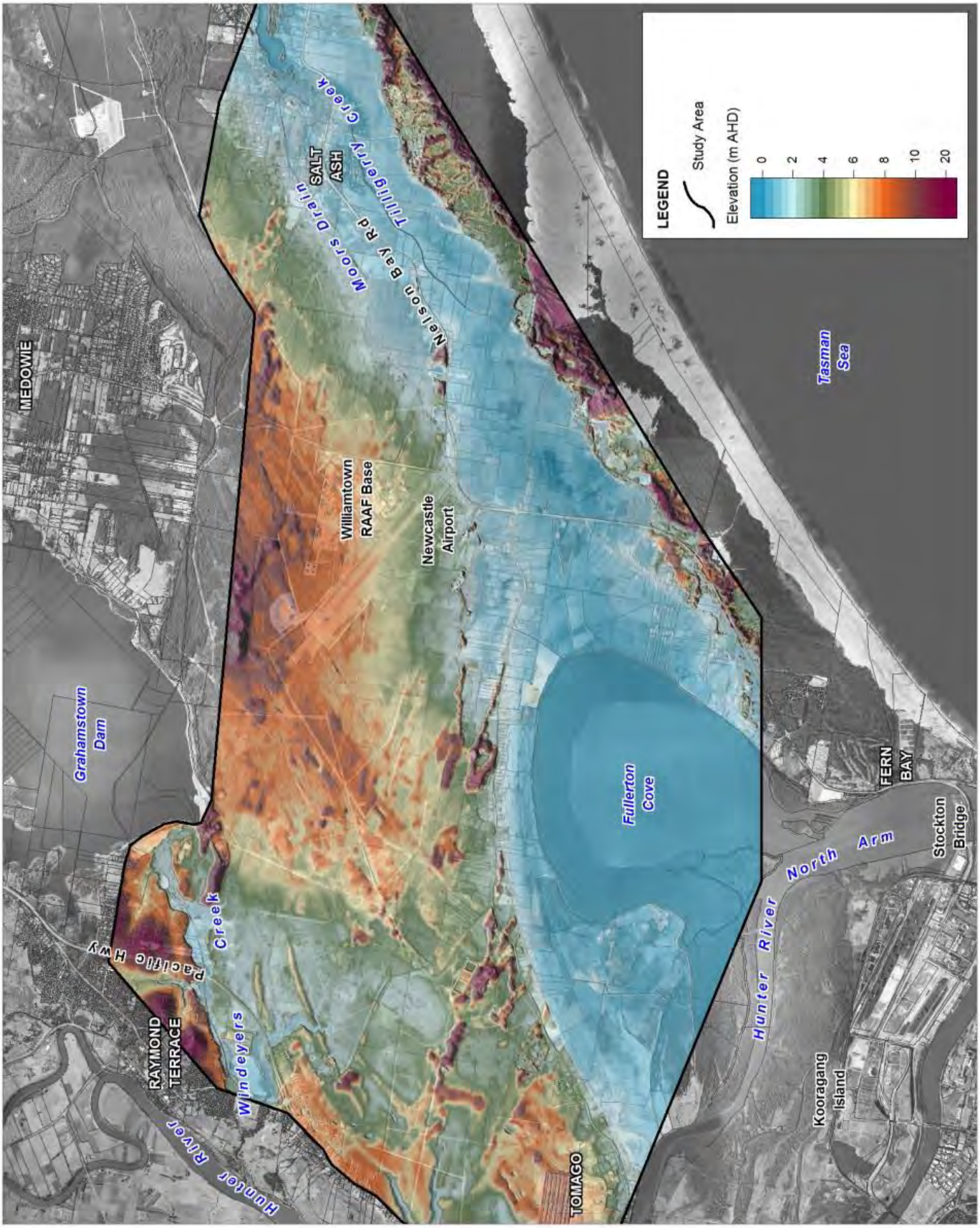
Much of the study area floodplain is located between Fullerton Cove to the west and Port Stephens to the east. Nelson Bay Road limits the transfer of flood waters from Fullerton Cove into the Williamtown floodplain. Tilligerry Creek, which flows to Port Stephens, has a set of flood gates and levee located at Salt Ash. These structures typically prevent elevated water levels in Port Stephens from flooding the Salt Ash floodplain.

During large flood events on the Hunter River a portion of the flood waters will flow eastwards from Fullerton Cove and into Port Stephens, through the Tilligerry Creek floodplain area. The transfer of water through this floodplain area is controlled by a number of topographic features – most notably the physical obstruction of Nelson Bay Road, which is elevated above the floodplain. Flow of water through Nelson Bay Road is restricted to only a small number of culverts, until the flood waters are sufficient to overtop the road crest.

Land use within the catchment primarily consists of bushland (60%), rural pasture (25%) and urban development (15%). The floodplain area principally remains undeveloped and largely occupied by rural farming.

The main urban communities within the study area include Tomago and Raymond Terrace, however as these are situated on higher ground they are unlikely to be affected by flooding. Properties situated within the lower-lying parts of the study area are located along Cabbage Tree Road, Nelson Bay Road and Lemon Tree Passage Road, with higher concentrations of urbanisation at both Williamtown and Salt Ash.

The study area is traversed by a number of important road connections, most notably Nelson Bay Road, which is the only transport route in and out of Port Stephens and Cabbage Tree Road. In order to provide flood-free transport routes, most of the transport routes are elevated above the natural floodplain levels, constructed on embankments with waterway openings (bridges/culverts) at appropriate cross drainage locations.



Title:

Topography of the Study Area

Figure: 2-1

Rev: A

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 1.25 2.5km

Approx. Scale

BMT WBM

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2.2 History of Flooding

The Williamtown / Salt Ash area may experience floods either due to the Hunter River overtopping its banks (and levees), tidal inundation or by excessive rainfall over the local catchment area, or a combination of these mechanisms. Floods due to the Hunter River have been well recorded, due to the gauging station managed by the State Government located at Raymond Terrace. Unfortunately, the same level of documentation for Tilligerry Creek or the other main drains within the project area is not available. However, the 1990 event is certainly the biggest local runoff flood experienced in the area given the volumes of rainfall. Table 2-1 summarises recorded Hunter River peak flood levels with local rainfall recorded at Williamtown summarised in Table 2-2. An overview of the historical flood events is provided hereunder.

Table 2-1 Historical Peak Flood Levels for the Hunter River

Flood event	Max. Hunter River level at Raymond Terrace (m AHD)	Max. Hunter River level at Hexham Bridge (m AHD)
February 1955	4.97	4.00
February 1990	2.86	1.64
April 2015	3.06	1.88
January 2016	2.84	1.50

Table 2-2 Williamtown Rainfall for Historical Events

Flood event	1-day Total (mm)	2-day Total (mm)	3-day Total (mm)
February 1955*	91	108	149
February 1990	276	451	474
April 2015	156	270	283
January 2016	225	262	291

Note * - Rainfall totals for Raymond Terrace with daily values not available for Williamtown

2.2.1 The 1955 Flood

The February 1955 flood was the largest flood on record in the Hunter River. In terms of flood magnitude, it represents a major river flood. The majority of the Williamtown/Salt Ash catchment is part of the Hunter River floodplain, even though it is behind the Fullerton Cove levee. During the 1955 flood, the levee at the time was completely submerged, and most of the Williamtown/Salt Ash area was flooded from the Hunter River.

The 1955 flood was caused by the remains of a tropical cyclone moving southwards from the tropics through the centre of Australia. A great deal of rain fell in the western portions of the Hunter River catchment and was funnelled into the Hunter River at Maitland. This, combined with rainfall on the Paterson River catchment produced an enormous volume of runoff passing through the narrow gap at Green Rocks. There was also substantial rainfall on the Williams River catchment, but the peak flow at Glen Martin occurred three days before the peak flood level at Raymond Terrace.

In 1955 the Fullerton Cove levee had a much lower crest level, and the main roads (Cabbage Tree Road, Nelson Bay Road especially) were also lower than at present. Water levels in the Hunter River completely submerged all embankments in the general study area, and inhibited drainage off the land for many days.

Water levels in the Hunter River were high enough (about 2.5 m AHD in Fullerton Cove) to contribute flow to Tilligerry Creek, with a water level gradient was established between Fullerton Cove and Salt Ash (i.e. water flowed from the Hunter River to Port Stephens via Tilligerry Creek). Water levels within Port Stephens were also high (about 1.7 m AHD) due to high flows in the Karuah River downstream backing up into Lower Tilligerry Creek.

All the low-lying land between Fullerton Cove, Williamtown and Salt Ash was completely inundated. Local flooding in the elevated parts of the project area also occurred due to heavy rainfall.

2.2.2 The 1990 Flood

The 1990 event was a combination of a major local runoff flood over the catchment and high water levels in the Hunter River downstream of the floodgates, preventing the local runoff to drain from the area, therefore increasing the upstream storage of flood waters.

Meteorological records show that the February 1990 flood event was caused by intense rainfall on the catchment as tropical cyclone Nancy tracked southwards down the coast of New South Wales, causing flooding in many coastal rivers. Heavy rainfall over the Lower Hunter River catchment lead to flooding which lasted several days. The two-day rainfall volume recorded at Williamtown RAAF Base was 451 mm (3^{rd} – 4^{th} March 1990) was comparable to the recorded two-day rainfall in March 1893 at Nobby's Head (335 mm) and West Maitland (439 mm) which also caused widespread flooding of the Lower Hunter Valley. The recorded 1-day, 2-day and 3-day totals at Williamtown are the highest on record (site commenced 1942).

The Hunter River did not overtop the Fullerton Cove levee, but its high water levels prevented the local runoff from being drained out of the project area for many days. All the low-lying areas behind the floodgates were inundated by runoff water until the Hunter River levels dropped.

2.2.3 The 2015 Flood

The April 2015 event was also dominated by heavy coastal rainfall, with around 164 mm being recorded in a two day period at Newcastle and 310 mm in a two day period at Raymond Terrace. Localised areas in the Paterson and Williams River catchments received extremely intense rainfall, resulting in the well documented loss of life and destruction of homes in Dungog. The associated flood response in these two river systems was the largest on record. A significant flood response was also recorded on Wollombi Brook and these flows combined to produce the largest flood event in the Hunter Estuary since 1955. However, the resultant flood event magnitude was still likely less than that of a 5% AEP flood condition, with flood waters not spilling into Hexham Swamp over the New England Highway.

The 2-day rainfall at Williamtown for the event is the second highest on record (1990 event highest) and is similar to the January 2016 2-day event total. In comparison to 2016 Intensity-Frequency-Duration (IFD) estimates for Williamtown, the 21st-22nd April 2016 2-day rainfall corresponds to an approximate 5% AEP design rainfall.

2.2.4 The 2016 Flood

The January 2016 event provided for similar mainstream Hunter River flooding conditions as the 1990 event. Accordingly, this represents a lower mainstream flooding condition than the April 2015 conditions. As per previous events of this magnitude, there is no significant floodwater contribution to the Tilligerry Creek floodplain from Hunter River overflows. The daily rainfall total of 225mm recorded at Williamtown on the 6th January 2016 represents the second highest daily total on record after the 276mm recorded on 3rd February 1990.

In comparison to 2016 Intensity-Frequency-Duration (IFD) estimates for Williamtown, the 6th January 2016 1-day rainfall corresponds to between a 5% and 2% AEP design rainfall. Anecdotal flooding reports from residents confirm the January 2016 event to be more severe than the April 2015 event for the local area.

2.3 Previous Studies

The Williamtown / Salt Ash Flood Study was completed by BMT WBM in 2005. Subsequent to the 2005 study was the Williamtown / Salt Ash Flood Study Review completed by BMT WBM in 2012 to supplement the original 2005 study by assessing the impacts of climate change on the previously determined flood levels within the study area.

In addition to the above studies, a number of previous studies have been completed that are related to flooding the Williamtown Salt Ash area including:

- Williams River Flood Study (BMT WBM, 2009)
- Port Stephens Design Flood Levels – Climate Change Review (WMA Water, 2010)
- Tilligerry Creek Flood Study (Lawson & Treloar, 1998)
- Lower Hunter River Flood Study (Lawson & Treloar, 1994)
- Port Stephens Flood Study Stages 1 to 3 (Manly Hydraulics Laboratory, 1997-1999)
- Williamtown Drainage Study (Stanil and Mounser Consulting, 1993)
- Lower Hunter River Flood Mitigation Scheme Williamtown Drainage System Preliminary Hydraulic Analysis (Patterson Britton & Partners, 1992)
- Williamtown-Tomago Drainage (Australian Water and Coastal Studies, 1990)

The Williamtown / Salt Ash Flood Study (2005) report contains comprehensive information on previous investigations and available flood data within the study area. The background information covered by the report included:

- Previous investigations within the study area;
- Historical flood information;

- Rainfall data; and
- Topographic survey data.

Presented in the following sections is an overview of the key previous studies competed.

2.3.1 Williamtown Salt Ash Flood Study (BMT WBM, 2005) and Williamtown Salt Ash Flood Study Review (BMT WBM, 2012)

The Williamtown / Salt Ash Flood Study (BMT WBM, 2005) was prepared for Council to define the existing flood behaviour between Raymond Terrace and Salt Ash and establish the basis for subsequent floodplain management activities. The Williamtown / Salt Ash Flood Study Review (BMT WBM, 2012) was prepared to inform Council of the likely changes in flood behaviour within the study area that may arise through future climate change conditions, particularly in relation to flood planning levels.

The Flood Study and Flood Study Review incorporated the following components:

- Compilation and review of available information including previous studies;
- Collection and review of historical flood information including community survey;
- Acquisition of topographical data for the catchment (originally photogrammetry data and updated to LiDAR data as part of the Flood Study Review);
- Development of a hydrological model (using RAFTS-XP software) and hydraulic model (using TUFLOW software) to simulate flood behaviour in the catchment;
- Calibration and validation of the developed models using the 1955, 1990 and 2000 historical flood events;
- Prediction of design flood conditions in the catchment using the calibrated models, and
- Production of design flood mapping series.

As part of the Flood Study Review significant changes were made to the TUFLOW hydraulic model developed as part of the 2005 Flood Study following the completion of the Williams River Flood Study (BMT WBM, 2009). The follow changes were made to the hydraulic model:

Floodplain topography updated to incorporate the LiDAR aerial survey data, acquired through the Department of Planning Central and Hunter Coasts LiDAR Project January 2007;

The Williams River Flood Study (BMT WBM, 2009) hydraulic model was taken as the base model and was extended to incorporate the additional area modelled by the Williamtown / Salt Ash model. Model details including hydraulic controls, hydraulic structures, model boundaries and roughness distribution from the Williamtown Salt Ash Flood Study model were replicated in the new model. Some additional minor modifications were also undertaken to improve model stability, in line with recent TUFLOW improvements. The result of this composite model construction was a 1D/2D linked hydrodynamic model, covering the Williams River from Dungog to Raymond Terrace, the Hunter River from Green Rocks to Newcastle Harbour and the Tilligerry Creek floodplain area from Fullerton Cove to Salt Ash. This includes the significant hydraulic controls of Nelson Bay Road and the Tilligerry Creek floodgates.

The revised TUFLOW hydraulic model detailed above has been adopted as the base model to define the existing flood behaviour and enable the assessment of potential floodplain management measures. However, further model review and development was undertaken for this study, as detailed in Section 4.2.

2.3.2 Williams River Flood Study (BMT WBM, 2009)

Dungog Shire Council and Port Stephens Council commissioned the Williams River Flood Study (BMT WBM, 2009) in order to define the riverine flood behaviour in the Williams River from Raymond Terrace to 5 km upstream of Dungog. The study encompasses the Lower Hunter River (from Green Rocks to Newcastle Harbour) and investigates the effect of combined flooding from both the Hunter and Williams Rivers.

The Williams River study and model development was subsequent to the completion of the Williamtown / Salt Ash Flood Study (BMT WBM, 2005). The Williams River study model provided a more robust representation of the interaction between Hunter River/Williams River and a better representation of the lower Hunter River floodplain. Accordingly, the model developed for the Williams River study was adopted as the baseline model for Williamtown Salt Ash Flood Study Review (BMT WBM, 2012).

2.3.3 Port Stephens Design Flood Levels – Climate Change Review (WMA Water, 2010)

This climate change review study was initiated by Port Stephens and Great Lakes Councils to help determine the possible implications of climate change on the adopted design flood levels in the Port Stephens estuary. The study builds on the Port Stephens Flood Study (MHL, 1998) and the Port Stephens Foreshore (Floodplain) Management Study and Plan (WMA, 2002).

None of the previous studies assessing flood levels in Port Stephens had considered potential climate change. The study found that the design still water levels within Port Stephens would also rise by the 0.4 m and 0.9 m levels recommended for sea level rise predictions for 2050 and 2100.

The design flood levels provided by the Port Stephens Climate Change Review at Taylors Beach (which is located where Tilligerry Creek enters Port Stephens) have been used to define downstream boundary conditions on Tilligerry Creek for the Williamtown Salt Ash hydraulic model developed as part of the Williamtown Salt Ash Flood Study Review (BMT WBM, 2012).

2.3.4 Lower Hunter River Flood Study (Lawson & Treloar, 1994)

The Lower Hunter River Flood Study was undertaken as part of a floodplain management strategy by Newcastle City and Port Stephens Councils in order to respond appropriately to the increasing development pressures in the Lower Hunter River.

The aim of the study was to deliver a computer model representing the flood processes in the Lower Hunter River. A 1-dimensional MIKE-11 model was adopted for the study. The outcomes of this 1994 study are important to consider for the Williamtown/Salt Ash study area as during severe flood conditions, the Hunter River backs up into Windeyers Creek, Fullerton Cove and Tilligerry Creek.

The Lower Hunter River Flood Study provided flood maps derived from 1-D results representing the estimated flood extent, velocities and flow distribution for the different calibration and design events. Provision of longitudinal flood profiles was made for the Hunter River main channel. Hunter River levels for the Williamtown/Salt Ash Flood Study (BMT WBM, 2005), for both calibration and design events, were taken from the Lower Hunter River Flood Study model results.

2.3.5 Tilligerry Creek Flood Study (Lawson & Treloar, 1998)

The Tilligerry Creek Flood Study was commissioned by Port Stephens Council in order to extend the Lower Hunter River Flood Study to Williamtown and Salt Ash. The floodplain areas between Fullerton Cove and Salt Ash are drained by Tilligerry Creek.

A 1-dimensional MIKE11 model was developed for Tilligerry Creek. The Hunter River boundary conditions were taken from the Lower Hunter River Flood Study results.

The results were presented using longitudinal profiles and 2-D contour maps, with all the approximations associated with translating 1-D results on a 2-D support.

The major relevant comments reported in the Tilligerry Creek Flood Study are summarised below:

- Influence of roads and levees: the Fullerton Cove levee is said to prevent the Hunter River from flooding the Long Bight Swamp for flood smaller than the 2% AEP event, flood waters would be kept within the cove. Bigger floods would overtop the levee, but the water would be contained between Nelson Bay Road and Cabbage Tree Road, leaving Williamtown unaffected directly by the Hunter River. Nelson Bay Road could only be overtopped by water levels rising above 2.2 m AHD, 0.2m higher than the estimated 1% AEP level.
- Although Williamtown, and the areas east of Nelson Bay Road, would be protected from the Hunter River waters, the presence of small culverts under Nelson Bay Road would allow water to pass through the embankment and inundate the upstream areas. The problem would be accentuated by upstream local runoff that could not get drained due to the high downstream water levels.
- Local runoff: most of local the runoff over the Tilligerry Creek catchment is directed to Salt Ash, either through Tilligerry Creek or the Moors Drain. However, a certain proportion flows west to Fullerton Cove, adding to any flood waters coming from the Hunter River.
- Floodgates: floodgates allow flood water to be drained downstream of a flooded area but only if the downstream water level is lower than the upstream level. In the case of Fullerton Cove or Salt Ash, downstream water levels (Hunter River or Port Stephens) regulate the rate of flow discharging from the Tilligerry Creek catchment.
- It is mentioned that there is a possibility for the Windeyers Creek catchment to connect to the Tilligerry Creek catchment during large Hunter River flood events. It was however concluded that the impact on Tilligerry Creek by Windeyers Creek flows would not be significant.
- Extreme event: an extreme event would overtop all roads and levees.

- Drainage time: it is mentioned that the flatness of the Tilligerry Creek floodplain leads to long inundation times. It is expected that full drainage of a 1% AEP flood event over the Tilligerry Creek catchment would take 10 to 15 days.

2.3.6 Port Stephens Flood Study – Stage 2 Design Water Levels and Wave Climate (Manly Hydraulics Laboratory, 1997)

The Port Stephens Flood Study was undertaken to determine the nature and extent of flooding around the foreshore of Port Stephens and Tilligerry Creek. The nature of the flooding has been defined in terms of design water levels and design wave climate in Port Stephens.

The study investigated the complex combination of factors influencing flood levels at any location in Port Stephens, and consequently in Tilligerry Creek. These factors include:

1 Port Stephens water level, which is influenced by:

(a) Astronomical tide levels;

(b) Ocean storm surge (oceanic wave setup and barometric effects);

2 Local wind setup within the Port;

3 Catchment runoff from rainfall;

4 Rain falling onto Port Stephens directly.

Sensitivity analysis in the Study proved that flood levels in Tilligerry Creek are controlled by the combination of rainfall-runoff and Port Stephens water levels. The report indicates that fixing 1% AEP flood levels at Mud Point at 1.76 m AHD represents a totally different and independent flood event to the event generating 1% AEP flood levels in Tilligerry Creek.

3 Community Consultation

3.1 The Community Consultation Process

Community consultation has been an important component of the current study. The consultation has aimed to inform the community about the development of the floodplain risk management study and its likely outcome as a precursor to the development of the floodplain risk management plan. It has provided an opportunity to collect information on their flood experience, their concern on flooding issues and to collect feedback and ideas on potential floodplain management measures and other related issues.

The key elements of the consultation process have been as follows:

- Consultation with the Floodplain Management Committee through meetings and presentations; and
- Public exhibition of the Draft Floodplain Risk Management Study and Plan (incorporating a community information session).

These elements are discussed in detail below.

3.2 The Floodplain Management Committee

The study has been overseen by the Floodplain Risk Management Committee (Committee). The Committee has assisted and advised Council in the development of the Williamtown Salt Ash Floodplain Risk Management Study and Plan.

The Committee is responsible for recommending the outcomes of the study for formal consideration by Council.

Members of the Floodplain Management Committee include representatives from the following:

- Port Stephens Council - Councillors;
- Staff from Port Stephens Council;
- Representatives from the NSW Office of Environment and Heritage;
- Representatives from the State Emergency Service (SES);
- Representatives from Hunter Water; and
- Community representatives.

3.3 Public Exhibition

The Draft Williamtown – Salt Ash Floodplain Risk Management Study and Plan was placed on public exhibition from Wednesday 2nd September 2015 to Wednesday 30th September 2015 with the report being made available at Council's website and Council Administration Building. Landowners, residents and businesses were invited to participate in the study by providing comment on the Draft report through formal submissions.

As part of the public exhibition of the Draft report, a community information session was held at Williamtown Hall Thursday 17th September 2015 4 pm to 6 pm. The session was attended by technical representatives from Port Stephens Council, OEH and BMT WBM (Consultant) providing the opportunity for local community members to receive additional feedback on any areas of concern or issues. Community attendance at the session was modest (~20 attendees) with no significant issues raised in relation to the Draft Report documentation and outcomes. Most community interest was around the current drainage and water quality issues.

3.3.1 Community Submissions

Following the close of public exhibition, three (3) submissions were received from the community as below:

- Tomaree Ratepayers and Residents Association Incorporated (TRRA Inc);
- a Port Stephens Councillor; and
- a resident of Nelson Bay Road, Salt Ash.

The submissions are included for reference in Appendix C. A summary of the key issues raised is provided below.

Local Drainage

Concerns were raised on the capacity of the local drainage system noting the potential impact of recent and future development in increasing pressure on the existing system through increased runoff. This concern was linked to the development approvals process and the requirement for appropriate drainage/flood management controls to be applied in development assessment and approvals. Further, there was recommendation for a local drainage study and management / maintenance plan.

Land Development and Approvals

Support was provided for the recognition of increasing flood risk and potential future liability associated with climate change and the need for appropriate development controls. In response to these concerns, there was general support for the recommended flood planning. Further support was noted for a more strategic planning approach in regards to the cumulative impact of floodplain development.

4 Existing Flood Behaviour

4.1 General Catchment Flood Behaviour

Flooding in the Williamtown / Salt Ash study area is primarily caused by three mechanisms or combination of them:

- Flooding due to local runoff;
- Flooding due to backwater effects of flooding in the Hunter River or elevated ocean tide, which may include overtopping of the levee system surrounding Fullerton Cove; and
- Flooding due to backwater effects of flooding in Port Stephens, which may include overtopping of the levee system at Salt Ash.

The dominant flooding mechanism (in terms of peak design water levels) for the Williamtown / Salt Ash locality is mainstream Hunter River flooding. Under these conditions, Hunter River flooding results in Fullerton Cove filling and discharging into the Tilligerry Creek floodplain, under cross-drainage structures and through overtopping of Nelson Bay Road.

Elevated roads and levee banks constructed in the area have an impact on flooding of the local floodplains. These elevated "controls" affect the flow of Hunter River floods onto the floodplain, and the drainage of the floodplain after both local catchment flooding and Hunter River inundation. During larger Hunter River floods, roads such as Nelson Bay Road, Lavis Lane and Oakfield Lane divide the floodplain into a series of "compartments" each of which fills before water then cascades into the next.

The Fullerton Cove Ring Levee provides flood protection from the moderate Hunter River floods. A flood with a predicted level of 1.3 m AHD in Fullerton Cove would just overtop the ring levee. Larger Hunter River floods, which overtop the ring levee, are controlled by the section of Nelson Bay Road between Cabbage Tree Road and Fullerton Cove Road. Flood levels in Fullerton Cove would need to rise above 2.0 m AHD, approximately 0.2 m above the existing 1% AEP level, before the lowest section of Nelson Bay Rd is overtopped.

Flooding of the area may also occur due to local rainfall. Runoff from areas to the north of Nelson Bay Road generally flows eastwards via Moors Drain, parallel to the road, into Tilligerry Creek, downstream of the floodgates at Salt Ash. When the capacity of the Moors Drain is exceeded, the excess water flows under Nelson Bay Road (via several culverts) and into the Tilligerry Creek floodplain. This water, combined with the rainfall that falls onto the floodplain directly, inundates the area for several days before it can drain into either Fullerton Cove or Port Stephens.

Inundation of the area due to coincident Hunter River or elevated ocean tide and local catchment flooding is a possibility. The coincident flooding would produce higher peak flood levels than local catchment flooding alone only in the lower Tilligerry Creek floodplain areas (mostly south of Cabbage Tree Road and Nelson Bay Road). Flooding on the northern side of Nelson Bay Road would not generally be affected by flood levels in Fullerton Cove.

Flood behaviour varies across the study area, in response to the topographical features and flooding mechanisms associated with different locations, as follows:

- Williamtown: only moderate to major Hunter River floods have the potential to have an impact on the area, due to the high level of the Fullerton Cove levee. The 1955 event resulted in significant overbank flooding. Local runoff flooding is, on the contrary, quite frequent in the Williamtown/Salt Ash area, especially due to the low level of the ground which is lower than high tide level, making drainage difficult. An example of a significant local runoff flood is the 1990 event.
- Windeyers Creek catchment: Windeyers Creek flows directly into the Hunter River, downstream of Raymond Terrace. The flood levels along Windeyers Creek are driven by flow conditions in the Hunter River. Hunter River flood water provides a backwater influence in Windeyers Creek, which fills the Windeyers Creek floodplain to the east of the Pacific Highway. The total volume of water flowing from the Hunter River along Windeyers Creek determines the flood level reached in the Windeyers Creek floodplain. Given the typical long duration of Hunter River flooding for major events, the peak flood levels attained in the Windeyers Creek floodplain are similar to the mainstream Hunter River levels at the confluence.
- Hunter River floodplain at Tomago Sandbeds: principally affected by Hunter River floods, the area bounded by Fullerton Cove, Cabbage Tree Road and Nelson Bay Road gets filled with Hunter River water once the Fullerton Cove levee is overtopped. The severity of flooding in the area depends on the magnitude of the Hunter River flood. The roads have high crest levels, generally preventing inundation of other flood prone land, although the presence of culverts under the roads does allow some inundation. Drainage of the land is directly related to the water levels in Fullerton Cove. If the water levels in Fullerton Cove stay high (due to Hunter River floods or elevated ocean tide), the Tomago Sandbed land can remain undrained. High tide levels are already sufficient to significantly inhibit drainage through the floodgates.
- Tilligerry Creek catchment: the catchment can be divided into two parts:
    - To the north of the Moors Drain, there is little backwater effect to flooding, with runoff flowing in a generally southerly direction. The depth of flood water is primarily related to the rainfall intensity.
    - To the south, runoff accumulates within the naturally low-lying swale between the Stockton Beach sand dunes and Nelson Bay Road. The water ponds in this area until the downstream conditions are favourable for drainage, i.e. low water levels downstream of the Salt Ash floodgates and downstream of the Fullerton Cove flood gates.

4.2 Review of Existing Model

The Williamtown / Salt Ash Flood Study (BMT WBM, 2005) included the development of a hydraulic model for the study area. Subsequent to completion of the Flood Study, further modelling of the Lower Hunter River system has been undertaken for the Williams River Flood Study (BMT WBM, 2009) and Williamtown Salt Ash Flood Study Review (BMT WBM, 2012). Further refinement of the existing models has been undertaken as part of the Floodplain Risk Management Study following detailed review of the previous modelling. Summarised hereunder is a history of the model development and configuration changes built in the current model.

4.2.1 Model Development and Configuration

The model developed for the Williamtown / Salt Ash Flood Study (BMT WBM, 2005) represents the first detailed flood model of the study area. This model was a fully hydrodynamic 1D/2D linked model, utilising the TUFLOW software modelling package. The model included 1D representation of drainage channels, creeks and hydraulic structures. Other significant hydraulic controls, such as elevated road embankments were incorporated as 3D breaklines to ensure that the crest levels that control flood propagation are properly defined.

The Hunter River flood inputs to the Williamtown / Salt Ash Flood Study model were extracted from the Lower Hunter River Flood Study (L&T, 1994) and applied as water level boundaries at Windeyers Creek and Fullerton Cove. A downstream tidal water level boundary was applied to Tilligerry Creek and local catchment inflows were input as flow hydrographs, output from the XP-RAFTS hydrological model.

As part of the Williamtown / Salt Ash Flood Study Review (BMT WBM, 2012), it was identified that the existing model boundary configuration of water level boundaries to represent inflows to the study area from the Hunter River is not suitable for considering the impacts of climate change. The modelled water levels from the Lower Hunter River Flood Study are only representative of the baseline flow, tidal and topographic conditions at the time of the study. These boundaries could not simply be modified to properly assess the impacts of climate change on flood behaviour within the study area. The interaction of flood flows on the Hunter River, Windeyers Creek and Tilligerry Creek and the sensitivity of flood levels in Fullerton Cove to increased tide levels at Newcastle Harbour is complex. This required a more robust model boundary configuration to predict flood levels in the study area to a reasonable accuracy.

The best approach to assess the impact of climate change on the Lower Hunter and its exchange of flows to the Tilligerry Creek floodplain was to model the Lower Hunter from upstream of Windeyers Creek to Newcastle Harbour. This enabled the impact of greater river flows (from increased design rainfall) and increased sea levels to be assessed properly in both isolation and combination. The Williams River Flood Study (BMT WBM, 2009) incorporates a model of the Williams River and the Lower Hunter River from Green Rocks to Newcastle Harbour. The availability of this model enabled the best approach for this study to be undertaken, by linking the hydraulic models from each study.

The Williams River Flood Study (BMT WBM, 2009) included the development of a hydraulic model for the Williams River catchment from Dungog to Raymond Terrace. It also incorporates the Lower Hunter River from Green Rocks to Newcastle Harbour. As for the Williamtown / Salt Ash Flood Study, this model is a fully hydrodynamic 1D/2D linked model, utilising the TUFLOW software modelling package. Similarly, the model is also based on a 2D domain grid resolution of 40 m.

Model inflows for the Williams River catchment were derived from hydrologic modelling of sub-catchment runoff using the XP-RAFTS software and the AR&R guidelines for estimating design rainfall. The Hunter River inflow boundary is consistent with that utilised by the Lower Hunter River Flood Study. The downstream tidal level boundary at Newcastle Harbour is consistent with the adopted boundary in the Lower Hunter flood model being developed for Newcastle City Council by DHI.

The Williams River Flood Study model was taken as the base model and was extended to incorporate the additional area modelled by the Williamtown / Salt Ash model. Hydraulic controls, hydraulic structures, model boundaries and roughness details etc. from the Williamtown model were replicated in the new model, whilst ensuring that any instances of duplication were avoided. Some additional minor modifications were also undertaken to improve model stability, in line with recent TUFLOW improvements. The result of this composite model construction was a 1D/2D linked hydrodynamic model, covering the Williams River from Dungog to Raymond Terrace, the Hunter River from Green Rocks to Newcastle Harbour and the Tilligerry Creek floodplain area from Fullerton Cove to Salt Ash. This includes the significant hydraulic controls of Nelson Bay Road and the Tilligerry Creek floodgates.

The existing model topography has largely been developed using LiDAR aerial survey data acquired through the Department of Planning Central and Hunter Coasts LiDAR Project, January 2007. More recent LiDAR covering the study area has been acquired by NSW Land and Property Information (NSW LPI) in 2013. Comparison of the 2007 and 2013 LiDAR provides for some differences in floodplain levels, typically of the order of 0.2-0.3 m but greater in some locations. This could be due to a number of factors, such as filtering algorithms, the nature of vegetation at the time of the data capture and the accuracy of the ground control points. Typically, the areas of greatest difference coincide with heavily vegetated parts of the floodplain. Ground survey data in the Fullerton Cove and Tomago localities held by BMT WBM from other projects confirmed the 2007 LiDAR data set to be a better match to the ground survey levels. Accordingly, the 2007 LiDAR was retained for representation of the general floodplain.

The 2007 LiDAR data was delivered as a gridded bare earth Digital Elevation Model (DEM) with a 2 m resolution. The quality assurance report states that the raw data has a vertical accuracy of +/- 150 mm root-mean-square error (RMSE) and a horizontal accuracy of +/- 600 mm RMSE. Ground filtering algorithms, specifically designed to suit this data set, had then been applied to the raw point cloud to produce the bare earth DEM. The dataset is generally of a good quality, however, the filtering algorithms struggle to remove areas of dense low-lying vegetation of wetland areas, such as reed beds and mangroves. Therefore, the topography around Fullerton Cove, which has large areas of these vegetation types, was left unchanged from the original model. The areas that were updated were restricted to that between Raymond Terrace, Tomago and Williamtown and between Fullerton Cove and Salt Ash.

Additional changes to the model topography were also made to Fullerton Cove and the Hunter River channel between Fullerton Cove and Newcastle Harbour. This was done to improve the transition between areas covered by bathymetric survey (in-channel regions) and areas covered by photogrammetric survey (floodplain regions). The original model DEM did not have a smooth transition between the two datasets and as a result was impacting slightly on the channel conveyance capacity.

Recent development in the lower Hunter floodplain has been incorporated into the TUFLOW model. The major developments include rail infrastructure constructed by Aurizon and Australian Rail Track Corporation (ARTC) in the Hexham locality, and the major industrial development of WesTrac along Tomago Road. The rail works incorporate newly constructed elevated road and rail embankments across the floodplain and a construction of a maintenance facility. The WesTrac development comprised filling of the floodplain to provide the flood immunity for the industrial site.

The 2013 LiDAR data provided for the best representation of current floodplain development conditions incorporating modified landforms for major development completed subsequent to the previous studies (e.g. WesTrac facility, Tomago). The data was also used to reinforce some of the key hydraulic controls such as road crest levels where data is typically unaffected by vegetation conditions.

The hydrologic and hydraulic models used in this study (i.e. those from both the Williamtown / Salt Ash Flood Study and the Williams River Flood Study) were previously calibrated and verified to available historical flood event data to establish the values of key model parameters and confirm that the models were capable of accurately predicting real flood events. Details of this process can be found in the relevant report for each flood study.

Model topography, cell size and other parameters, such as roughness values, were retained from the original models (albeit with some minor local modifications). Accordingly, a model re-calibration was not required.

The local sub-catchment definition in the Williamtown Salt Ash study area is relatively coarse in the existing model configurations. Whilst being appropriate for simulation of the contribution to mainstream Hunter River flood conditions, the local overland flow path distribution is not adequately resolved. The local sub-catchments were further modelled using a direct rainfall (rainfall on grid) approach in the TUFLOW model in order to provide indicative local catchment flood inundation.

It is noted that the local sub-catchments are characterised by typically sandy soils and highly undulating topography with numerous depressions, a function of the relic sand dunes. Infiltration losses accordingly would be expected to be high and these processes may not be well represented in the existing modelling. Accordingly, the local catchment mapping provided in the current study is indicative only and may be refined by more detailed local overland flow studies, with further consideration of the local soil characteristics and small scale drainage features that may influence the overland flow behaviour.

4.2.2 Review of Flood Frequency Analysis

The Lower Hunter River Flood Study (Green Rocks to Newcastle) (PWD, 1994) included a Flood Frequency Analysis (FFA) of water levels at Raymond Terrace. This FFA has been used as the basis for design flood estimation in the Hunter Estuary for all of the studies undertaken since 1994. There is an additional 23 years of complete annual maxima data available at the Raymond Terrace gauge since the original FFA, which is now out of date and in need of review.

As part of ongoing studies in the Lower Hunter, BMT WBM has undertaken an updated FFA at Raymond Terrace. This utilised the historic data detailed in the 1994 study and the continuous gauged data recorded at the site since 1994.

There are inherent uncertainties regarding the estimation of design flood flows, particularly for the large magnitude events. The revised FFA provides for some improvement over that undertaken in 1994 as it has been derived using a larger dataset and with the latest approach recommended by AR&R. Additional details of the updated FFA are provided for reference in Appendix B.

A comparison of the design flood levels at Raymond Terrace from the revised FFA with those from the 1994 study is presented in Table 2. The revised levels are typically 0.2 m to 0.3 m higher than the previous levels, although the revised 1% AEP level is equivalent. There are a number of reasons for the differences between the two, including:

- There is an extra 20+ years of annual maxima data from which to derive the revised FFA;
- Consideration of changes in rating curve between historical events; and
- Application of different probability distribution and plotting parameters.

Table 4-1 Comparison of Design Flood Levels from the 1994 and Revised FFAs

Design Event	Flood Level (m AHD))	
	1994 FFA	Revised FFA
20% AEP	2.1	2.4
10% AEP	2.7	2.9
5% AEP	3.1	3.2
2% AEP	3.7	4.1
1% AEP	4.8	4.8
0.5% AEP	(not estimated)	5.2

4.3 Climate Change Scenarios

The NSW Floodplain Development Manual (DIPNR, 2005) requires consideration of climate change in the preparation of Floodplain Risk Management Studies and Plans, with further guidance provided in:

- Floodplain Risk Management Guideline – Practical Consideration of Climate Change (DECC, 2007); and
- Flood Risk Management Guide – Incorporating Sea Level Rise Benchmarks in Flood Risk Assessments (DECCW, 2010).

Key elements of future climate change (e.g. sea level rise, rainfall intensity) are therefore important considerations in the ongoing floodplain risk management.

In 2009, the NSW Government incorporated consideration of potential climate change impacts into relevant planning instruments. The NSW Sea Level Rise Policy Statement (DECCW, 2009) was prepared to support consistent adaptation to projected sea level rise impacts. The policy statement incorporated sea level rise planning benchmarks for use in assessing potential impacts of sea level rise in coastal areas, as well as in flood risk and coastal hazard assessments. The benchmarks were a projected rise in sea level, relative to the 1990 mean sea level, of 0.4 m by 2050 and 0.9 m by 2100.

Subsequently, the NSW Government announced its Stage One Coastal Management Reforms (September, 2012). As part of these reforms, the NSW Government no longer recommends statewide sea level rise benchmarks for use by local councils, but instead provides councils with the flexibility to consider local conditions when determining future hazards within their LGA.

Accordingly, it is recommended by the NSW Government that councils should consider information on historical and projected future sea level rise that is widely accepted by scientific opinion. This may include information in the NSW Chief Scientist and Engineer's Report entitled 'Assessment of the Science behind the NSW Government's Sea Level Rise Planning Benchmarks' (2012).

The NSW Chief Scientist and Engineer's Report (2012) acknowledges the evolving nature of climate science, which is expected to provide a clearer picture of the changing sea levels into the future. The report identified that:

- The science behind sea level rise benchmarks from the 2009 NSW Sea level Rise Policy Statement was adequate;
- Historically, sea levels have been rising since the early 1880s;
- There is considerable variability in the projections for future sea level rise; and
- The science behind the future sea level rise projections is continually evolving and improving.

For the majority of climate change analysis undertaken in flood risk assessments within the Port Stephens LGA to date, the potential impacts of sea level rise have been based on sea level rise projections from the 2009 NSW Sea Level Rise Policy Statement. Given that the Chief Scientist and Engineer's Report finds the science behind these sea level rise projections adequate it was agreed between Council and BMT WBM that the potential impacts of sea level rise for the Williamtown-Salt Ash catchment continue using previous benchmarks.

The Intergovernmental Panel on Climate Change (IPCC) is the leading body for the assessment of climate change globally. Since its establishment in 1988, the IPCC have released five climate change reports, the most recent of which is known as the *'Fifth Assessment Report'* known as AR5 which was realised in four parts between September 2013 and November 2014. This report supersedes the four previous IPCC reports. The AR5 provides a thorough discussion about climate change science, with the outcome of the study focused strongly on the documentation of the likely impacts of climate change in the global context.

The documented impacts were representative of broad geographical regions (i.e. polar and equatorial regions) and were based on a range of future greenhouse gas emissions and concentration scenarios (IPCC, 2013). These future scenarios are referred to as known as Representative Concentration Pathways (RCPs). They focus on the 'concentrations' of greenhouse gases that lead directly to a changed climate, and include a 'pathway' – the trajectory of greenhouse gas concentrations over time to reach a particular radiative forcing at 2100. The four RCPs cover a range of emission scenarios with and without climate mitigation policies. For example, RCP8.5 is based on minimal effort to reduce emissions. Particular focus is given to RCP4.5 (low emissions pathway) and RCP8.5 (high emissions pathway).

Utilising the outcomes of IPCC AR5, CSIRO and the Australian Bureau of Meteorology have prepared tailored climate change projection reports for Australian regions (known as clusters) including the East Coast region. The *East Coast Cluster Report – Climate Change Projections for*

Australia's Natural Resource Management Regions (Dowdy et al, 2015) included projections for expected sea level rise as shown in Figure 4-1.

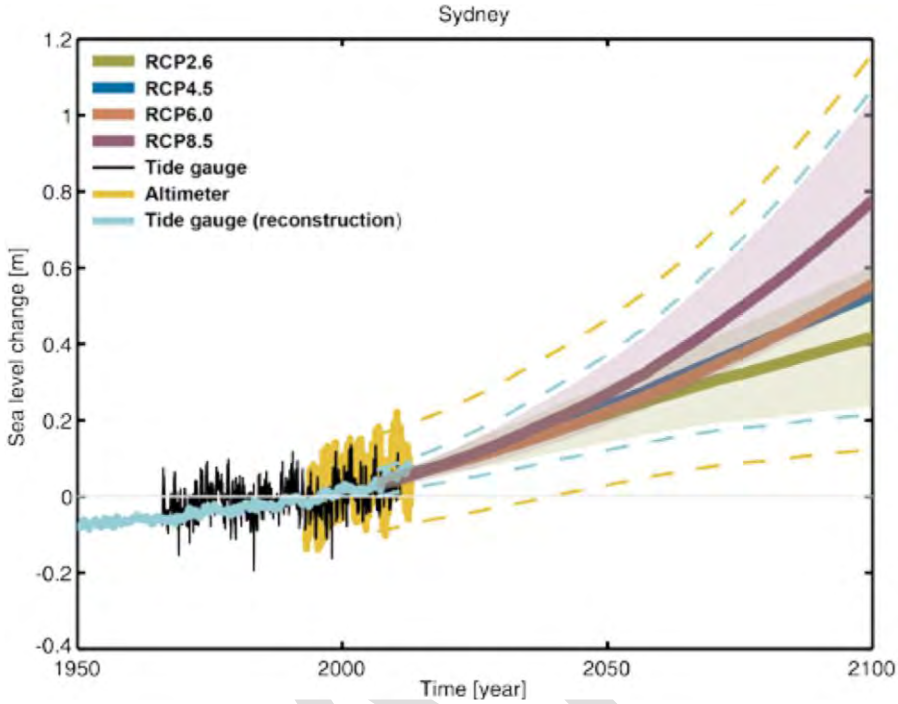


Figure 4-1 Sea Level Rise Projections (Dowdy et al, 2015)

Numerous climate models have been applied in determining the sea level rise estimates with the solid lines in Figure 4-1 providing the multi-model mean projections – e.g. purple line for RCP8.5 scenario. The shaded purple represents the uncertainty range associated with the modelling of the RCP8.5.

The 0.4 m and 0.9 m sea level rise allowances currently adopted by Council are consistent with the upper uncertainty bound 2050 and 2100 projections under the RCP8.5 (high emissions) pathway.

Worsening coastal flooding impacts as a consequence of sea level rise in lowland areas such as along Tilligerry Creek are of particular concern for the future. Regional climate change studies (e.g. CSIRO, 2004) indicate that aside from sea level rise, there may also be an increase in the maximum intensity of extreme rainfall events. This may include increased frequency, duration and height of flooding and consequently increased number of emergency evacuations and associated property and infrastructure damage.

The predicted impact of climate change on rainfall conditions includes:

- Increase in average annual rainfall – changes in annual rainfall conditions is unlikely to have a significant on impact on flooding regimes. However, wetter than average conditions may increase the opportunity for wet antecedent conditions at the onset of a rainfall event.
- Increases in rainfall intensity – climate change impacts on flood producing rainfall events are expected to show a trend for more frequent, higher intensity storms. This increase in design rainfall intensity will translate into higher peak flows and runoff volumes providing for increased flood inundation in the Hunter River.

In 2007 the NSW Government released a guideline for practical consideration of climate change in the floodplain management process that advocates consideration of increased design rainfall intensities of up to 30%. Future planning and floodplain management in the catchment will need to take due consideration of this increased flood risk.

Dowdy et al. (2015) includes projected changes in heavy rainfall events including the potential increase in 20-year return period maximum 1-day rainfall as shown in Figure 4-2. The blue and purple columns in Figure 4-2 represent the RCP4.5 and RCP8.5 scenarios respectively. The relative change in the 20-year return level of maximum 1-day rainfall is approximately 18% for the low-emissions pathway (RCP4.5) and 25% for the high-emissions pathway (RCP8.5).

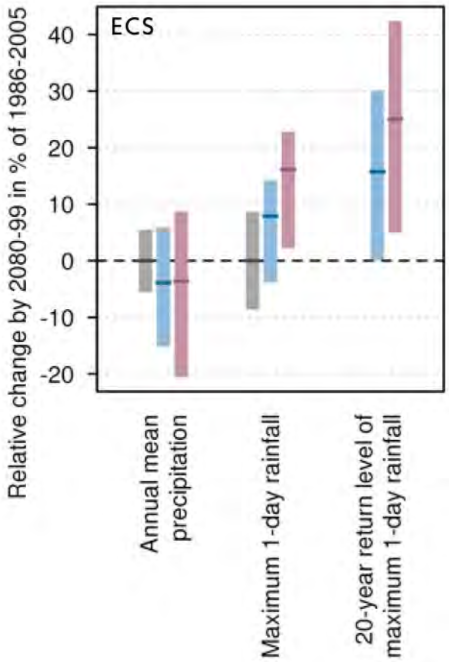


Figure 4-2 Projected Changes in Rainfall (Dowdy et al, 2015)

With consideration of the above, Council has adopted the following climate change provisions in consideration of flood planning in the LGA:

- Sea level rise benchmarks of 0.4 m and 0.9 m; and
- Rainfall intensity increases of 20%.

The sea level rise benchmarks were adopted by Council in 2009 consistent with the State Government Policy at the time. Council's current Floodplain Risk Management Policy adopted 8th March 2016 adopts Flood Planning Levels based on the 1% AEP (annual exceedance probability) flood event in the year 2100 plus 0.5 metre freeboard.

4.4 Revision of AR&R Guidelines

Australian Rainfall and Runoff: A Guide to Flood Estimation (AR&R) is a national guideline for the estimation of design flood characteristics in Australia. Engineers Australia has undertaken a revision of AR&R. The revision process included 21 research projects, which have been designed to fill knowledge gaps that have arisen since the 1987 edition was published. The AR&R 2016 Update was officially released in November 2016.

The Bureau of Meteorology (BoM) has released the new 2016 Intensity-Frequency-Duration (IFD) design rainfalls as part of the revision of AR&R. Detailed IFD relationships across the country were last investigated prior to the publication of the 1987 edition of AR&R. The new IFD design rainfall estimates are based on a more extensive rainfall database then the 1987 IFD design rainfall estimates with statistical analysis of an additional 30 years of rainfall data as well as data from an additional 2300 rainfall stations included in the new rainfall database.

The IFD data presented in Table 4-2 and Table 4-3 provides for the total rainfall depth for a given storm duration based on the 1987 and 2016 IFD design rainfall estimates respectively.

Table 4-2 Design Rainfall Estimates Based on 1987 IFD Data (mm)

Duration (hours)	Rainfall Depth (mm) for Design Event Frequency				
	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP
1	44	49	56	66	73
2	57	64	74	86	96
3	66	74	85	100	111
6	84	95	109	128	142
12	109	122	142	167	186
24	144	164	190	224	250

Table 4-3 Design Rainfall Estimates Based on 2016 IFD Data (mm)

Duration (hours)	Rainfall Depth (mm) for Design Event Frequency				
	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP
1	46	57	68	83	95
2	59	72	86	105	121
3	67	83	99	121	139
6	86	105	126	154	178
12	110	135	162	200	232
24	141	173	208	258	300

As evidenced in Table 4-2 and Table 4-3, there are some significant differences in the updated 2016 IFD estimates in comparison to the 1987 IFD data. Generally, the 2016 data provides for increases in the design rainfall estimate. A comparison of the design rainfall estimates in the form of percentage change in design rainfall estimate (change from 1987 IFD to 2016 IFD value) is shown in Table 4-4. With respect to key 1% AEP flood planning event, the 2016 IFD data provides for significantly higher estimates of design rainfall to the 1987 IFD data. Accordingly, there is a general trend of the 2016 IFD data providing for increasingly higher design rainfall estimates for larger magnitude events in comparison to the 1987 IFD data.

With respect to the Williamtown-Salt Ash study area, the release of the new IFDs provides the potential underestimation of design rainfall from the 1987 IFD relationships. However, this is only relevant for the local catchment conditions. The dominant flooding mechanism in terms of peak flood levels across the broader study area is Hunter River flooding. The design Hunter River conditions are based on the FFA analysis of Raymond Terrace records and accordingly not influenced by design rainfall estimates via a rainfall-runoff estimation approach. However, for future local catchment/drainage assessments, the new IFDs should be used for sensitivity analysis.

Table 4-4 Percentage Change in 2016 IFD Rainfall Estimates from 1987 IFD Data

Duration (hours)	Change in Design Rainfall Depth from 1987 to 2016 IFD Data (%)				
	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP
1	6%	15%	20%	25%	30%
2	4%	12%	16%	22%	26%
3	3%	12%	16%	21%	25%
6	2%	11%	15%	21%	25%
12	1%	10%	14%	20%	25%
24	-2%	6%	10%	15%	20%

4.5 Design Flood Conditions

Design floods are hypothetical floods used for planning and floodplain risk management investigations. They are based on having a probability of occurrence specified either as:

- Annual Exceedance Probability (AEP) expressed as a percentage; or
- Average Recurrence Interval (ARI) expressed in years.

This report uses the AEP terminology. Refer to Table 4-5 for a definition of AEP and the ARI equivalent.

Table 4-5 Design Flood Terminology

AEP[1]	ARI[2]	Comments
0.5%	200 years	A hypothetical flood or combination of floods which represent the worst case scenario likely to occur on average once every 200 years.
1%	100 years	As for the 0.5% AEP flood but with a 1% probability or ~100 year return period.

AEP[1]	ARI[2]	Comments
2%	50 years	As for the 0.5% AEP flood but with a 2% probability or ~50 year return period.
5%	20 years	As for the 0.5% AEP flood but with a 5% probability or ~20 year return period.
10%	9.5 years	As for the 0.5% AEP flood but with a 10% probability or ~9.5 year return period.
20%	4.5 years	As for the 0.5% AEP flood but with a 20% probability or ~4.5 year return period.
Extreme Flood / PMF[3]		A hypothetical flood or combination of floods which represent an extreme scenario.

1 Annual Exceedance Probability (%)

2 Average Recurrence Interval (years) – approximate interval years provided in table with AEP = 1-exp(-1/ARI)

3 A PMF (Probable Maximum Flood) is not necessarily the same as an Extreme Flood. For the current study, the Extreme Flood is adopted as 3 times the 1% AEP flow magnitude.

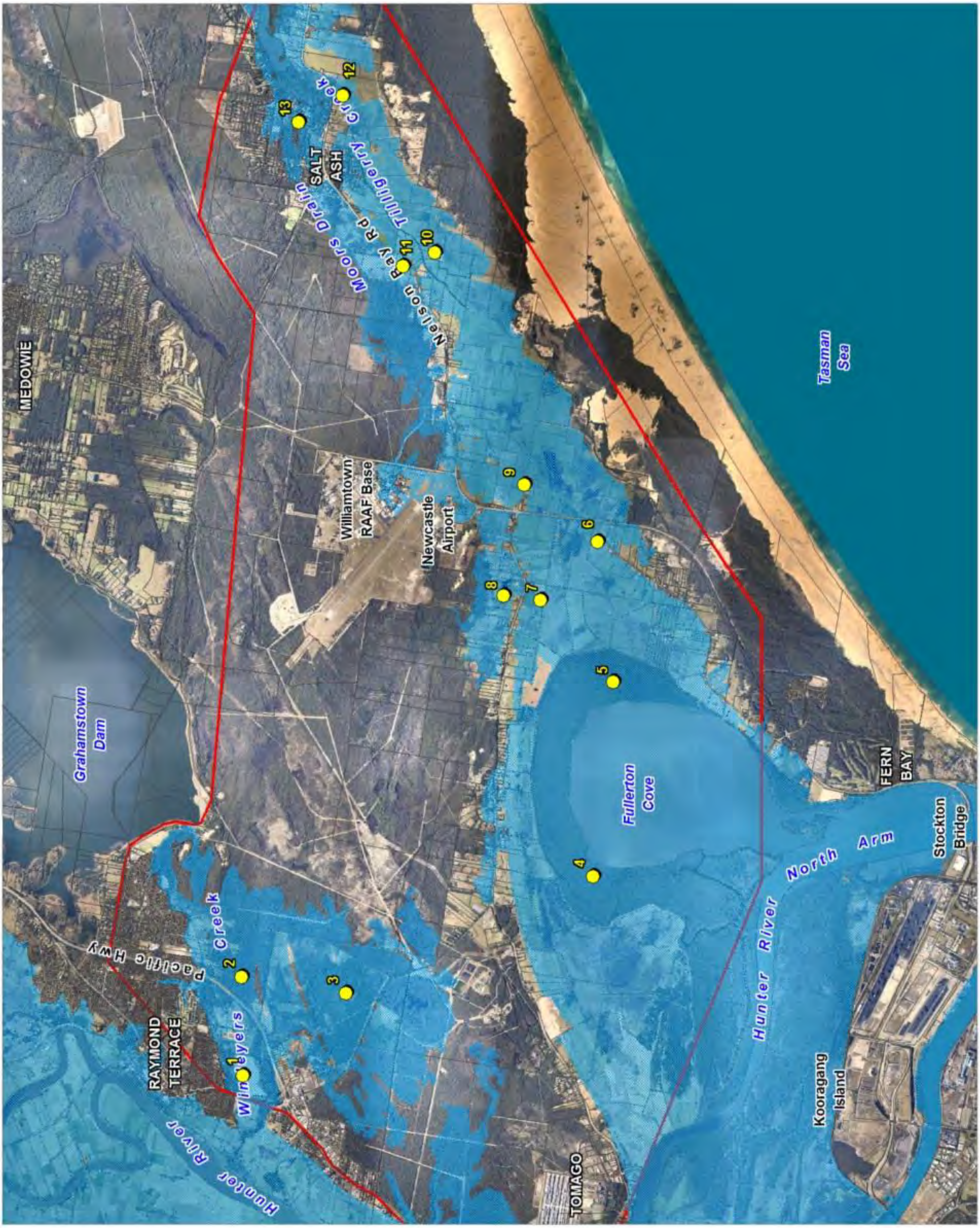
The Williamtown / Salt Ash Flood Study tested a range of coincident design flood conditions, including Hunter River flows, elevated sea levels and local catchment runoff. The study found that the critical condition when determining the 1% AEP flood levels within the study area was a 1% AEP design flow in the Hunter River – for which 50% AEP sea level and 10% AEP local catchment inflow conditions were adopted. In consultation with Council, this set of flood conditions has been adopted as the baseline 1% AEP design flood for the current study.

A range of model simulations have been undertaken to establish both existing and future scenario design flood conditions across the Williamtown-Salt Ash study area as summarised below:

- Existing Conditions – design events simulated for range of events from 20% AEP up to the Extreme Flood (adopted as 3x 1% AEP). Design Hunter River inflows based on revised Flood Frequency Analysis (refer to Section 4.2.2), coincident 50% AEP Newcastle Harbour and Port Stephens flood levels, 10% AEP local catchment inflows.
- Future conditions – 1% AEP design events simulated for flood planning purposes including provisions for sea level rise and rainfall intensity increase:
    - 0.4 m SLR +20% flow increase (indicative 2050 planning horizon)
    - 0.9 m SLR + 20% flow increase (indicative 2100 planning horizon)

The design flood results are presented in a flood mapping series in Appendix A for the simulated baseline 1% AEP event and future planning scenarios incorporating climate change provisions.

Flood levels at key locations within the study area (as shown) are reported in for the range of design event magnitudes for existing conditions. Similarly, shows the corresponding 1% AEP peak design flood levels for existing and future planning scenarios incorporating climate change allowances. The design flood inundation extents for the 20% AEP, 1% AEP and Extreme Flood events are shown in Figure 4-4.



Title:

Flood Level Reporting Locations

Figure: 4-3

Rev: A

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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0 1.25 2.5km
Approx. Scale

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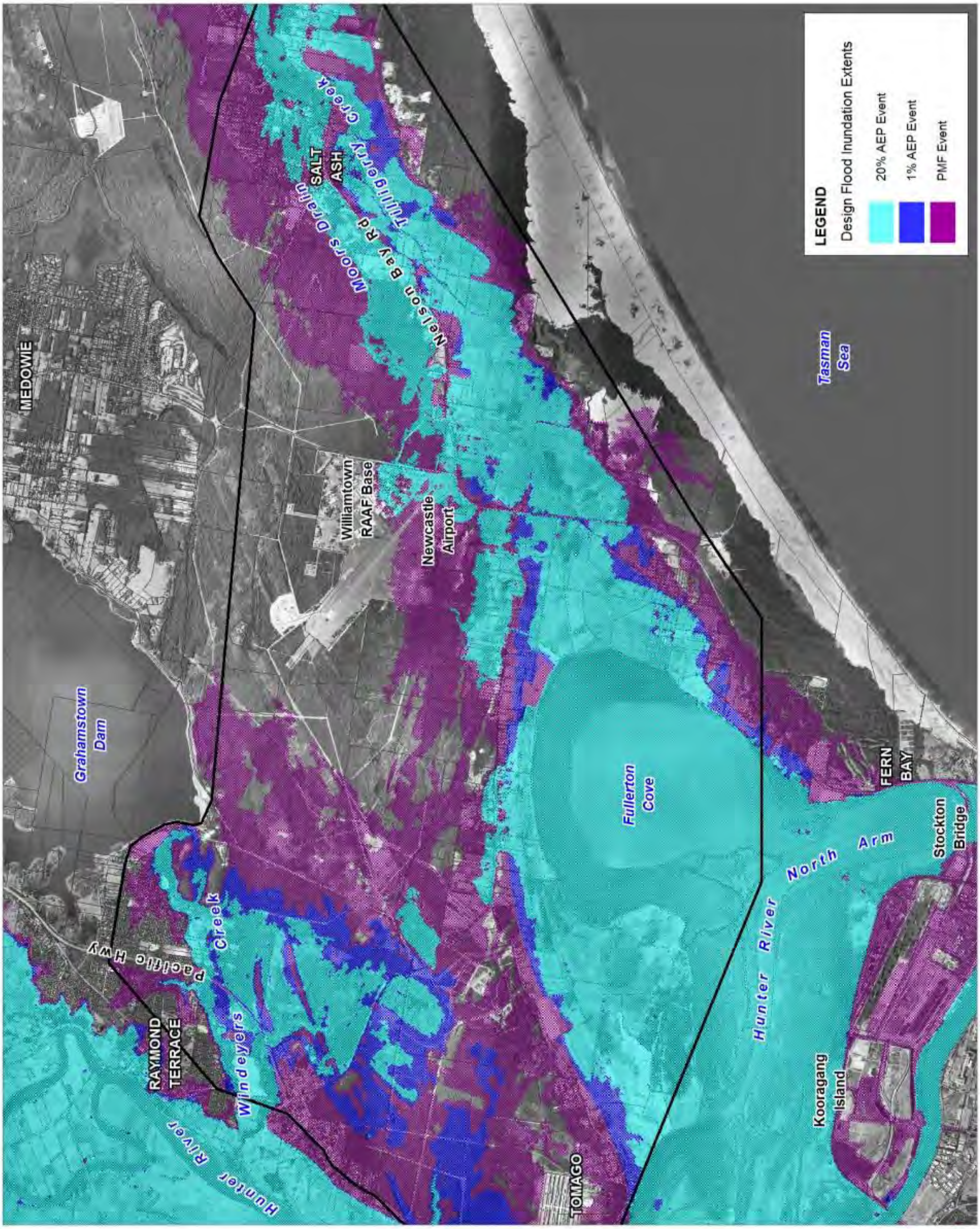
Table 4-6 Modelled Flood Levels at Key Locations for Existing Conditions

ID	Location	Modelled Flood Level (m AHD					
		10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	PMF
1	East of Old Pacific Highway	2.70	3.05	3.88	4.66	5.07	8.35
2	East of New Pacific Highway	2.78	3.11	3.88	4.63	5.06	8.31
3	North of Masonite Road	2.84	3.11	3.87	4.60	5.06	8.25
4	Fullerton Cove West	1.25	1.26	1.44	1.81	2.05	5.43
5	Fullerton Cove East	1.26	1.27	1.38	1.59	1.87	5.26
6	Fullerton Cove Road	0.92	0.92	0.95	1.43	1.87	5.20
7	South of Cabbage Tree Road	0.93	0.93	0.94	1.44	1.87	5.22
8	North of Cabbage Tree Road	1.69	1.69	1.69	1.69	1.86	5.22
9	Lavis Lane	0.94	0.94	0.96	1.11	1.24	5.18
10	South of Nelson Bay Road	0.94	0.94	0.96	1.11	1.24	4.94
11	North of Nelson Bay Road	1.79	1.79	1.79	1.79	1.79	4.92
12	Upstream of Tilligerry Creek Flood Gates	0.90	0.90	0.90	1.01	1.12	4.52
13	Salt Ash	1.76	1.76	1.76	1.76	1.76	4.54

Table 4-7 Modelled 1% AEP Flood Levels at Key Locations for Future Conditions

ID	Location	Modelled 1% AEP Flood Level (m AHD)				
		Existing	0.4m SLR	0.4m SLR + 20%	0.9m SLR	0.9m SLR +20%
1	East of Old Pacific Highway	4.66	4.69	5.15	4.74	5.20
2	East of New Pacific Highway	4.63	4.66	5.15	4.71	5.20
3	North of Masonite Road	4.60	4.63	5.15	4.70	5.20
4	Fullerton Cove West	1.81	2.04	2.29	2.41	2.59
5	Fullerton Cove East	1.59	1.94	2.16	2.35	2.51
6	Fullerton Cove Road	1.43	1.93	2.16	2.33	2.50
7	South of Cabbage Tree Road	1.44	1.94	2.16	2.34	2.50
8	North of Cabbage Tree Road	1.69	1.91	2.16	2.32	2.50
9	Lavis Lane	1.11	1.36	1.59	2.23	2.47
10	South of Nelson Bay Road	1.11	1.36	1.59	2.21	2.43
11	North of Nelson Bay Road	1.79	1.80	1.92	2.14	2.42
12	Upstream of Tilligerry Creek Flood Gates	1.01	1.34	1.58	2.20	2.38
13	Salt Ash	1.76	1.84	1.90	2.31	2.38



Title:

Design Flood Inundation Extents

Figure: 4-4

Rev: A

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Approx. Scale

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Longitudinal profiles showing predicted flood levels along the Hunter River and the Tilligerry Creek floodplain are shown in Figure 4-5. Flood extents for the baseline 1% AEP event were shown on . The overall flood inundation extents for the baseline 1% AEP condition and climate change scenarios are very similar. The increase in flood inundation area from the 1% AEP event with climate change is limited given the study area topography. Floodwaters are generally confined within the broad floodplain regions, with flood depths increasing with flood event magnitude, but not generally resulting in substantial increase in floodplain area inundation.

From Figure 4-5 it can be seen that upstream of Hexham Bridge the sea level rise scenarios have little impact on peak flood levels. There is only a small difference between flood levels for the baseline condition and the 0.4 m and 0.9 m SLR scenarios. However, the increased flood flow scenarios do have a significant impact, with peak flood levels increasing by around 0.4- 0.5 m for the 20% flow increase.

Between Hexham Bridge and Fullerton Cove the influence of sea level rise becomes more apparent, with the impact of increased flood flows reducing. A sea level rise of 0. m, results in around a 0.2 m increase to the 1% AEP flood level in Fullerton Cove. A sea level rise of 0.9 m by 2100, results in around a 0.6 m increase to the 1% AEP flood level in Fullerton Cove. The impact of increased flood flows on peak flood levels in Fullerton Cove is less pronounced than upstream of Hexham Bridge, due to the more expansive floodplain. For the 1% AEP event peak flood levels increase by around 0.3 m for the 20% flow increase.

The response of peak flood levels to potential climate change impacts in the study area between Nelson Bay Road and the Tilligerry Creek flood gates is more complex than further upstream. In this area, the flood levels are driven by the volume of water spilling into the Tilligerry Creek floodplain over Nelson Bay Road at both Williamtown and Salt Ash, from the Hunter River and Tilligerry Creek respectively. For the baseline condition, 0.4 m SLR and 0.4 m SLR +20% scenarios, the flow of water into the floodplain area is largely restricted to the capacity of the cross drainage structures through Nelson Bay Road. Once the flood levels increase further and significant amounts of water begin to spill over Nelson Bay Road, the floodplain area quickly fills, producing much higher flood levels. This is the case for the 0.9 m SLR and 0.9 m SLR +20% climate change scenarios. For these events a flood gradient across the floodplain area becomes evident as the floodplain is conveying a significant flow (spilling over from Fullerton Cove) and the influence of the various embankments/controls on the floodplain are drowned out.

Flood depths in the study area are typically in the order of 0.5 m to 1 m in the Tilligerry Creek floodplain and 1 m to 2 m in the Windeyers Creek storage area. The depths increase for the climate change scenarios, to 1 m to 2 m in the Tilligerry Creek floodplain and over 2 m in the Windeyers Creek storage area, for the 2100 +20% scenario.

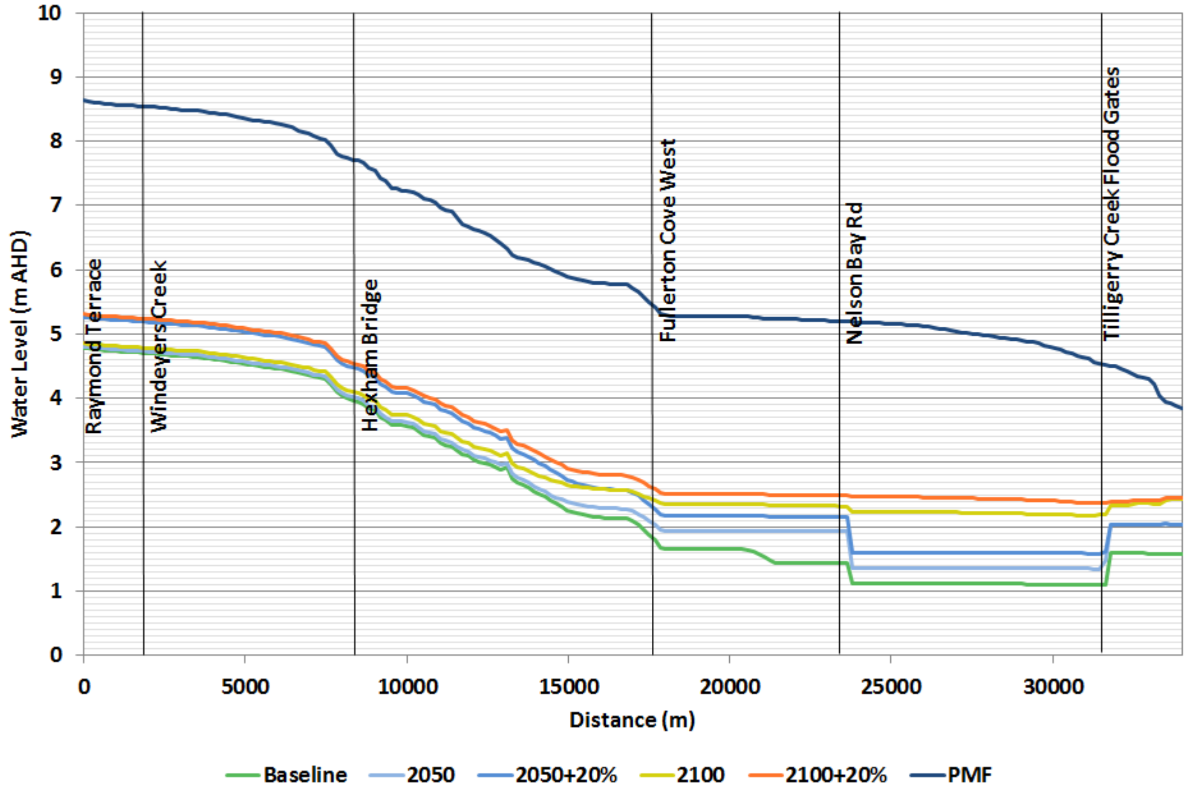


Figure 4-5 Design Flood Level Profiles

The flooding of the Hunter River is characterised by relatively high flood velocities. In-channel velocities are typically in the order of 2 m/s, with floodplain velocities between 0.5 m/s and 1 m/s. Within the study area the velocities are generally lower, being generally less than 0.25 m/s. However, localised velocities can be higher, in the order of over 1 m/s. This is likely to be influenced by local topography, particularly in the local catchment flooded areas, where velocities along major flow paths will be higher. However, velocity results in these areas should be treated with caution as the relatively coarse model grid resolution is unlikely to represent localised velocity variances in sufficient detail.

4.6 Flood Risk Mapping

The revised design flood results for the Williamtown Salt Ash study area are presented in a flood mapping series included in Appendix A.

Additional flood risk mapping was also undertaken to define the hydraulic category and flood hazard distributions across the study area.

4.6.1 Hydraulic Categorisation

Hydraulic categorisation is one of the tools used to identify flood behaviour and risk. Outcomes of the categorisation are primarily used to inform future land use planning. The categorisation is not used to assess individual developments, but rather to give a catchment-scale overview of which areas may be appropriate for various types of land use.

There are no prescriptive methods for determining what parts of the floodplain constitute floodways, flood storages and flood fringes. Descriptions of these terms within the Floodplain Development Manual (NSW Government, 2005) are essentially qualitative in nature. Of difficulty is the fact that a definition of flood behaviour and associated impacts is likely to vary from one floodplain to another depending on the circumstances and nature of flooding within the catchment.

The hydraulic categories as defined in the Floodplain Development Manual are:

- **Floodway** - Areas that convey a significant portion of the flow. These are areas that, even if partially blocked, would cause a significant increase in flood levels or a significant redistribution of flood flows, which may adversely affect other areas.
- **Flood Storage** - Areas that are important in the temporary storage of the floodwater during the passage of the flood. If the area is substantially removed by levees or fill it will result in elevated water levels and/or elevated discharges. Flood Storage areas, if completely blocked would cause peak flood levels to increase by 0.1m and/or would cause the peak discharge to increase by more than 10%.
- **Flood Fringe** - Remaining area of flood prone land, after Floodway and Flood Storage areas have been defined. Blockage or filling of this area will not have any significant effect on the flood pattern or flood levels.

A number of approaches were considered when attempting to define flood impact categories across the study catchment. The approach that was adopted derived a preliminary floodway extent from the velocity * depth product (sometimes referred to as unit discharge). The floodway extent was then locally adjusted where appropriate. The peak flood depth was used to define flood storage areas. The adopted hydraulic categorisation is defined in Table 4-8.

Table 4-8 Hydraulic Categories

Floodway	Velocity * Depth > 0.3	Areas and flowpaths where a significant proportion of floodwaters are conveyed (including all bank-to-bank creek sections).
Flood Storage	Velocity * Depth < 0.3 and Depth > 0.5 metres	Areas where floodwaters accumulate before being conveyed downstream. These areas are important for detention and attenuation of flood peaks.
Flood Fringe	Velocity * Depth < 0.3 and Depth < 0.5 metres	Areas that are low-velocity backwaters within the floodplain. Filling of these areas generally has little consequence to overall flood behaviour.

The Floodplain Development Manual notes that areas being tested by the above criteria should be treated as contiguous entities, having regard for topography and location within the overall flood-prone area. They must not be separated or considered in a piecemeal fashion. To ensure contiguous definition of floodways, particularly in the area through Fullerton Cove and downstream of Nelson Bay Road, local adjustments have been made through the interpretation of main flow paths defined by the flow distribution. Figure 4-6 shows the flow distribution for the 1% AEP 2100 condition flood planning event. The velocity x depth distribution has been interpreted to provide an indicative main flow region to define a contiguous floodway network.

The adopted hydraulic categories for the 1% AEP 2100 condition flood planning event is shown in Figure 4-7.

The adopted hydraulic categories also include the local drainage network as floodways. The floodway extent along drainage channel alignments incorporates a 40m buffer width, representative of a riparian/drainage corridor for flow conveyance preservation.

4.6.2 Flood Hazard

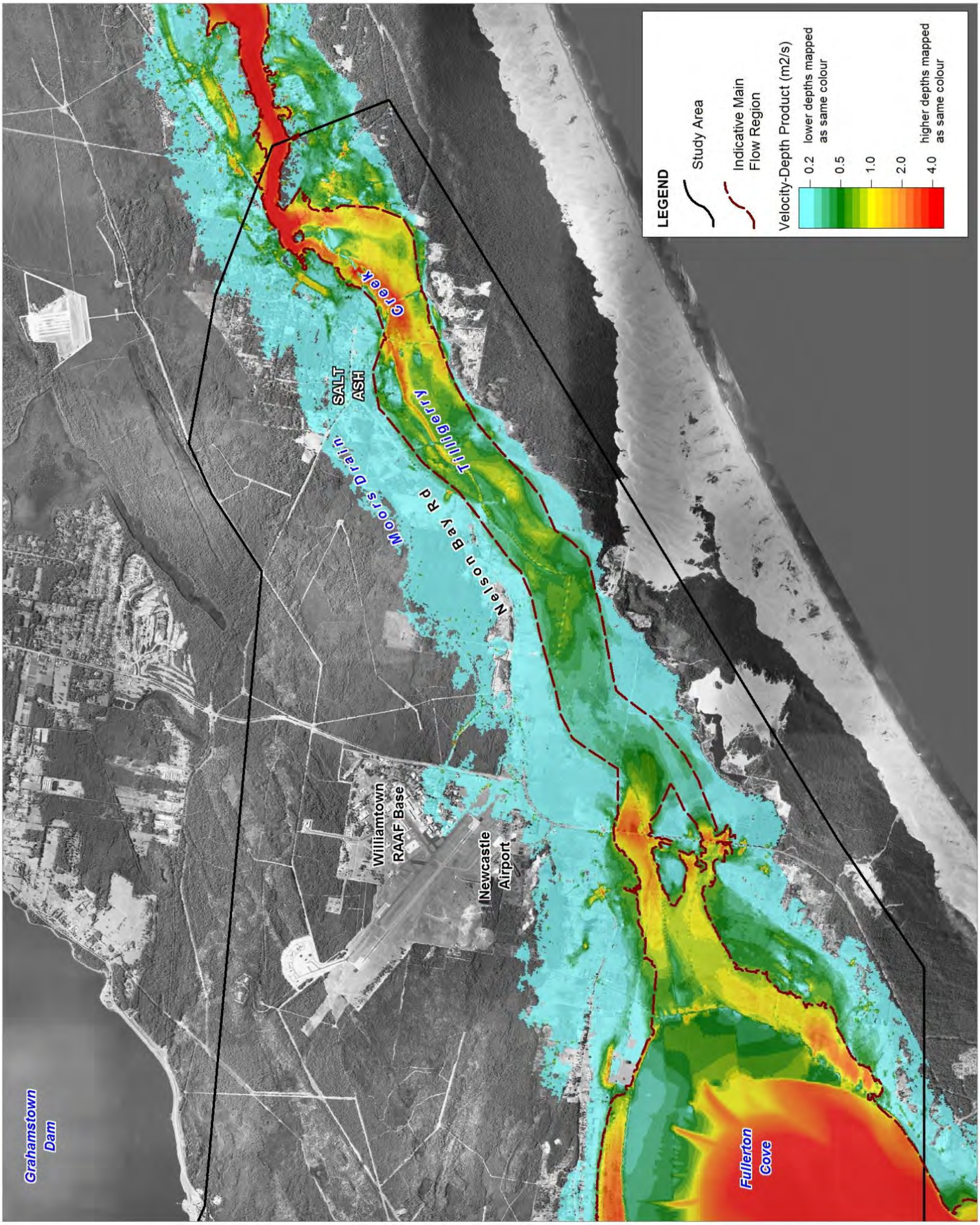
The NSW Governments Floodplain Development Manual (2005) defines flood hazard categories as follows:

- **High hazard** – possible danger to personal safety; evacuation by trucks is difficult; able-bodied adults would have difficulty in wading to safety; potential for significant structural damage to buildings; and
- **Low hazard** – should it be necessary, trucks could evacuate people and their possessions; able bodied adults would have little difficulty in wading to safety.

Hazard categorisation is carried out to establish how hazardous (i.e. dangerous) various parts of the floodplain are. Primarily the hazard is a function of the depth and velocity of floodwater, however, the hazard categorisation considers a wider range of flood risks, particularly those relating to personal safety and evacuation. These hazard factors are derived from both hydraulic risk factors (such as depths and velocities) and human / behavioural issues (such as flood readiness).

The key factors influencing flood hazard or risk are:

- Size of the Flood
- Flood Depth and Velocity
- Flood Readiness
- Rate of Rise - Effective Warning Time
- Duration of Inundation
- Obstructions to Flow
- Access and Evacuation



Title:

Flow Distribution to Define Floodways - 1% AEP Event
2100 Planning Condition: +0.9m Sea Level Rise + 20% Flow

Figure: **4-6**

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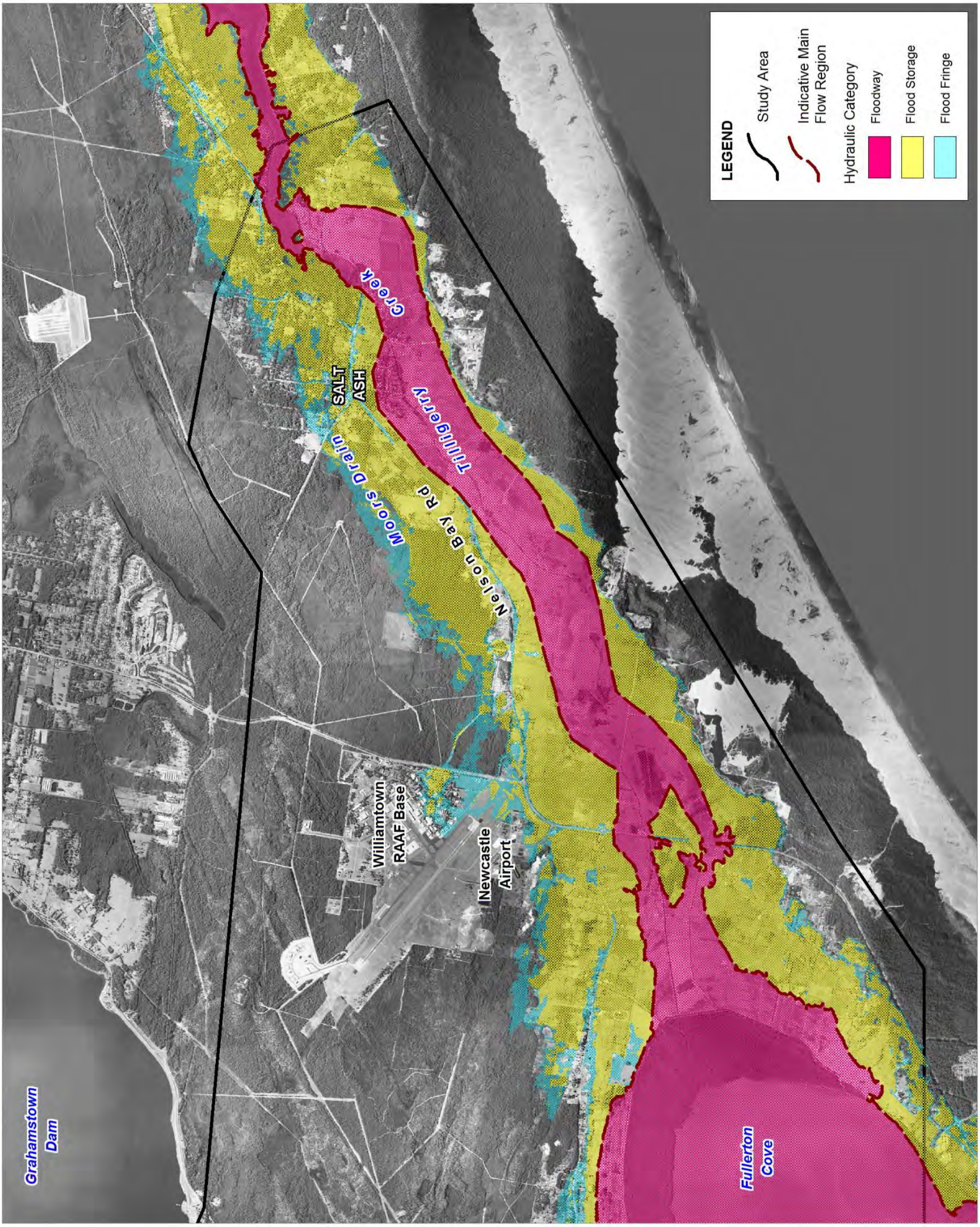

Title:

Adopted Hydraulic Categories - 1% AEP Event
2100 Planning Condition: +0.9m Sea Level Rise + 20% Flow

Figure: **4-7**

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BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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4.6.2.1 Size of Flood

The size of flood will have an obvious and significant influence on the degree of flood risk. Relatively frequent or minor floods would typically be associated with a low flood hazard, whilst the major or rare flood events are likely to provide for high hazard flood conditions.

The design flood extents for a range of flood magnitudes for the study area are shown in . There is not a significant change in inundation extents across the catchment between the 5% AEP and 1% AEP events albeit with increasing flood depths and flow rates.

4.6.2.2 Depth and Velocity

Depth and velocity hazards have been identified according to the provisional hydraulic hazard categories provided in the Floodplain Development Manual. This has been further sub-categorised to show the predominant 'type' of hydraulic hazard (i.e. high velocity, depth, or combination) as shown in Figure 4-8.

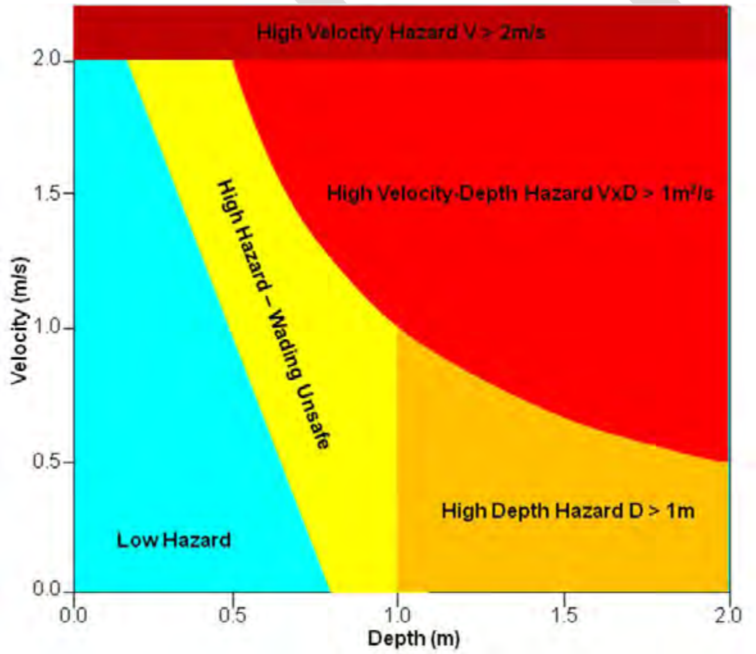


Figure 4-8 Hydraulic Hazard as a Function of Depth and Velocity

4.6.2.3 Flood Readiness

The term 'flood readiness' encompasses a broad range of factors, including familiarity with flooding in the catchment, awareness of evacuation procedures and preparation for a flood (e.g. development of flood plans). Flood readiness can refer to individuals, organisations, communities and businesses.

The 1955 flood event represents the last major flood event on the Hunter River system, particularly in the context to flood affectation to the broader Williamtown-Salt Ash study area. As previously discussed, the major flood risk in Williamtown-Salt Ash localities largely emanates from significant overtopping of Nelson Bay Road adjacent to Fullerton Cove. Significant overtopping only occurs in the major events over and above the 1% AEP event. Accordingly, with a limited recent history of major flooding on the Hunter River, the general preparedness of the community for a major flood event such as the 1955 magnitude is expected to be low.

4.6.2.4 Rate of Rise

The rate of rise of floodwaters is typically a function of the catchments topographical characteristics such as size, shape and slope, and also influences such as soil types and land use. Flood levels rise faster in steep, constrained areas and slower in broad, flat floodplains. A high rate of rise adds an additional hazard by reducing the amount of time available to prepare and evacuate.

Major flooding through Tilligerry Creek floodplain is only initiated following significant transfer of Hunter River floodwater across Nelson Bay Road from Fullerton Cove. Whilst substantial flood warning time of the order of days may be afforded to general flooding through the Lower Hunter (refer Section 4.6.2.6), significant inundation across the lower floodplain areas east of Nelson Bay Road can occur over a matter of hours following initial overtopping.

Figure 4-9 shows indicative timings of flow across Nelson Bay Road and rise in flood levels in the downstream floodplain area relative to peak water level conditions at Hexham Bridge. The figure shows the simulated flood conditions for the 0.5 % AEP event, which may be considered generally representative of a 1955 event flood condition.

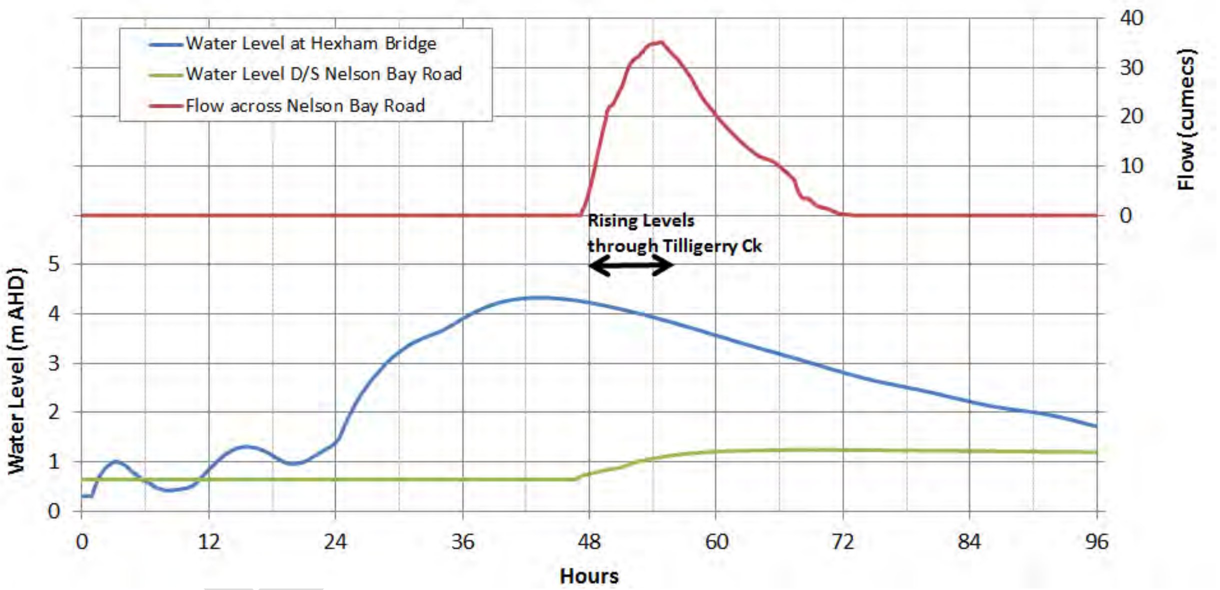


Figure 4-9 Rate of Rise of Floodwater (Design 0.5% AEP Flooding)

4.6.2.5 Duration of Flooding

The greater duration of flood inundation, the greater potential impacts on damages and disruption to the community. The duration of flooding is largely related to the size and duration of the rainfall event over the catchment.

Figure 4-9 can again be referred to in considering general durations of flooding for typical Hunter River events. Whilst there would be expected to be variability in flooding timing and durations for individual events, elevated flood level conditions in the Hunter River would typically remain for a few days, with near peak conditions sustained for up to a day.

For the Tilligerry Creek floodplain areas east of Nelson Bay Road, elevated flood level conditions close to peak levels may be sustained for a number of days. This extended period of inundation is due to the relatively slow draining of the system via the floodgates at Salt Ash, also dependent water level conditions in the Port Stephens estuary.

4.6.2.6 Flood Warning Times

The amount of warning available for an approaching flood can have a significant impact on the risk to life. Less warning time clearly represents a greater risk to the community as there is less opportunity to respond appropriately and implement risk-reduction measures. Minimal warning time also means that emergency services are unlikely to be able to provide any assistance or direction for affected communities.

To assess flood warning opportunity for the study area, consideration has been given to the levels of warning times as defined in Table 4-9.

Table 4-9 Flood Warning Time Categories

No effective warning	<1 hr	No time for pro-active and systematic organisation of flood mitigation, evacuation, emergency response etc. Individuals would be self-directed in regards to emergency response.
Minimal warning	1-6 hrs	Limited assistance and direction likely from emergency services. Measures requiring minimal time for implementation may be appropriate for flood management.
Moderate warning	6-12 hrs	Potential assistance and direction from emergency services, depending on time of day. Measures requiring moderate time, or less, for implementation may be appropriate for flood management.
Good warning	12+ hrs	Significant assistance and direction from emergency services may be available, including assistance with evacuation. Most measures requiring some form of on-demand implementation would be appropriate for flood management.

Available flood warning times for the Lower Hunter River downstream of Raymond Terrace exceed 12 hours (refer to Section 7.3.1 for further detail). Accordingly, it is expected that appropriate flood emergency response would be initiated by the responsible agencies in managing the flood risk in the Williamtown-Salt Ash study area.

4.6.2.7 Effective Flood Access

Access and evacuation difficulties arise from:

- high depths and velocities of floodwaters over access routes;
- difficulties associated with wading (uneven ground, obstruction such as fences);
- the distance to higher, flood free ground;
- the number of people and capacity of evacuation routes;
- the inability to communicate with evacuation and emergency services;
- the availability of suitable equipment (e.g. heavy vehicles, boats);
- a low level of community awareness of evacuation procedures or requirements; and
- a willingness of residents to remain at their property.

Nelson Bay Road forms the principal flood access route through the Tilligerry Creek floodplain from Fullerton Cove to Salt Ash and continuing on outside the study area through to Port Stephens. The road is elevated above the general floodplain and provides effective flood access particularly with consideration of the available flood warning times.

There are numerous existing properties in the low-lying floodplain area through the Tilligerry Creek floodplain. Typically these developments have enabled dwellings to be been constructed on fill platforms with similar elevated access. It is noted however, there are many existing developments with access road levels lower than Nelson Bay Road. These lower-level access are expected to be compromised prior to the potential closure of the main Nelson Bay Road regional access route. This is not considered a major constraint to effective evacuation of these areas given that the broader floodplain inundation is only initiated with overtopping of Nelson Bay Road at Fullerton Cove. As noted with respect to flood warning times for the Hunter River, appropriate flood emergency response would be expected to be initiated with the potential overtopping of Nelson Bay Road at Fullerton Cove being the trigger.

It is also expected that as redevelopment occurs over time, both building floor levels and access road levels will be constructed to the higher flood planning levels accommodating the climate change allowances.

4.6.3 Adopted Flood Hazard Categories

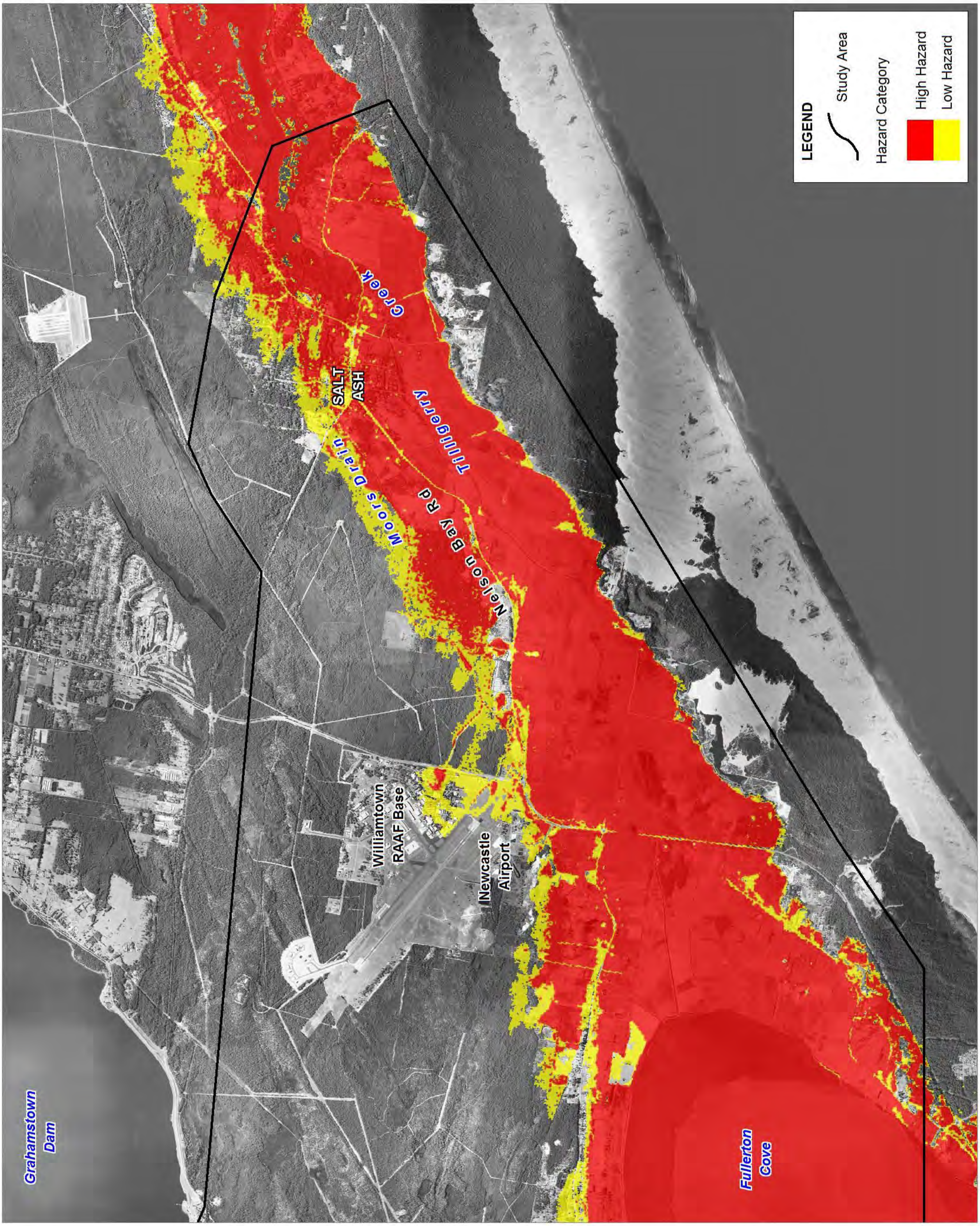
The provisional flood hazard as defined in the Floodplain Development Manual is principally based upon the hydraulic hazard defined by the combination of depth and velocity of floodwater as discussed in Section 4.6.2.2. In considering the other factors contributing to flood hazard for the study area, the following points are noted:

- Flooding in the lower Hunter River system downstream of Raymond Terrace is afforded a significant flood warning time and accordingly provides for evacuation opportunity for the study area.
- Significant road inundation does not occur below the 1% AEP flood magnitude, and is largely initiated with overtopping of Nelson Bay Road downstream of Fullerton Cove. Accordingly, the availability of road access coupled with the warning time does not increase risk significantly through loss of access or limited evacuation opportunity.

- If Nelson Bay Road is overtopped and thereby providing for inundation and isolation of property downstream of Fullerton Cove, an extended period of days of inundation may be anticipated as the floodwater volume drains from the system. Given it is only for events in excess of 1% AEP and that evacuation should have been effected, this would provide inconvenience to residents rather than represent any significant increase in overall risk.

Accordingly, the principal driver of the flood hazard is the hydraulic hazard as indicated by the distribution of velocity and depth of floodwater across the floodplain. The flood hazard categories adopted for the Williamtown / Salt Ash area are presented in Appendix A for the design 1% AEP flood conditions. Under existing conditions, the high flood hazard areas are typically confined to the broader Hunter River floodplain upstream of Nelson Bay Road. The majority of area downstream in the Tilligerry Creek floodplain with concentration of existing development areas typically defined as low hazard. With increasing severity of flood affectation under climate change scenarios, more extensive areas of the floodplain become high hazard.

Figure 4-10 shows the flood hazard categories in the Tilligerry Creek floodplain area for the 1% AEP 2100 planning conditions. This scenario provides for extensive overtopping of Nelson Bay Road downstream of Fullerton Cove and accordingly extensive flooding through the Tilligerry Creek floodplain. Typical flood depths across the floodplain in this scenario are 1 – 2 m, providing for the widespread high hazard flood conditions.



Title:

Adopted Flood Hazard Category
2100 Planning Condition: +0.9m Sea Level Rise + 20% Flow

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5 Property Inundation and Flood Damages Assessment

A flood damage assessment has been undertaken to identify flood affected property, to quantify the extent of damages in economic terms for existing flood conditions and to enable the assessment of the relative merit of potential flood mitigation options by means of benefit-cost analysis.

The general process for undertaking a flood damages assessment incorporates:

- Identifying properties subject to flooding;
- Determining depth of inundation above floor level for a range of design event magnitudes;
- Defining appropriate stage-damage relationships for various property types/uses;
- Estimating potential flood damage for each property; and
- Calculating the total flood damage for a range of design events.

5.1 Property Data

5.1.1 Location

Property locations have been derived from Council's cadastre information and associated detailed aerial photography of the catchment. Linked within a GIS system, this data enables rapid identification and querying of property details.

A property database has been developed detailing individual properties within the floodplain area with potential for flood inundation.

5.1.2 Land Use

For the purposes of the flood damage assessment, property was considered as either residential or commercial. Commercial properties have been identified from the property survey.

Public infrastructure and utility assets have been excluded from the damages assessment.

5.1.3 Ground and Floor Level

Council provided a database of surveyed floor levels for existing property across the study area. The full database included floor level survey for some 649 properties comprising of 586 residential, 53 commercial and 10 Government/public utility buildings. Ground levels for the sites have been derived from the available LiDAR data.

5.1.4 Flood Level

The flood modelling results were used to generate a continuous flood profile across the floodplain. Simulated flood levels were queried from TUFLOW's GIS output at each property reference point. The resulting output was used to identify flooding characteristics such as the number and type of properties affected, frequency of inundation and the depth of inundation.

5.2 Property Inundation

A summary of the number of properties potentially affected by above floor flooding for a range of flood magnitudes is shown in Table 5-1. The tables distinguish between residential property and industrial/commercial enterprise. The distribution of the affected properties for each design flood event is shown Figure 5-1.

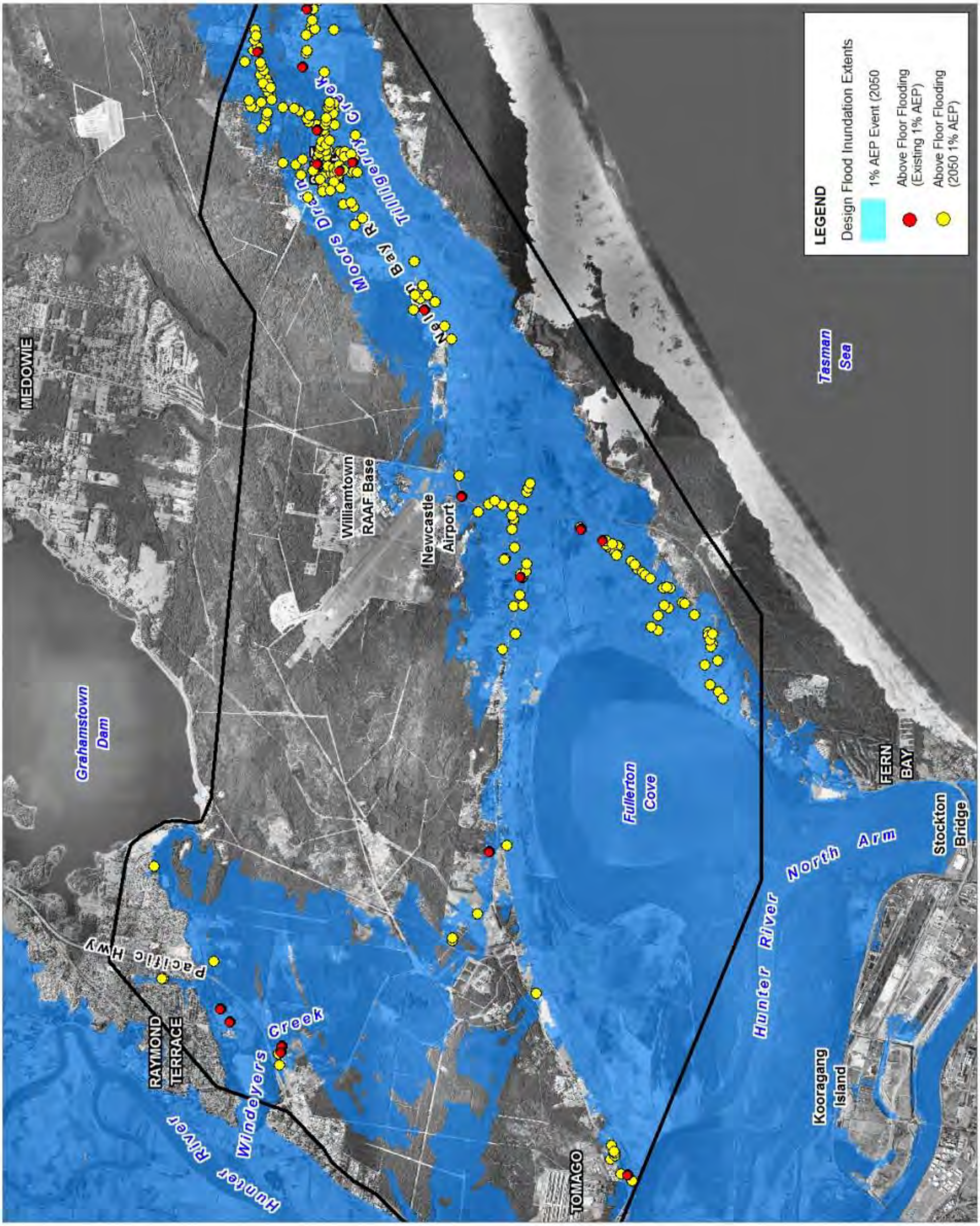
Table 5-1 Number of Properties Affected by Above Floor Flooding (Existing Conditions)

Design Flood Event	Building	
	Residential	Commercial
5% AEP	9	1
2% AEP	10	1
1% AEP	14	5
0.5% AEP	23	14
Extreme Flood	542	61

Only a limited number of properties have been identified at risk of above floor flooding given the nature of the existing development in the catchment. Most existing properties have been constructed on elevated fill platforms in line with previous Council development requirements. However, the flood risk to existing development is significantly increased with consideration of future flooding conditions incorporating climate change as summarised in Table 5-2.

Table 5-2 Number of Properties Affected by Above Floor Flooding (Future Conditions)

Design Flood Event	Building	
	Residential	Commercial
1% AEP Existing Conditions	14	5
1% AEP +0.4m SLR+10% Flow	45	16
1% AEP +0.9m SLR+20% Flow	191	29



Title:

Property Inundation Above Floor Level
1% AEP Event Existing and Future (2050) Conditions

Figure: **5-1**

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Detailed review of property characteristics and local flood conditions for the properties identified as potentially affected by above floor flooding provides further context of the flood risk. This assessment indicates the potential overstatement of property inundation in Table 5-1 and Table 5-2.

Under existing conditions at the 5% AEP flood magnitude, 9 residential and 1 commercial property are identified at risk of above floor flooding. The following conditions are noted at these properties:

- The simulated flood affectation at 5 residential and 1 commercial property is driven by local catchment flooding conditions rather than mainstream Hunter River flows. The peak flood conditions at these properties is driven by the performance of local drainage culverts downstream of the sites. In each of the instances, the property floor levels are lower than the low point or overflow of the road control downstream. Accordingly, if local drainage culvert capacity is exceeded and floodwater builds behind the road embankment, the properties may be subject to inundation. As noted, local catchment flooding conditions have not been modelled in detail. Accordingly, further detailed analysis of the local catchments and culvert performance would confirm potential for property inundation. Figure 5-2 shows the locations of the properties and corresponding culverts on Cabbage Tree Road, Nelson Bay Road and Lemon Tree Passage Road.
- The potential flooding at the 4 other residential properties is driven by the tidal surge boundary conditions in Tilligerry Creek. The properties are located downstream of the flood gates, and have floor existing floor levels lower (<1.6m AHD) than the corresponding storm surge condition in Tilligerry Creek. At the 5% AEP magnitude, there is limited flow contribution from the Hunter River such that the Port Stephens boundary conditions coupled with local runoff drive the peak flood conditions.
- For 2 of the residential properties noted above, the above floor flooding is likely not to be associated with the habitable floor of the main residence. In one instance the inundation is for a separate granny flat. The second instance is for a two-storey property with a lower floor level of only 1.28m AHD. The history of development approval for the dwelling has not been identified, although it does represent a level below expectations for a habitable floor level.

In addition to the properties discussed above for the 5% AEP inundation, the 1% AEP event provides for an additional 5 residential and 4 commercial properties. The following points are noted for similar consideration of local property details for these properties:

- For 3 of the additional residential properties identified, floor levels are at ~1m AHD and below and are in one instance a granny flat, with the other 2 properties lower floors of a two-storey residence.
- The additional 4 commercial/industrial properties identified are all subject to mainstream flooding from the Hunter River at the 1% AEP event. In all cases the properties have 2% AEP flood immunity.

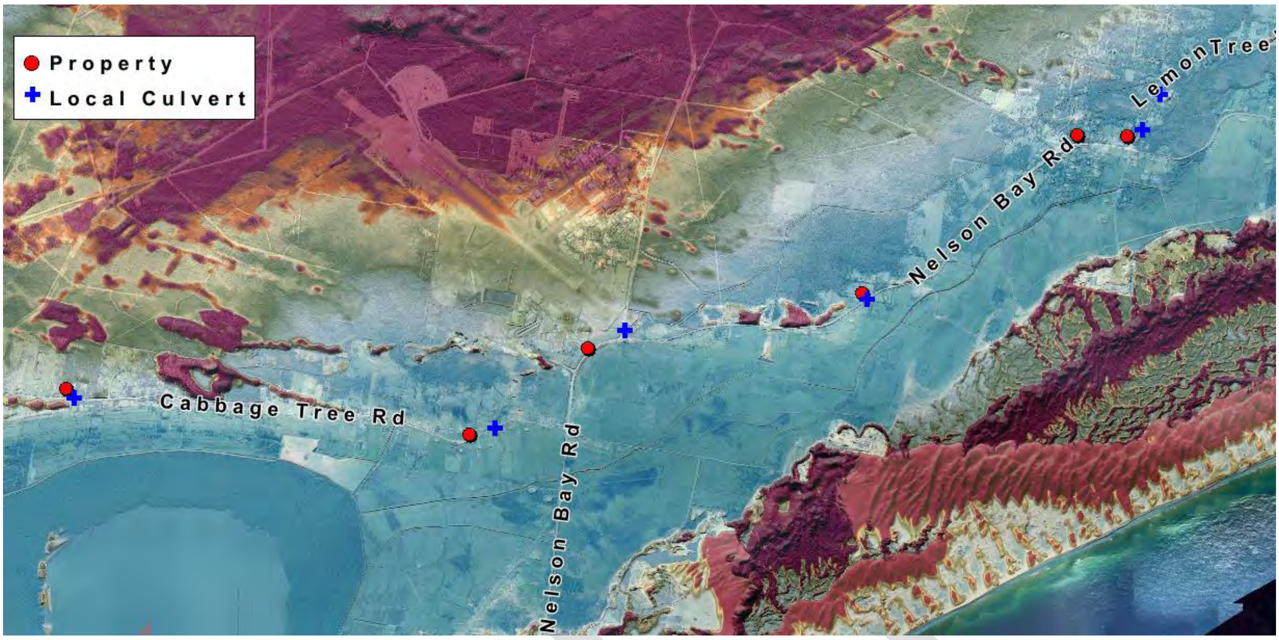


Figure 5-2 Location of Properties and Culverts for Local Capacity Assessment

Notwithstanding the commentary above, all properties identified in Table 5-1 have been included in the flood damages calculations provided in the following sections. The local flooding and property conditions identified are considered further in the assessment of potential flood management options.

5.3 Flood Damages Assessment

5.3.1 Types of Flood Damage

The definitions and methodology used in estimating flood damage are summarised in the Floodplain Development Manual. Figure 5-3 summarises the "types" of flood damages as considered in this study. The two main categories are 'tangible' and 'intangible' damages. Tangible flood damages are those that can be more readily evaluated in monetary terms, while intangible damages relate to the social cost of flooding and therefore are much more difficult to quantify.

Tangible flood damages are further divided into direct and indirect damages. Direct flood damages relate to the loss, or loss in value, of an object or a piece of property caused by direct contact with floodwaters. Indirect flood damages relate to loss in production or revenue, loss of wages, additional accommodation and living expenses, and any extra outlays that occur because of the flood.

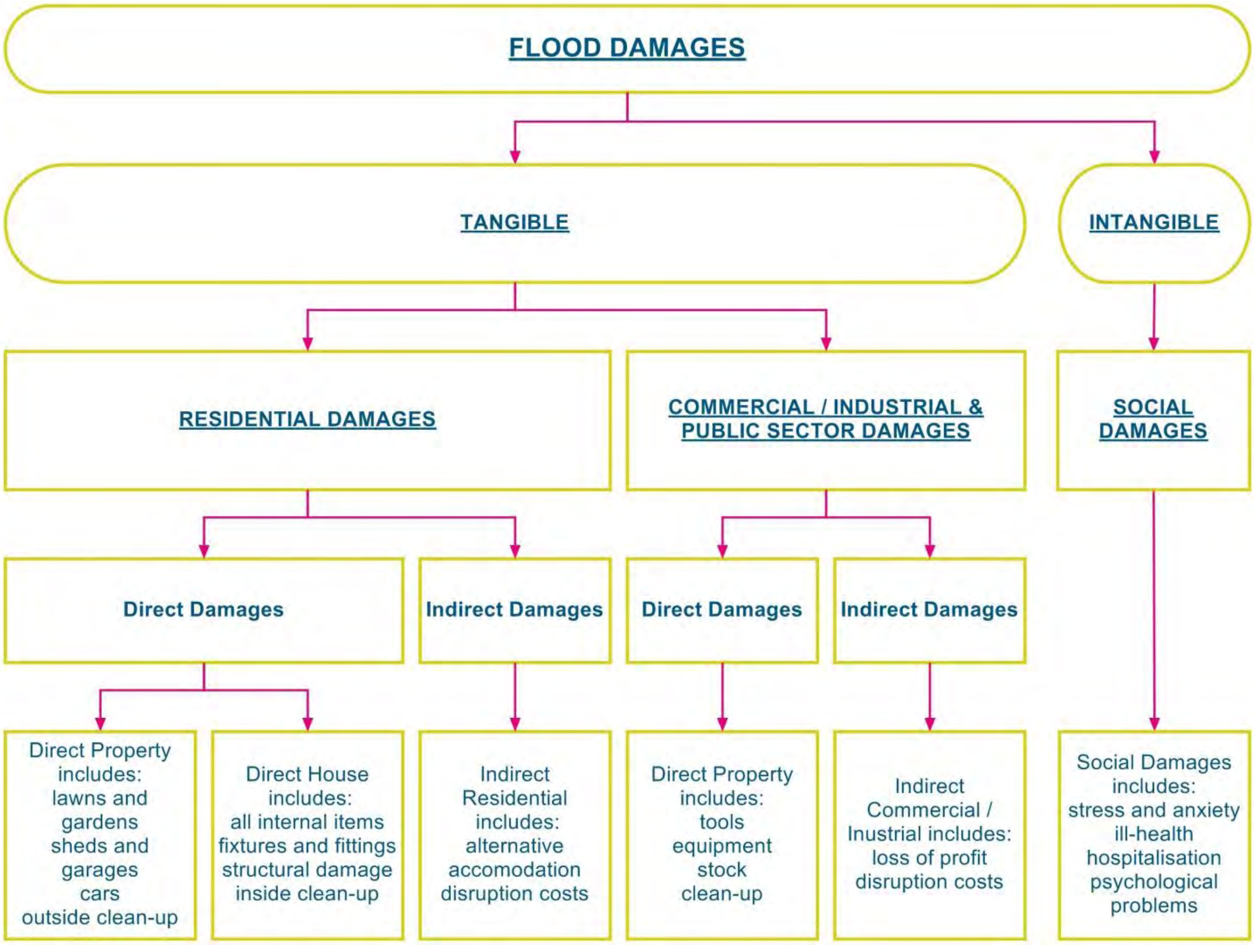


Figure 5-3 Types of Flood Damage

5.3.2 Basis of Flood Damage

Flood damages have been calculated using the data base of potentially flood affected properties and a number of stage-damage curves derived for different types of property within the catchment. These curves relate the amount of flood damage that would potentially occur at different depths of inundation, for a particular property type. Residential damage curves are based on the OEH guideline stage-damage curves for residential property.

Different stage-damage curves for direct property damage have been derived for:

- Residential dwellings (categorised into small, typical or raised categories); and
- Commercial premises (categorised into low, medium or high damage categories).
    - Apart from the direct damages calculated from the derived stage-damage curves for each flood affected property, other forms of flood damage include:
- Indirect residential, commercial and industrial damages, taken as a percentage of the direct damages;
- Infrastructure damage, based on a percentage of the total value of residential and business flood damage; and

- Intangible damages relate to the social impact of flooding and include:
  - inconvenience,
  - isolation,
  - disruption of family and social activities,
  - anxiety, pain and suffering, trauma,
  - physical ill-health, and
  - psychological ill-health.

The damage estimates derived in this study are for the **tangible damages only**. Whilst intangible losses may be significant, these effects have not been quantified due to difficulties in assigning a meaningful dollar value. The adopted stage damage curves are provided in Appendix C.

5.3.3 Summary of Flood Damages

The peak depth of flooding was determined at each property for the 20%, 10%, 5%, 2%, 1% and 0.5% AEP events and the PMF event. The associated flood damage cost to each property was subsequently estimated from the stage-damage relationships. It should be noted that this flood damage assessment only took in to consideration above floor flooding (i.e. damages incurred to yards due to above ground flooding such as damaged fences and landscaping were not taken into consideration). Total damages for each flood event were determined by summing the predicted damages for each individual property.

Table 5-3 provides a summary of the flood damages calculations for flooding of property in the Williamtown-Salt Ash study area.

Table 5-3 Predicted Flood Damages for Existing Conditions

Event	Damages for Flood Event
10% AEP	$496K
5% AEP	$522K
2% AEP	$556K
1% AEP	$1,069K
0.5% AEP	$2,089
Extreme Flood	$58,340
Average Annual Damage (AAD)	$213K

The Average Annual Damage (AAD) is the average damage in dollars per year that would occur in a designated area from flooding over a very long period of time. In many years there may be no flood damage, in some years there will be minor damage (caused by small, relatively frequent floods) and, in a few years, there will be major flood damage (caused by large, rare flood events). Estimation of the AAD provides a basis for comparing the effectiveness of different floodplain management measures (i.e. the reduction in the AAD).

The total estimated flood damage to occur in a 1% AEP catchment flood event is $1.1M, increasing to an estimated $58M worth of damage for the Extreme Flood.

As summarised in Table 5-2, the increased severity in flooding associated with climate change scenarios provides for a significant increase in potential property inundation and subsequent flood damages. Much of this increased risk is associated with sea level rise provisions which would be expected to occur progressively over time. The progressive sea level rise provides for non-stationary environment in which to calculate average annual damage over a long period of time, such that the conventional methods of AAD calculation cannot be applied. It is also likely that redevelopment over time, include redevelopment to directly combat changing flood conditions via climate change influences, would significantly change the flood risk profile of development across the study area. Accordingly, meaningful assessment of future flood risk damages is difficult. Nevertheless, it is important to recognise the progressive increase in flood damage potential associated with future climate conditions. The management options presented in Section 7 acknowledge this increasing flood risk over time, with climate change adaptation being a common theme and indeed requirement for sustainable flood planning in the study area.

6 Review of Existing Planning Provisions

Land use planning and development controls are key mechanisms by which Council can manage some of the flood related risks within flood-affected areas of Williamtown and Salt Ash (as well as across the wider LGA).

A review of existing planning controls has been undertaken with the objective to:

- review the existing planning and development controls framework relevant to the formulation of planning instruments and the assessment of development applications in the Williamtown / Salt Ash area, and
- make specific planning recommendations in regards to flood risk management, including an outline of suggested planning controls.

6.1 State Environmental Planning Policies

The State Environmental Planning Policies (SEPPs) deal with issues significant to the State and people of New South Wales. The following SEPPs have specific relevance to flood planning within the study area.

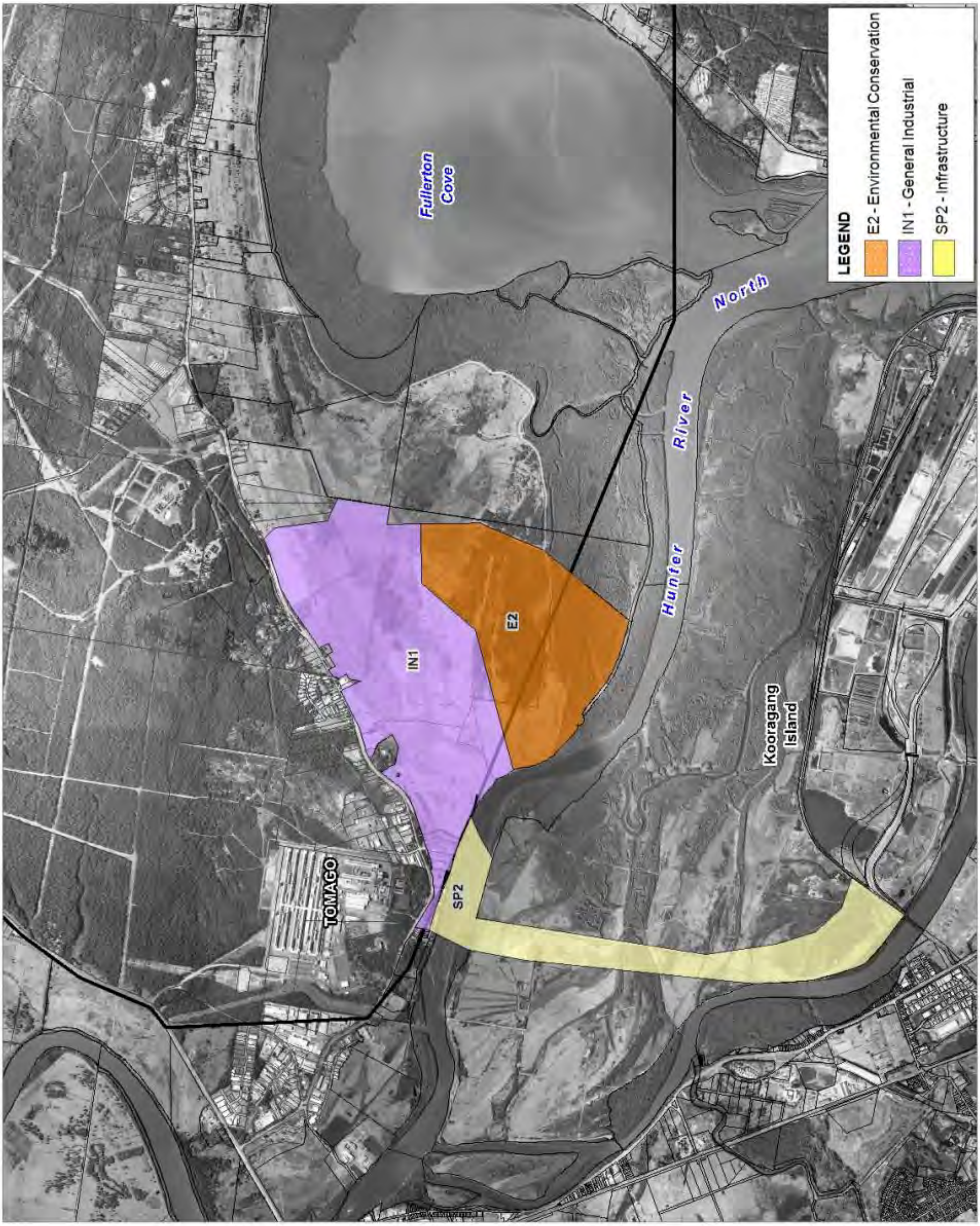
6.1.1 SEPP State Significant Precincts

The aim of this policy is to facilitate the development, redevelopment or protection of important urban, coastal and regional sites of economic, environmental or social significance to the State. In June 2007 the NSW Government declared land at Tomago as State Significant. This change was enacted through the Major Projects State Environmental Planning Policy (SEPP).

Historically, the land has been used for agricultural purposes (grazing); however, it was zoned for industrial development in 2003 (under the now repealed State Environmental Planning Policy No 74 - Newcastle Port and Employment Lands [SEPP 74]).

The Tomago Industrial Land zoning under the SEPP is shown in Figure 6-1 (refer to Section 6.2 for broader area land use zoning). The area extends from the North Arm of the Hunter River, northward to Tomago Road, and includes a corridor to Kooragang Island on the South Arm of the Hunter River. The principal potential development area zoned as General Industrial comprises some 375 hectares adjacent to Tomago Road. Approximately 240 hectares have been allocated as an environmental conservation zone, providing some protection to adjacent SEPP 14 (refer Section 6.1.2) and Ramsar listed Hunter Estuary wetland areas. The infrastructure zoning provides for transport corridors linking the Tomago site to the industrial areas at Kooragang Island and on the South Arm of the Hunter River.

Recent development approvals (WesTrac and Northbank) assessed under SEPP State Significant Precincts within the Tomago precinct are presented further in Section 6.4.



Title:
SEPP State Signifcant Precints (Tomago)

Figure: **6-1**

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6.1.2 SEPP 14 – Coastal Wetlands

The aim of this policy is to ensure that the coastal wetlands are preserved and protected in the environmental and economic interests of the State. The policy applies to local government areas outside the Sydney metropolitan area that front the Pacific Ocean. Land Clearing, levee construction, drainage work or filling may only be carried out within these wetlands with the consent of the local Council and the agreement of the Director General of the Department of Planning. A development triggering SEPP14 also is required to be accompanied by an Environmental Impact Statement.

Clause 7 of SEPP 14 states;

7 Restriction on development of certain land

(1) In respect of land to which this policy applies, a person shall not:

(a) clear that land,

(b) construct a levee on that land,

(c) drain that land, or

(d) fill that land,

except with the consent of the Council and the concurrence of the Director.

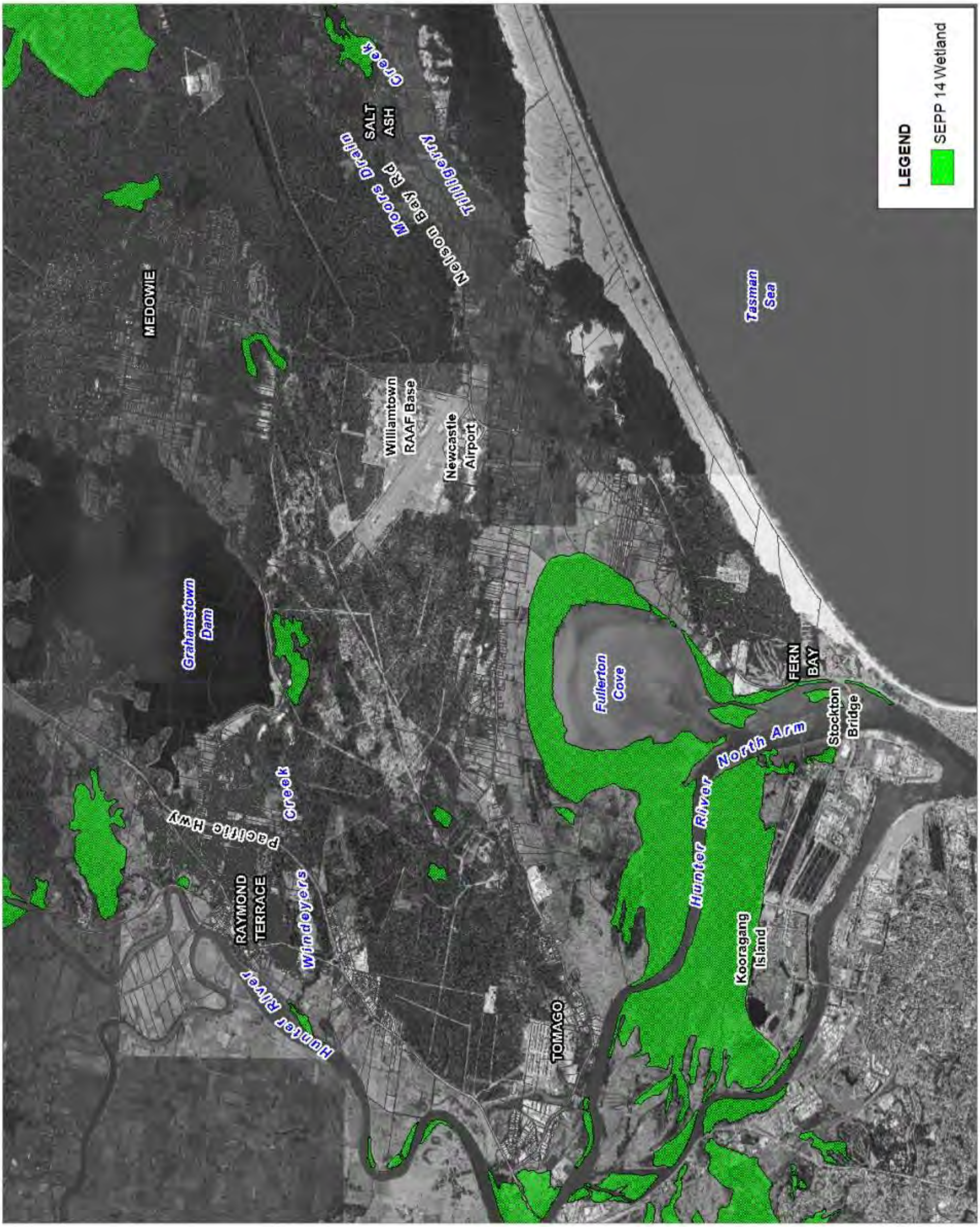
The extent of SEPP 14 wetlands within the study area is shown in Figure 6-2. The principal areas within the Port Stephens LGA are on the left bank of the Hunter River North Arm, typically within the levee system around Tomago and Fullerton Cove. The sites are typically low-lying floodplain area with significant flood risk. Coupled with existing environmental zonings (refer Section 6.2) and protections under SEPP14, it is unlikely extensive development of these areas would occur.

6.1.3 SEPP 71 – Coastal Protection

State Environmental Planning Policy No. 71 – Coastal Protection (SEPP 71) aims to protect and manage the natural, cultural, recreational and economic attributes of the New South Wales coast. SEPP 71 aims for development in the NSW coastal zone to be appropriate and suitably located, in accordance with the principles of the Ecologically Sustainable Development (ESD). The policy provides for: the protection of and improvement to public access compatible with the natural attributes coastal foreshores; and protects and preserves Aboriginal cultural heritage, visual amenities of the coast, the beach environment and amenity, native coastal vegetation, marine environment of New South Wales, and rock platforms.

The key elements of SEPP 71 with specific reference to flooding and water management constraints for proposed development include consideration of:

- the likely impact of coastal processes and coastal hazards on development and any likely impacts of development on coastal processes and coastal hazards, and
- the likely impacts of development on the water quality of coastal waterbodies.



Title:
Williamtown / Salt Ash SEPP 14 Wetlands

Figure: **6-2**

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6.2 Port Stephens Local Environment Plan (2013)

A Local Environmental Plan (LEP) is prepared in accordance with Part 3 Division 4 of the EP&A Act 1979 and operates as a local planning instrument that establishes the framework for the planning and control of land uses. The LEP defines zones, permissible land uses within those zones, and specific development standards and special considerations with regard to the use or development of land.

The Port Stephens Local Environment Plan 2013 (LEP 2013) (Port Stephens Council, 2013) (commenced on 22 February 2014) has been prepared in accordance with the NSW State Government's Standard Instrument (Local Environmental Plans) Order 2006, which requires local Councils to implement a Standard Instrument LEP. The State Government has created the Standard Instrument LEP to assist in streamlining the NSW Planning system.

Clause 7.3 of the Port Stephens LEP 2013 relates to development on flood liable land. The LEP provisions incorporate general considerations in regard to development of flood liable land. These provisions require the approval process to consider the impact of proposed development on local flood behaviour, the impact of flooding on the development and the requirements of adopted Floodplain Management Plans that are applicable. Specifically Clause 7.3 states:

(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 shown 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) will not 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) will not 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.

(6) In this clause:

flood planning level means the level of a 1:100 ARI (average recurrent interval) flood event plus [0.5] metres freeboard.

The key requirements of the Williamtown Salt Ash Floodplain Risk Management Study in relation to the LEP provisions include:

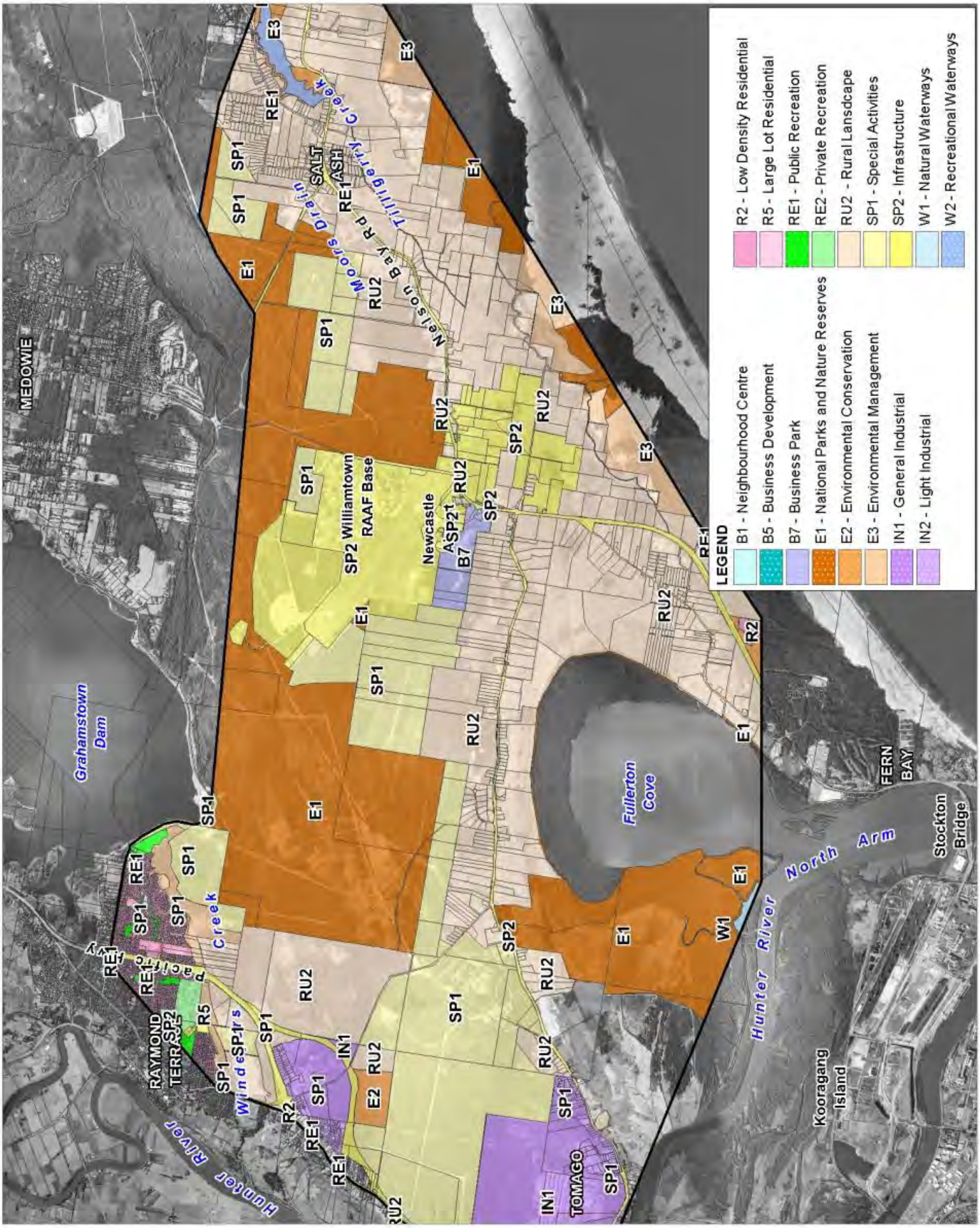
- Establishment of Flood Planning Levels – the general flood planning level is based on the 1% AEP (1 in 100-year ARI) as noted in the LEP. Design flood behaviour for the full range of design events has been established though the development of numerical models. Council is provided a full suite of design flood mapping including peak flood inundation extents, water levels, depths and velocities.
- Definition of Flood Planning Area – the Flood Planning Area encompasses the land below the Flood Planning Level, i.e. the 1% AEP flood level plus 0.5 m freeboard.
- Description of Flood Risk/Hazard – in addition to the flood inundation mapping, floodplain classifications of hydraulic category (floodway, flood storage, flood fringe) and flood hazard (low hazard, high hazard) have been developed (refer to Section 4).

6.2.1 Land Use Zoning

The Port Stephens LEP 2013 identifies a number of land use zones including existing and future development areas, based on stated objectives for each zoning and provisions made for each zoning. There are 17 land use zones identified within the Williamtown Salt Ash Floodplain Risk Management Study area as summarised in Table 6-1 and shown in Figure 6-3.

Table 6-1 Land Use Zones within the Williamtown-Salt Ash Study Area

Rural Zones	**Special Purpose Zones**
RU2 – Rural Landscape Lots	SP1 – Special Activities
	SP2 – Infrastructure
Residential Zones	**Recreation Zones**
R2 – Low Density Residential	RE1 – Public Recreation
R5 – Large Lot Residential	RE2 – Private Recreation
Business Zones	**Environment Protection Zones**
B1 – Neighbourhood Centre	E1 - National Parks and Nature Reserves
B5 – Business Development	E2 - Environmental Conservation
B7 – Business Park	E3 - Environmental Management
Industrial Zones	**Waterway Zones**
IN1 – General Industrial	W1 – Natural Waterways
IN2 – Light Industrial	W2 – Recreational Waterways



Title:

Williamtown / Salt Ash Land Use Zones

Figure: 6-1

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It is evident from Figure 6-3 that the majority of land use zones lying within the 1% AEP flood extent comprise RU2 – Rural Landscape lots. This is representative of the existing development within the broader Tilligerry Creek floodplain and represents the majority of existing development at risk of flooding as identified in Section 5.2.

6.3 Port Stephens Development Control Plan 2014

The Port Stephens Development Control Plan 2014 (DCP 2014) is the supporting document for the Port Stephens LEP 2013, and provides guidance and detailed requirements for development. Development provisions for catchment Flood Management are provided in the DCP 2014 based on development type and hydraulic and hazard categorisation

The definition of floodplain categories adopted in DCP 2014 and also described in Council's Floodplain Risk Management Policy (PSC, 2015) link directly to development controls. The hydraulic and hazard mapping (refer to Section 4.6 and Appendix A) undertaken is consistent with these DCP provisions.

Councils existing categorising is based on floodplain risk in terms of the hazard (low hazard and high hazard) and the location (floodway area, flood storage area and flood fringe area):

a) Minimal risk flood prone land (above the Flood Planning Level and below the Flood prone land extent)

b) Low hazard – flood fringe area

c) Low hazard – flood storage area

d) Low hazard – floodway area

e) High hazard – flood fringe area

f) High hazard – flood storage area

g) High hazard – floodway area

Whilst some development controls vary in accordance with land use type, the provisions in general provide for:

- Minimum floor level requirements for habitable buildings of the 1% AEP flood level + 0.5 m freeboard. This is consistent with the FPL provisions in the LEP.
- Minimum floor level requirements for critical use infrastructure (e.g. hospitals, residential care facilities) are the Probable Maximum Flood (PMF) level.
- Restrictions on development within areas identified as floodway – these typically represent high hazard flood areas and areas in which development would significantly alter flood behaviour.
- Limitations of the placement of fill within the floodplain which has the potential to displace floodwater and exacerbate flooding conditions elsewhere.

6.4 Major Development Projects and Approvals

There have been a number of recent major development projects and approvals in the study area. Given the scale and nature of these developments, flooding investigations have been a key component of the development assessment and approvals process. The following sections provide an overview of the major development approvals that impact on flood behaviour in the study area.

6.4.1 Tomago Industrial Park (WesTrac Facility)

The site is within the Tomago State Significant Precinct as identified under the SEPP shown in Figure 6-1. Approval was provided for subdivision of the site for industrial purposes, bulk earthworks across the site and the establishment of a WesTrac Facility and associated infrastructure. The construction of the WesTrac Facility represents Stage 1 of the site development which has been completed. The Stage 2 and Stage 3 subdivision areas represent future development areas of the Industrial Park.

The site area and staging is shown in Figure 6-4. The site comprises approximately 116 hectares of previously vacant agricultural land located on Tomago Road.

A condition of the approval requires revision of the Stage 2/3 subdivision plan to exclude development within a 22 hectare conservation area as shown in Figure 6-4. The conservation area is designated to protect existing coastal saltmarsh habitat.

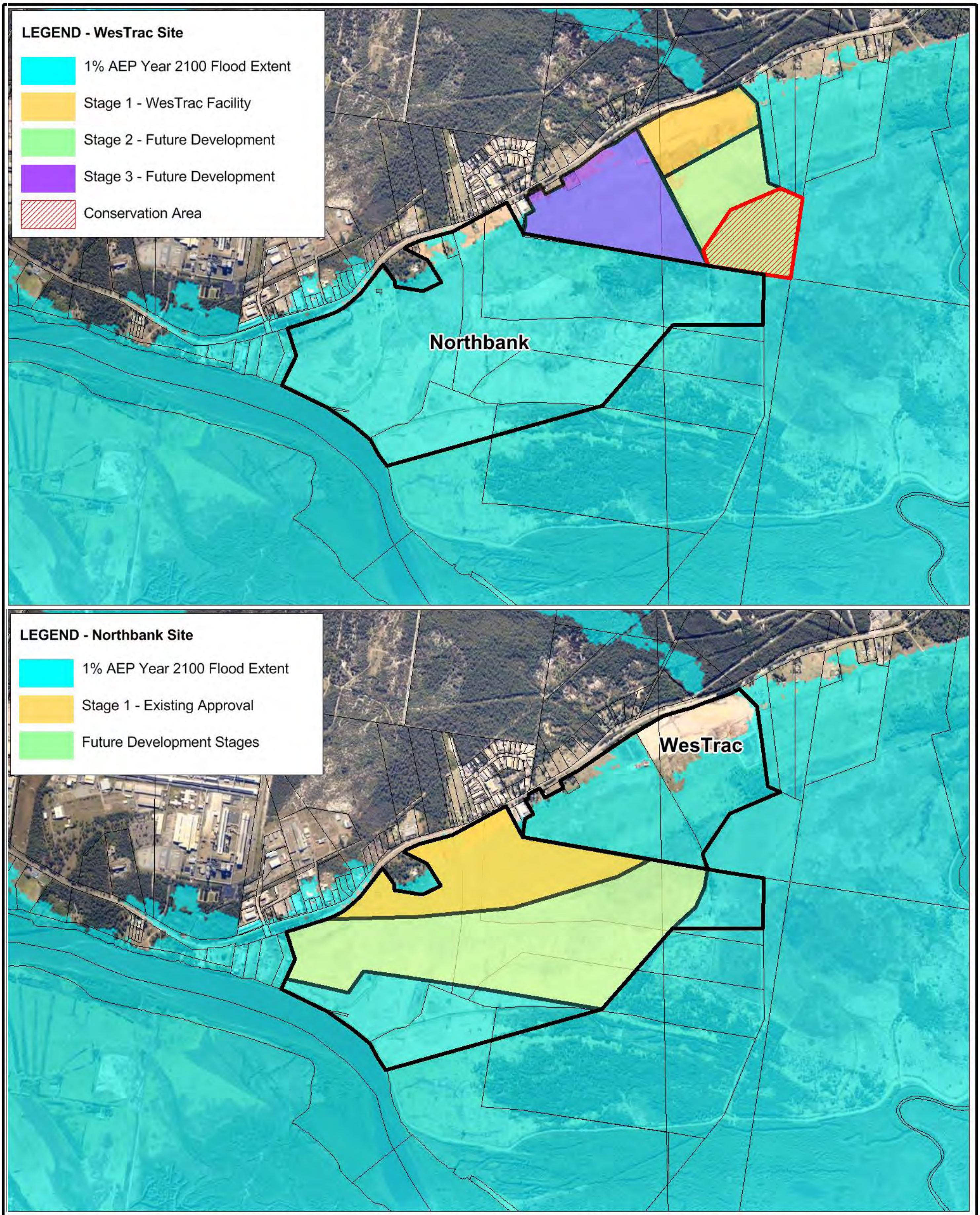
In establishing existing design flood conditions, the completed WesTrac facility which included significant landform change in filling the site to appropriate flood planning levels, is incorporated into the modelling. Given the scale of the potential full development of the site in the future, consideration of the impact of additional filling is given in Section 7.1.8 in association with other future development areas within the floodplain.

6.4.2 Northbank Enterprise Hub Industrial and Business Park

As with the WesTrac site noted above, the Northbank site is within the Tomago State Significant Precinct. The approval provides for the staged subdivision of the site for future industrial development, with projects works including bulk earthworks across the site and construction of infrastructure to service the industrial park, including roads and drainage.

The site area and staging is shown in Figure 6-4. The site comprises approximately 241 hectares of previously vacant agricultural land located on Tomago Road. The approval provides for the filling of the land for Stage 1 with additional conditions for the future stages, particularly in relation to floodplain management.

The development application assessments found that development of all stages of the Project may result in increased flooding impacts on adjacent properties and across the broader Hexham area. The Stage 1 development area was identified in order to limit flood level increases to no more than 20 mm. This limit was identified by the Department as being consistent with other recently approved developments in the Hexham area.



Title:

Tomago State Significant Precinct Approvals

Figure: 6-3

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The full future development area provided for potential flood level increases of 40 mm more broadly across the Hexham Swamp floodplain for the 1% AEP event. Reference has been made to the City of Newcastle having identified a cumulative target for flood level increases of no more than 40 mm across the region. This was from the Lower Hunter Valley Floodplain Management Study Volume B – Planning Implementation Strategy (PBP, 2001) in which the threshold of acceptable increase in water levels around the perimeter of Hexham Swamp from future cumulative floodplain development was taken as 40 mm. This limit has again been referenced in the Newcastle City-wide Floodplain Risk Management Study and Plan (BMT WBM, 2012.).

Accordingly, the Department of Planning's assessment notes potential flood level increases of 40 mm across the region for the future development of the Northbank site. Beyond the Stage 1 implementation, in which the flood level increase threshold of 20 mm has been adopted, the approval requires further flood verification studies to establish the flood level increases from subsequent stages. Recommendations were also made in regards to potential financial compensation for landowners affected by increases in flood level above the accepted 20 mm impact.

With no construction on the Northbank site commenced to date, the establishment of the design flood conditions do not incorporate any of the approved Northbank development. As with the neighbouring WesTrac site, the impact of the Northbank approvals on design flood conditions is discussed in Section 7.1.8 in association with cumulative impacts of other potential floodplain development.

6.4.3 Hexham Rail Infrastructure

Two major rail infrastructure projects have recently been constructed within the Hunter River floodplain at Hexham. The Hexham Train Support Facility (Aurizon) and Hexham Relief Roads (Australian Rail Track Corporation (ARTC)) projects were approved as State significant infrastructure under the State and Regional Development SEPP.

The Train Support Facility covers an area of approximately 250 ha in the vicinity of Hexham Bridge. The development of the site involves the construction of a fill platform for new train servicing and maintenance facilities. The Hexham Relief Roads upgrade is around 2.5 km in length and is situated between the Train Support Facility and the existing railway. It involves constructions of rail tracks parallel to the existing alignment of the Main Northern Railway. The works also include an access road off the New England Highway at Tarro to the Train Support Facility.

The detailed flood risk assessments undertaken as part of the project approvals process indicated the works provided no broad regional change in design flood conditions. The constructed works have been incorporated into the current study models in establishing design flood conditions.

6.4.4 Pacific Highway Upgrade

The NSW Government is planning for a future extension of the M1 Pacific Motorway to the Pacific Highway at Raymond Terrace. The proposed upgrade involves building 15 kilometres of dual carriageway motorway with two lanes in each direction, bypassing Hexham and Heatherbrae.

Planning for the M1 Pacific Motorway extension to the Pacific Highway at Raymond Terrace began in October 2004 and has involved an extensive community consultation program to identify a preferred route and develop a concept design. A design was displayed for community comment in

2008 with feedback considered to develop a refined design which was announced in 2010 (http://www.rms.nsw.gov.au/projects/hunter/m1-motorway-raymond-terrace-upgrade/).

The route was reserved in the Newcastle and Port Stephens Local Environmental Plans. Whist the route lies outside the Williamtown-Salt Ash study, there is some potential for modification of the existing flow distribution in the Hunter River floodplain, and thereby impact on design flood conditions. Route selection and design typically incorporates substantial environmental impact assessment including flooding, and accordingly any impact of future project construction will be established through the design process.

7 Potential Floodplain Management Measures

Measures which can be employed to mitigate flooding and reduce flood damages can be separated into three broad categories:

- **Flood modification measures**: modify the flood's physical behaviour (depth, velocity) and includes flood mitigation dams, retarding basins, on-site detention, channel improvements, levees, floodways or catchment treatment;
- **Property modification measures**: modify property and land use including development controls. This is generally accomplished through such means as flood proofing (house raising or sealing entrances), planning and building regulations (zoning) or voluntary purchase; and
- **Response modification measures**: modify the community's response to flood hazard by informing flood-affected property owners about the nature of flooding so that they can make informed decisions. Examples of such measures include provision of flood warning and emergency services, improved information, awareness and education of the community and provision of flood insurance.

The following sections provide a first pass assessment of options by determining if they would be applicable / suitable to the flooding characteristics of the Williamtown / Salt Ash area.

7.1 Flood Modification Measures

The principal flooding mechanism in the study area is major Hunter River flooding. Accordingly, there is limited opportunity for flood modification options to mitigate flooding on a catchment scale. Moreover, in the context of the study area, the existing flood risk exposure to existing property is relatively limited such that expensive, broad scale catchment flood management measures are not required at this stage.

Under climate change scenarios, existing flooding conditions are expected to gradually exacerbate in the study area. With increasing flood risk, the floodplain risk management options provide a focus on progressive climate change adaptation.

The following flood modification options represent possible future works in order to adapt to the potential changing flood environment as climate change impacts manifest. None of the works are proposed in the immediate term, rather, they are recommended as evolving measures to either maintain existing design flood risk standards/flood immunity or to integrate into future flood planning scenarios to set development controls for future development.

7.1.1 Nelson Bay Road Upgrades

In the flood planning context for the Williamtown-Salt Ash study area, the elevation of Nelson Bay Road impacts has two key implications:

- Control of the magnitude and timing of flows from the Hunter River system spilling onto the Tilligerry Creek floodplain – this is specific to the section of road between Fullerton Cove and Williamtown to the south of the Cabbage Tree Road intersection; and

- Definition of road flood immunity and accordingly flood access/evacuation potential – Nelson Bay Road is the principal flood access route along the Tilligerry Creek floodplain between Fullerton Cove and Salt Ash in the study area, but also as the main access route between Port Stephens and the broader Newcastle region.

Nelson Bay Road is constructed on an elevated embankment, typically some 1.5-2.0 m above floodplain levels. The existing road profile provides generally for a 1% AEP flood immunity under existing conditions.

A key road section of interest is the section south of the Cabbage Tree Road intersection. This section includes the existing low-point along the alignment over the Fourteen Foot Drain and Ten Foot Drain crossings and corresponds to the main overflow section of Hunter River floodwater spilling from Fullerton Cove into the Tilligerry Creek floodplain. This section of Nelson Bay road is represented in Figure 7-1 showing the local floodplain topography and long section profile.

The elevated nature of the Nelson Bay Road embankment is evident in Figure 7-1. The low point in the profile sits at approximately 1.8 m AHD, through a 250 m section to the north of the Fourteen Foot Drain crossing. The road crest elevation at the cross drainage culverts is approximately 2.0 m AHD. Similarly, there is a secondary low section of around 300 m width around the Ten Foot Drain crossing with a road crest elevation of around 2.0 m AHD.

The design peak flood levels across Nelson Bay Road were presented in the flood profiles in Figure 4-5. The peak design 1% AEP flood level upstream of Nelson Bay Road at this location is 1.5 m AHD under existing conditions. Accordingly, the road at the existing level prevents extensive overtopping, thereby protecting the Tilligerry Creek floodplain downstream from extensive inundation. At the 1% AEP flood condition, the source of flows in the Tilligerry Creek floodplain are a combination of the local catchment inputs and the Hunter River contributions via the culverts at the Fourteen and Ten Foot Drains. Overtopping of Nelson Bay Road at this location is initiated at the 0.5% AEP design event, with a peak design flood level upstream of the road of around 1.9 m AHD. The simulated flow across the road for the 0.5% AEP event is only some 4 m^3/s, compared with a combined culvert flow at the two drains of some 45 m^3/s. However, with increasing flood magnitude the contribution of flow from overtopping of Nelson Bay Road increases rapidly.

For the PMF event, flow from the Hunter River conveyed across Nelson Bay Road to the Tilligerry Creek floodplain exceeds 4,000 m^3/s, with peak flood levels around 5.2 m AHD. Corresponding flow in the Hunter River North Arm and South Arm are in excess of 17,000 m^3/s and 5,000 m^3/s respectively. Accordingly, the transfer of flow to Tilligerry Creek floodplain at the PMF level represents a major component of the overall Hunter River flow distribution.

In considering potential changes to the existing road configuration in order to manage Hunter River flows, there would seem little requirement for works given the effective standard of protection / road immunity is of the order of 0.5% AEP design standard. As noted however, with progressive climate change influences (refer to Figure 4-5), increases in flood levels will gradually reduce the flood immunity of the existing road and increase the level of overtopping and corresponding flow through to Tilligerry Creek and the Williamtown-Salt Ash communities.

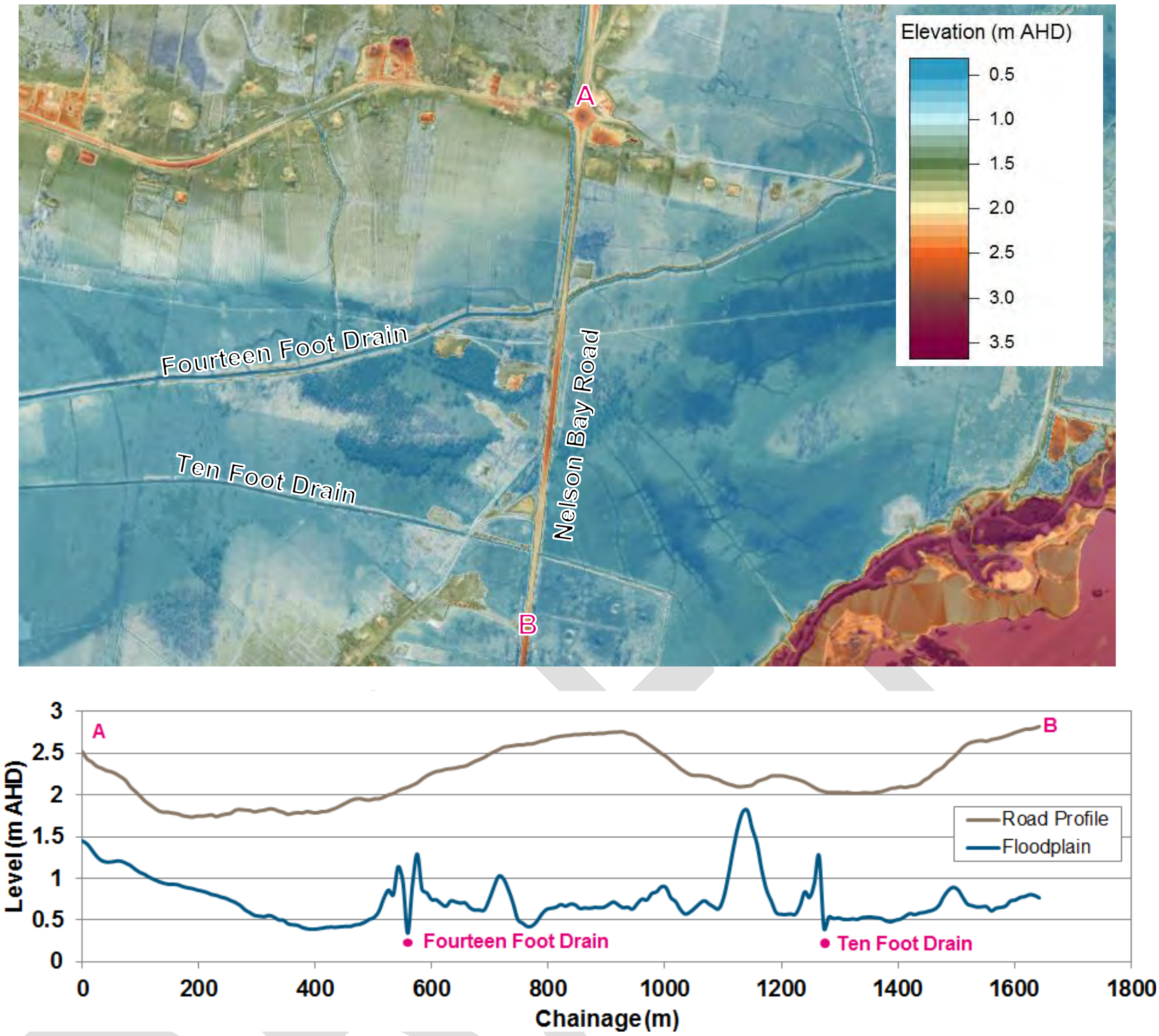


Figure 7-1 Nelson Bay Road at Fullerton Cove

Raising of Nelson Bay Road has been considered as a potential management option in order to combat the impacts of progressive climate change. The key objective of the works is to control the distribution of flow between the Hunter River and Tilligerry Creek floodplain. The flow across Nelson Bay Road relative to the main Hunter River floodplain is summarised in Table 7-1 for a range of climate change scenarios. The climate change scenarios provide for sea level rise and peak flow increases as discussed in Section 4.3.

Table 7-1 shows the increase in flow overtopping Nelson Bay Road for the 1% AEP event corresponding to the increase in upstream flood levels. For all scenarios it can be seen that the flow overtopping Nelson Bay Road is relatively minor in comparison to the total Hunter River discharge combining the North Arm and South Arm flows. Accordingly, raising of Nelson Bay Road to limit/remove the overtopping would have minimal change on the overall flow distribution. It would be anticipated that the North Arm of the Hunter River and broader Fullerton Cover floodplain area would need to accommodate the redistributed flow. Even for the future 1% AEP flood condition incorporating 0.9 m sea level rise and 20% flow increase (nominal Year 2100 planning condition), the Nelson Bay Road discharge represents less than 5% of the total flow in the North Arm.

Table 7-1 Nelson Bay Road Overtopping and Hunter Flow Distribution

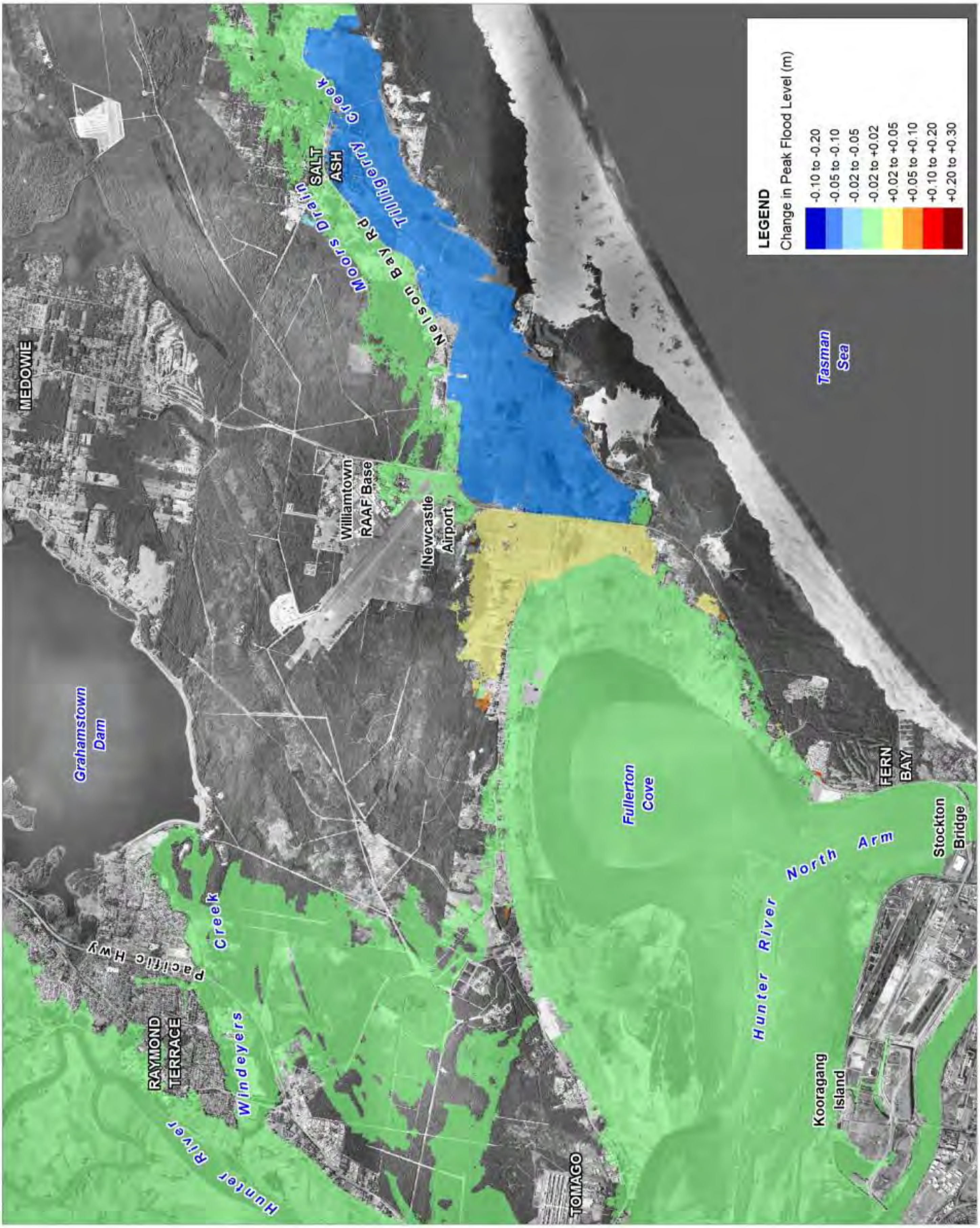
Event	Existing Condition 1% AEP	1% AEP +0.4 m SLR	1% AEP +0.4 m SLR +20% Flow	1% AEP +0.9 m SLR +	1% AEP +0.9 m SLR +20% Flow
Peak Level U/S NB Road	1.5 m AHD	1.9 m AHD	2.2 m AHD	2.3 m AHD	2.5 m AHD
Flow across NB Road	0 m^3/s	12 m^3/s	110 m^3/s	300 m^3/s	390 m^3/s
North Arm Flow	6000 m^3/s	6420 m^3/s	7400 m^3/s	6920 m^3/s	7860 m^3/s
South Arm Flow	1740 m^3/s	1790 m^3/s	2150 m^3/s	1890 m^3/s	2230 m^3/s

The developed model has been applied to simulate the impact of raising Nelson Bay Road to a minimum level of 2.5 m AHD. This level provides 1% AEP flood immunity for the road for the nominal Year 2100 planning condition.

The change in peak flood level through raising Nelson Bay Road is shown in Figure 7-2 and Figure 7-3 for the 1% AEP event with 0.4 m sea level rise / 20% increase in flow (nominal 2050 planning condition) and 0.9m sea level rise / 20% increase in flow (nominal 2100 planning condition) respectively. The road raising eliminates the flow overtopping (~110^3/s for 2050 and ~390m^3/s for 2100) of the existing road profile and accordingly there is a corresponding decrease in peak flood levels downstream of Nelson Bay Road. Under this road raising scenario, the residual flooding in the broader Tilligerry Creek floodplain is limited to the local catchment inflows and the discharges through the culverts on Nelson Bay Road for the Fourteen Foot Drain and Ten Foot Drain. The general reductions in peak flood level in the Tilligerry Creek floodplain are in the order of 0.1 m for the 2050 planning condition 0.3 m for the 2100 planning condition. The 2100 condition shows a greater benefit in terms of the road raising, given the greater magnitude of flow being controlled from spilling into Tilligerry Creek. Accordingly, the road raising can be seen to be effective in offsetting potential increases in peak flood levels associated with climate change in this locality.

It is noted that there is no corresponding reduction in the Moors Drain area. This is largely due to flooding conditions in this part of the floodplain being driven by the local flows emanating from (in most part) the Airport precinct. Accordingly, the control of Hunter River flows spilling over Nelson Bay Road at Fullerton Cove provides limited benefit.

The simulated results show a corresponding increase in peak flood level immediately upstream of the raised section of Nelson Bay Road. This reflects the restriction of flow spilling over the road, which is essentially redistributed or maintained within the broader floodplain of Fullerton Cove and the Hunter River North Arm. Simulated peak flood level increases upstream of Nelson Bay Road are 0.03 m and 0.07 m for the 2050 and 2100 planning conditions respectively.



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Peak Flood Level Impact - Nelson Bay Road Raising
1% AEP +0.4m SLR + 20% flow scenario

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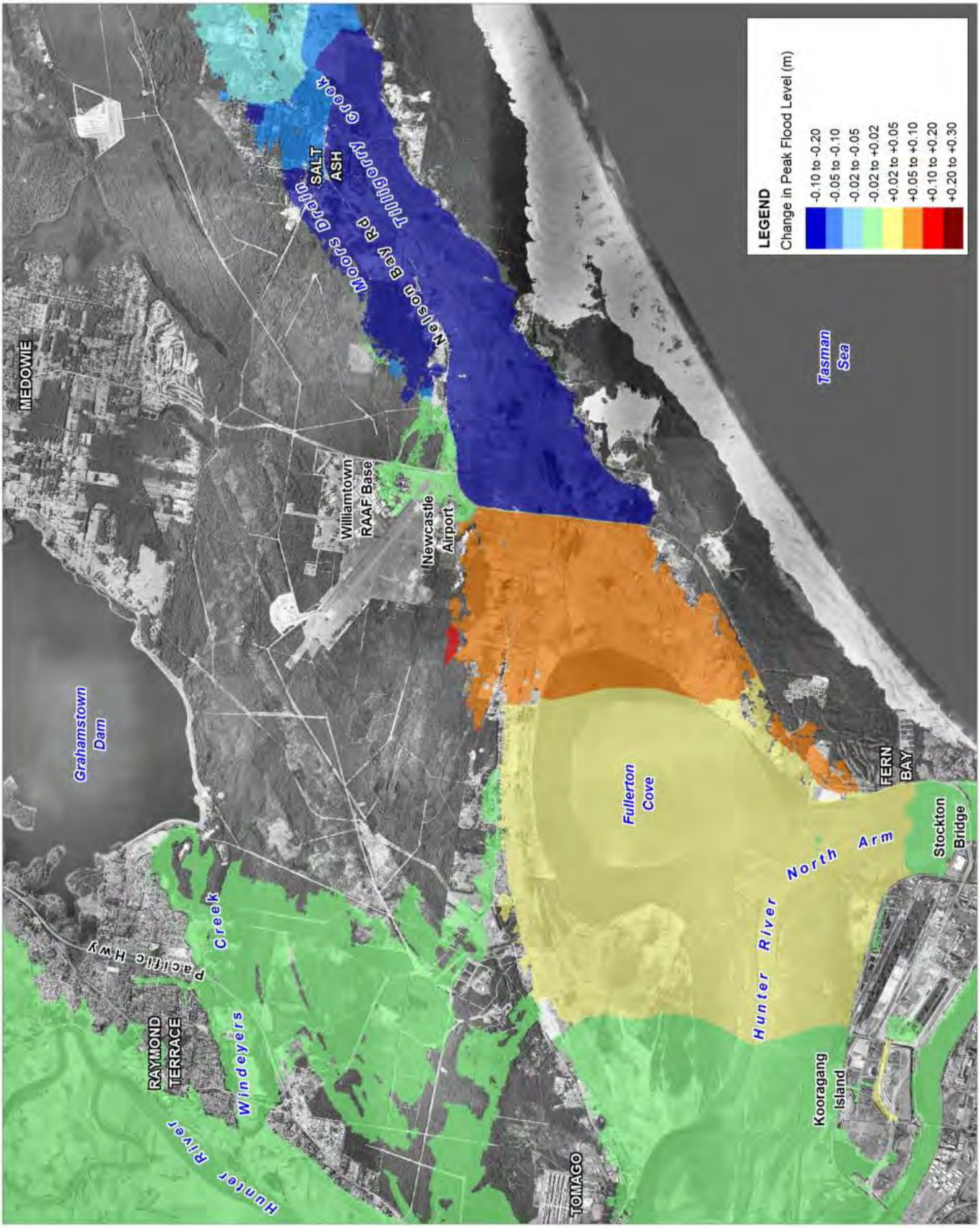

Title:

Peak Flood Level Impact - Nelson Bay Road Raising
1% AEP +0.9m SLR + 20% flow scenario

Figure: 7-3

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For the 2050 condition, upstream impacts are largely limited to downstream of the Fullerton Cove levee. For the 2100 condition, the impacts further throughout the upstream floodplain through Fullerton Cove and the Hunter River North Arm.

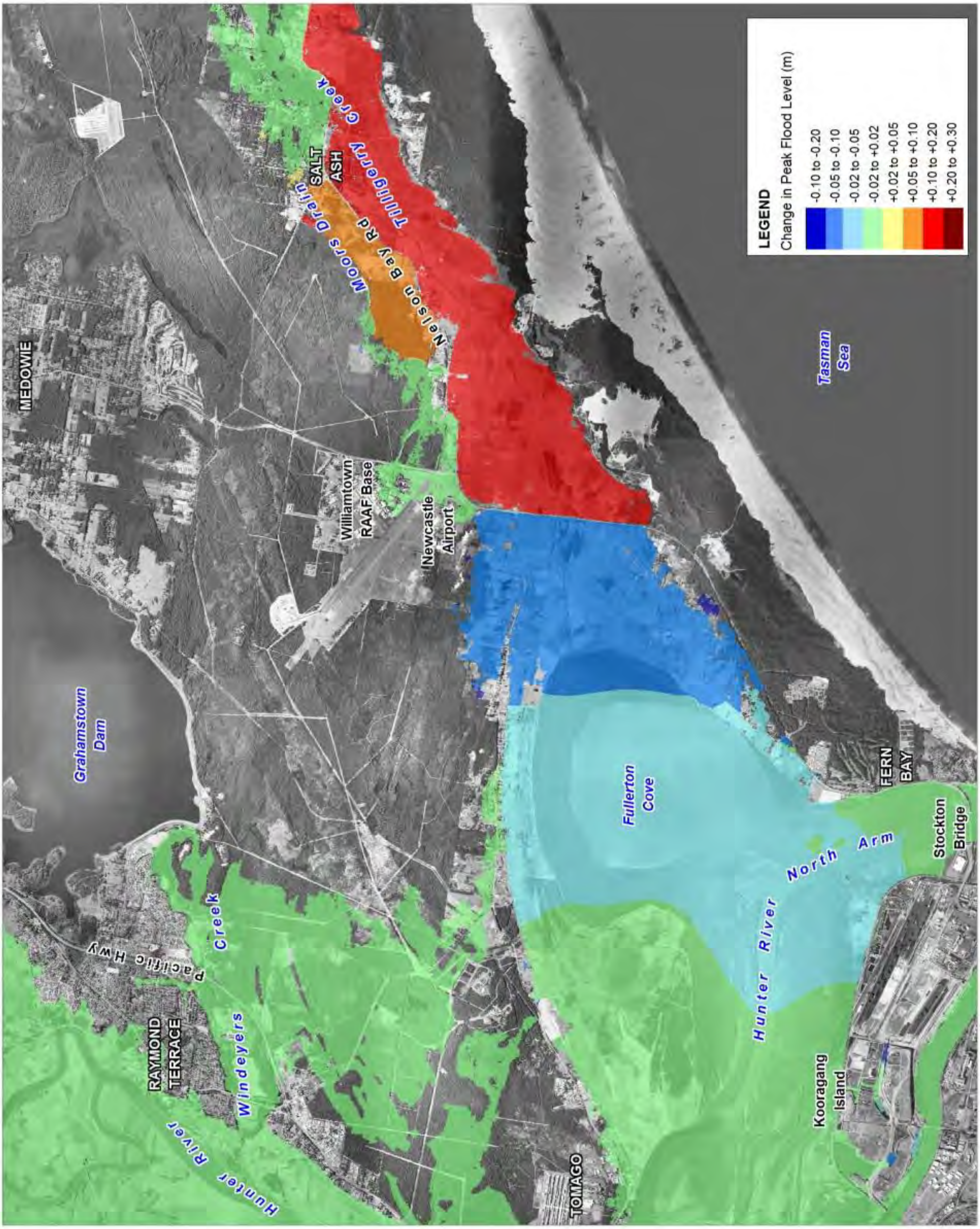
Whilst potentially providing an effective measure to manage increasing flood levels in the Tilligerry Creek floodplain, there are several existing properties upstream of Nelson Bay Road which may be adversely impacted. It is noted however, that the major impacts are associated with a future planning condition somewhat into the future. Accordingly, there may be some change to development within the impacted area over this time providing further opportunity to manage potential impacts.

Lowering of Nelson Bay Road has been considered as an alternative flood risk management option. Noting some existing development upstream of the road being affected by raising of the road, the corresponding area would be expected to benefit from a lowering of the road. Associated with the lowering is in an increase in discharge to the Tilligerry Creek floodplain such that the area downstream of the road would be expected to be adversely impacted by this option. The modelled option has considered lowering of Nelson Bay Road to existing floodplain levels, thereby providing no impedance to flow. This would obviously have flood access implications, however, the simulated result is also representative of a complete bridging of this section of road as opposed to a raised embankment.

The change in peak flood level through lowering Nelson Bay Road is shown in Figure 7-4 and Figure 7-5 for the 1% AEP 2050 planning condition and 1% AEP 2100 planning condition respectively. The 2050 condition provides for the most significant changes in the peak flood level distribution with general increases of the order of 0.5 m in the Tilligerry Creek floodplain downstream. The increase in peak flood levels downstream of Nelson Bay Road is a function of the increased flow from ~110 m^3/s (as per Table 7-1) to ~370 m^3/s. There is a corresponding decrease in flood levels in the order of -0.08 m immediately upstream of Nelson Bay Road. Peak flood levels are also reduced to a lesser degree further upstream into the Fullerton Cove and Hunter River North Arm floodplain area as a result of the lowering of Nelson Bay Road, as the key hydraulic control in the area.

The impact of lowering the road is less for the 2100 planning event. This is due to the extensive overtopping of the existing road under this flow condition and the lesser control of the elevated embankment on peak flood conditions. Nevertheless, there is still some adverse impact to the Tilligerry Creek floodplain downstream. The increase in peak flood levels downstream of Nelson Bay Road is a function of the increased flow from ~390 m^3/s (as per Table 7-1) to ~560 m^3/s. For the 2100 condition, the 0.9 m sea level rise on Tilligerry Creek tailwater conditions has a significant influence on peak flood level conditions, thereby reducing the sensitivity to the increase flow transfer across Nelson Bay Road.

There seems little merit in lowering of Nelson Bay Road as a potential option. Lowering of the road would provide for a significant increase in flow to the Tilligerry Creek floodplain and resulting increase in peak flood levels. The benefit of lowering the road would be realised in reducing peak levels between the road and the Fullerton Cove levee where there is limited existing development to directly benefit. However, the raising option as noted appears to be a more effective measure for the broader floodplain area, particularly in response to potential climate change influences.



Title:

Peak Flood Level Impact - Nelson Bay Road Lowering 1% AEP +0.4m SLR + 20% flow scenario

Figure: **7-4**

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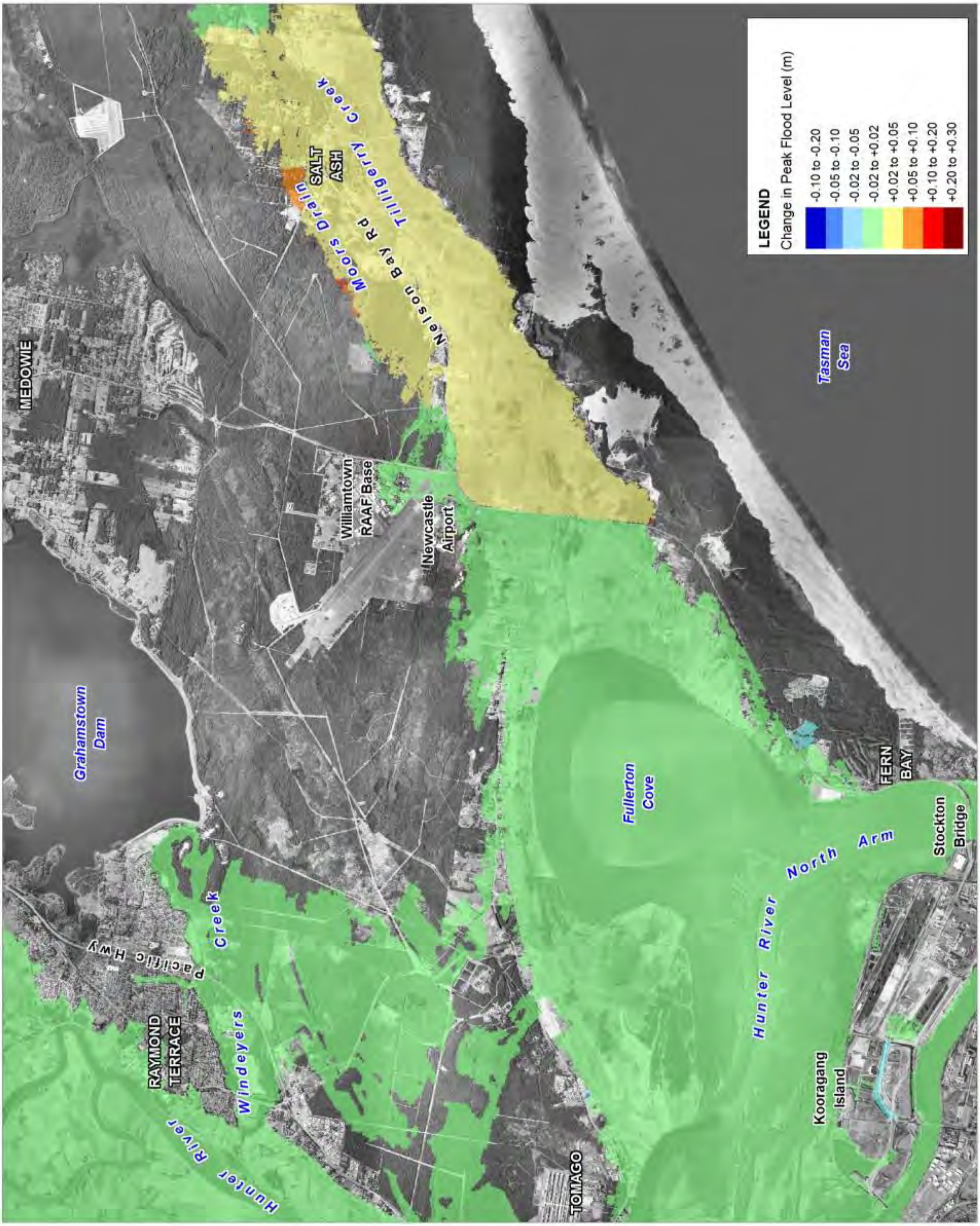

Title:

Peak Flood Level Impact - Nelson Bay Road Lowering
1% AEP +0.9m SLR + 20% flow scenario

Figure: **7-5**

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The changes to the existing Nelson Bay Road profile considered above have focused on the section between Fern Bay and Williamtown as a means of controlling the flow distribution to the lower floodplain. More generally, Nelson Bay Road serves as the primary access route through the study area connecting Newcastle to Port Stephens. Accordingly, the road is significant for local and regional flood access.

Figure 7-6 shows a long-section profile along Nelson Bay Road from Fullerton Cove to beyond Salt Ash. The upper section of the figure shows the general topography and alignment of the road with long section chainages shown for reference. The lower section of the figure shows the long-section profile of the approximate road crest level. Key intersection locations along Nelson Bay Road are shown for reference.

There are a number of key low points in the existing profile, most notably the area adjacent to Fullerton Cove as discussed above and the section near Marsh Road towards the Port Stephens end, before tying into higher ground. However, the current road profile still provides for 1% AEP flood immunity under existing conditions.

The existing flood immunity of the road will gradually decrease, with progressive climate change impacts increasing design peak flood level conditions. The section of road south of Cabbage Tree Road is overtopped by Hunter River flows in the 1% AEP 2050 planning condition event as presented in Table 7-1 (peak flood level ~2.2 m AHD) and addressed in the road options discussed above. The section around Marsh Road is susceptible to overtopping from the storm surge conditions from the Port Stephens estuary in the same event (peak flood level ~2.0 m AHD). Accordingly, in providing 1% AEP flood immunity to the 2050 planning condition, these two sections would need to be raised of the order 0.3-0.5 m.

To maintain a 1% AEP flood immunity for Nelson Bay Road moving through to 2100 peak flood level ~2.5 m AHD) and beyond, progressive raising of further sections of the road is required. Initially the road section requiring raising would be limited to the sections south of Cabbage Tree Road (chainage 0.5-2 km in Figure 7-6) and Marsh Road (chainage 11.5-13 km). With the progressive influence of sea level rise, a more extensive section of road adjacent to the Moors Drain (6-9 km chainage) would need to be addressed.

Whilst not specifically requiring immediate works, road upgrades may be undertaken in association with regular maintenance programs (e.g. resurfacing) to provide progressive lifting of the existing road surface profile and maintain appropriate flood immunity. Therefore the recommendation in the Floodplain Risk Management Plan does not provide for immediate upgrade works, but rather for NSW Roads and Maritime Services to include a long term road raising program within their road asset management plans. The requirement for progressive road raising will be linked to the manifestation of climate change impacts and reduced flood immunity. Accordingly, there may be a considerable lag time before any specific works are required and continual review of the emerging climate change science would typically inform this element of the Flood Plan. However, it is envisaged that road raising works would be undertaken pro-actively in order to improve or at least maintain current flood immunity standards in advance of the impacts of climate change.

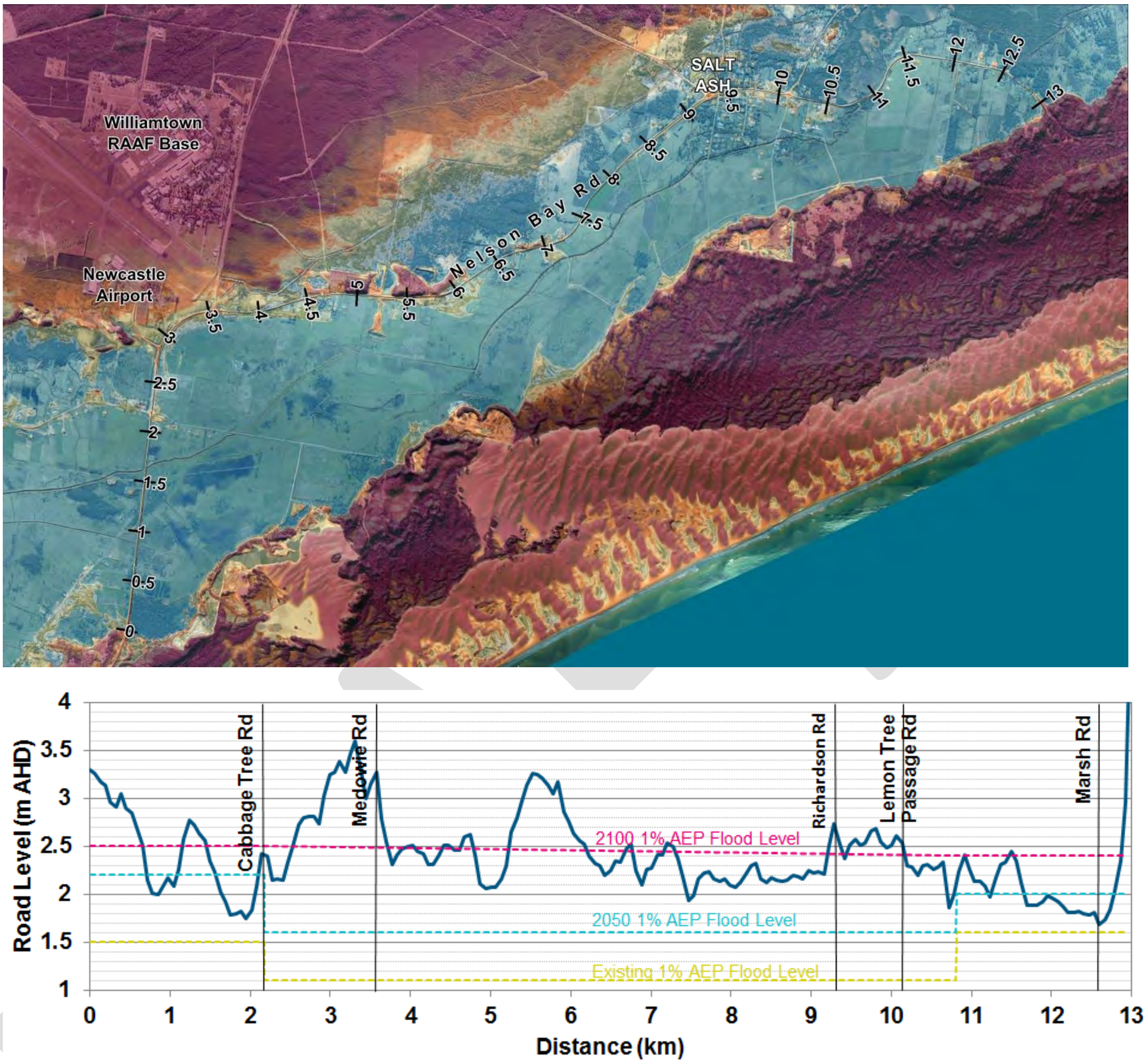
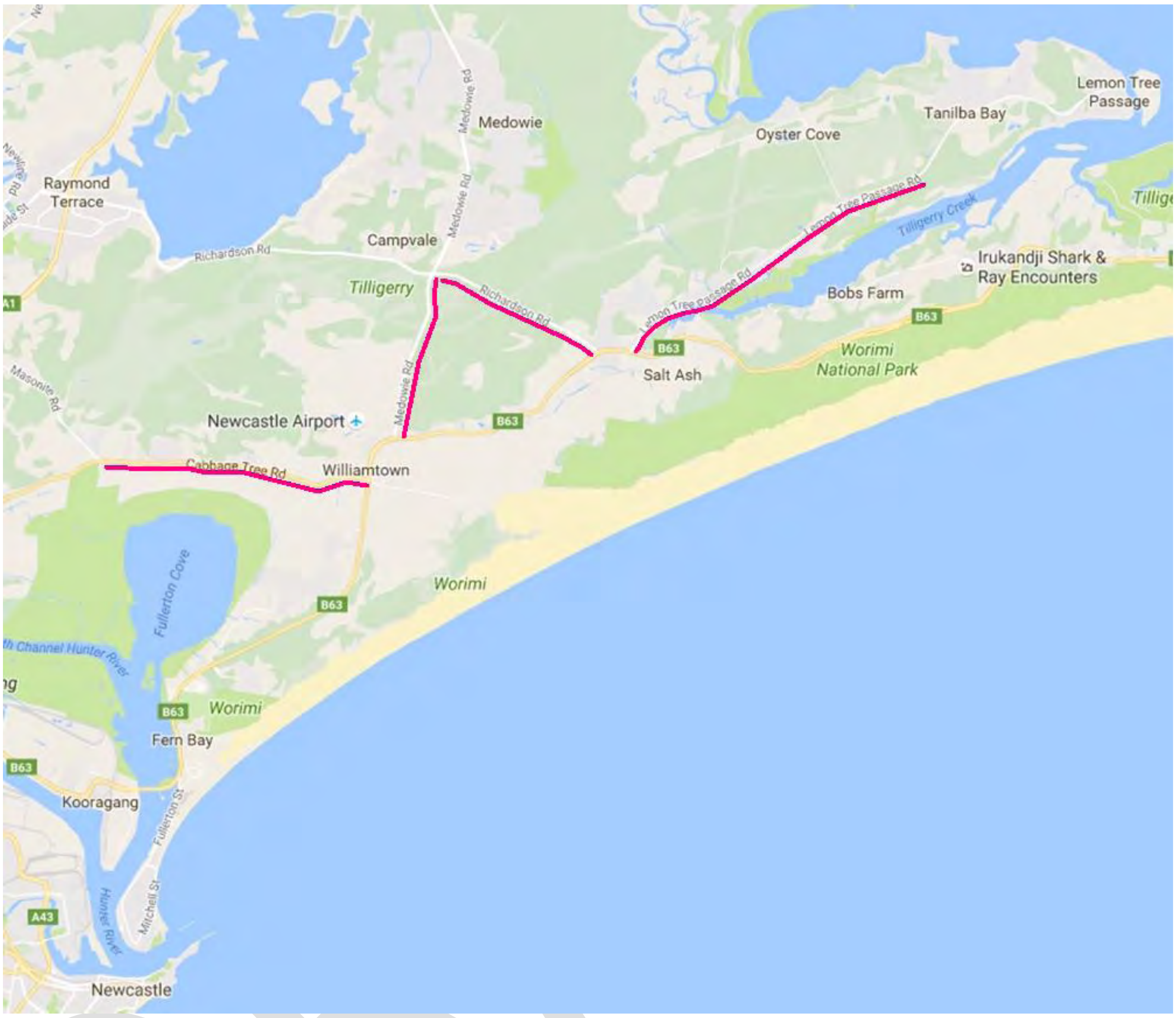


Figure 7-6 Nelson Bay Road Profile

7.1.2 Regional Road Network

Nelson Bay Road serves as the principle access route between Newcastle and Port Stephens. As presented in Section 7.1.1, the existing flood immunity of this key transport route will lessen under the influence of climate change as design flood levels progressively increase. In addition to Nelson Bay Road, there are other local road routes that also will be subject to decreasing levels of service in regard to flood immunity.

Figure 7-1 shows some of the important local road connections linking through the Williamtown-Salt Ash floodplain. In addition to Nelson Bay Road, Cabbage Tree Road, Medowie Road, Richardson Road and Lemon Tree Passage Road have been highlighted as significant local route connections.



(Google Maps image)

Figure 7-7 Local Road Network

Long-section profiles along these routes are presented hereunder to demonstrate the relative levels and identify lengths of the routes susceptible to inundation under future flooding conditions.

Figure 7-8 shows the long-section profile along Cabbage Tree Road from the intersection of Nelson Bay Road extending westward for some 2 km to the Dawsons Drain. The top portion of the figure shows the chainage location along the road and the relative local floodplain topography as defined by available LiDAR data.

The lowest point along Cabbage Tree Road of approximately 1.5 m AHD is at the Middle Creek drain crossing. Comparison of the design peak flood levels provided in Table 7-1 with the levels along Cabbage Tree Road indicate this low point is equivalent to the existing design 1% AEP peak flood level for Hunter River flooding. The design peak flood levels for the nominal 2050 and 2100 planning condition incorporating climate change impacts provide for peak levels of 2.2 m AHD and 2.5 m AHD respectively. Under these conditions, significant lengths of Cabbage Tree Road would be subject to inundation including large depths of flooding particularly at the existing Middle Drain low point. At the nominal 2100 planning condition, almost the full length of the road between Nelson Bay Road and Dawsons Drain would be inundated. The level of Cabbage Tree Road to the west of Dawsons Drain is in excess of 2.5 m AHD, such that key road flood immunity issues are of less concern along that stretch of road.

It is noted that the Extreme Flood levels in the Hunter River at this location are ~5.2 m AHD, which would inhibit use of the road for flood evacuation purposes once overtopping has been initiated.

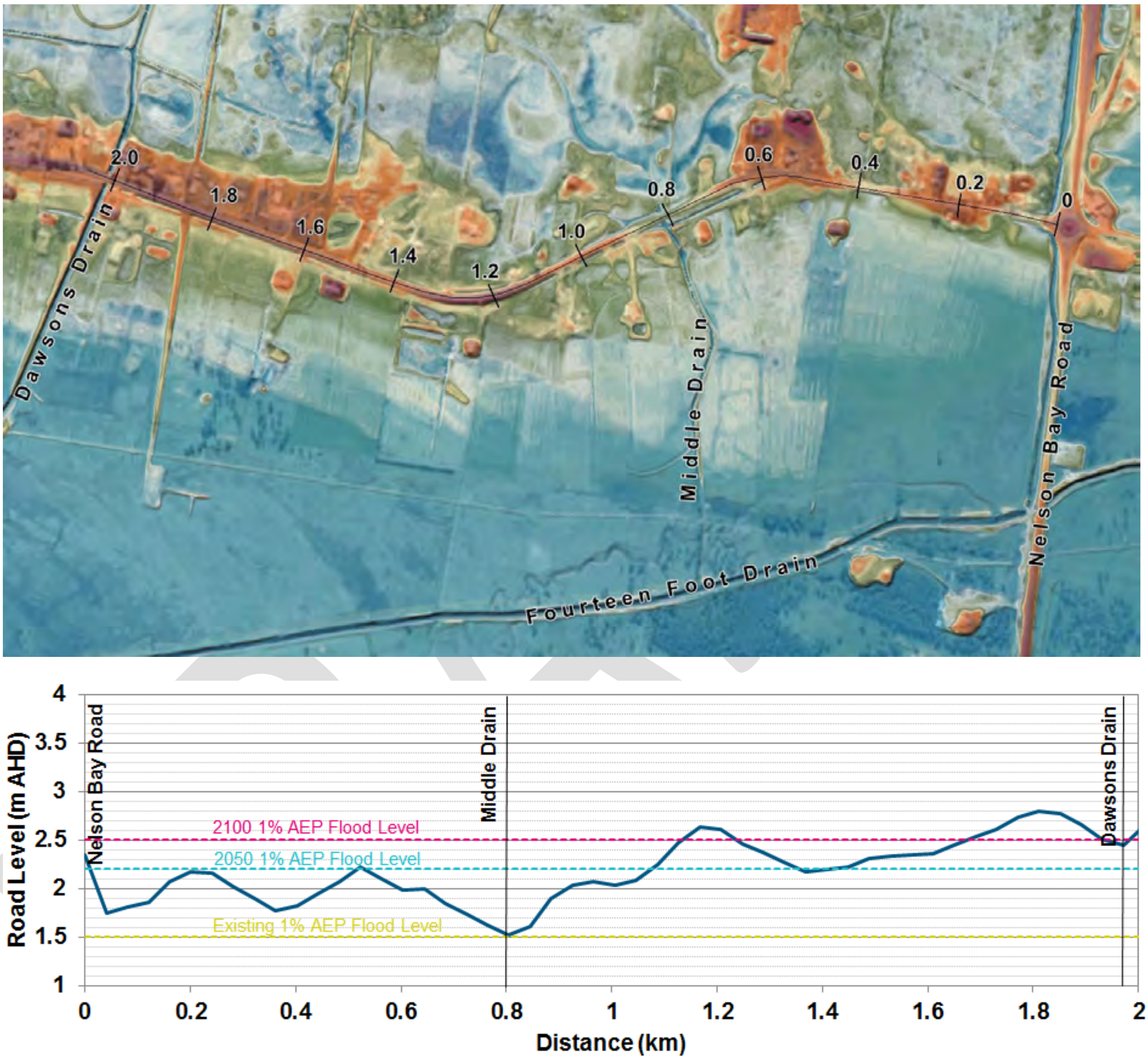


Figure 7-8 Cabbage Tree Road Profile

Figure 7-9 shows the long-section profile along Richardson Road extending a distance 1.2 km north-west from the intersection of Nelson Bay Road. The existing road levels are typically above 2.4 m AHD and accordingly provides for 1% AEP flood immunity up to the nominal 2100 planning condition incorporating the adopted climate change provisions. Extreme Flood levels are approximately 4.8 m AHD and accordingly would render Richardson Road un-trafficable once overtopping is initiated.

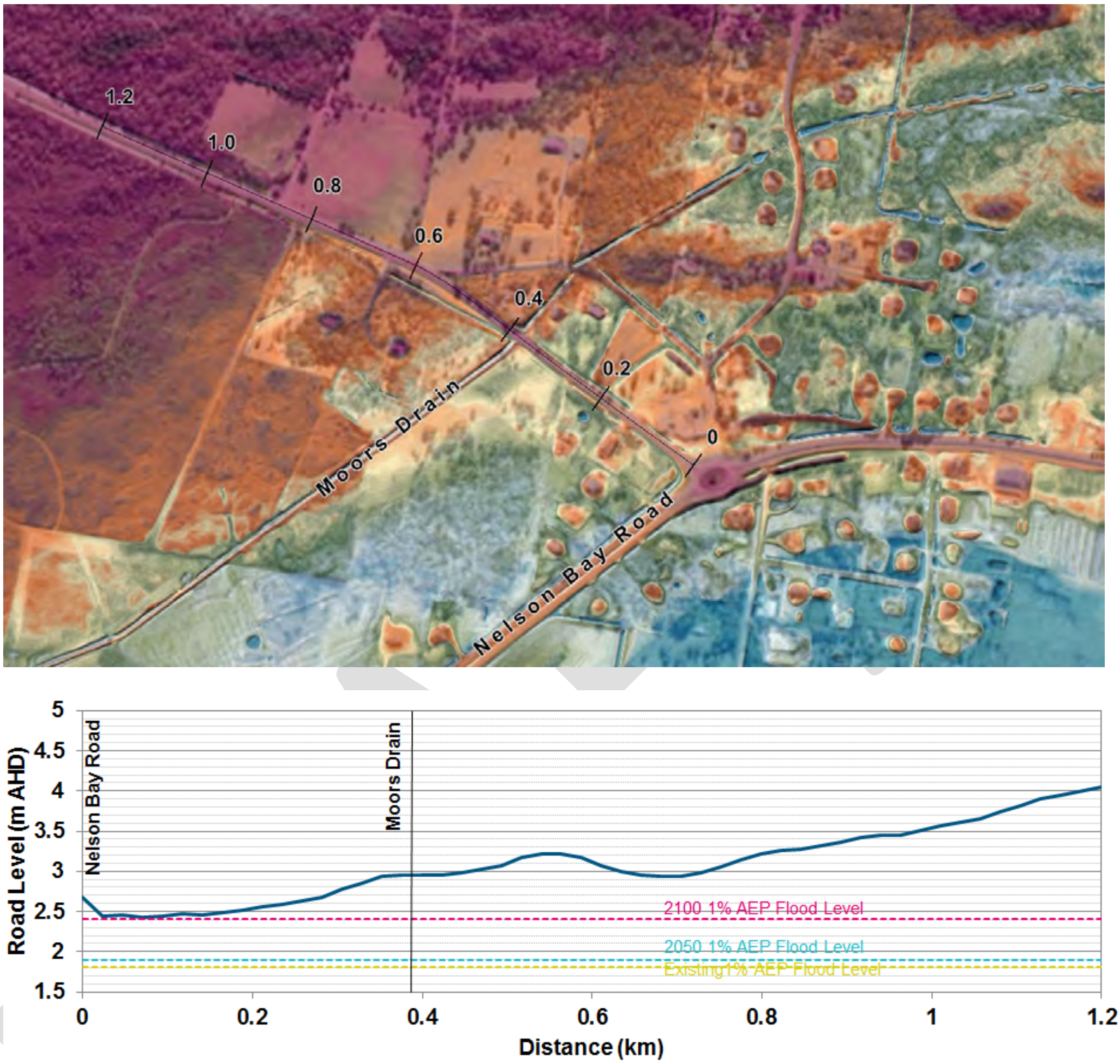


Figure 7-9 Richardson Road Profile

Figure 7-10 shows the long-section profile along Lemon Tree Passage Road extending a distance 4.5 km north-east from the intersection of Nelson Bay Road through to Oyster Cove Road. This is the principal road route to access the communities around Tanilba Bay and Lemon Tree Passage on the southern foreshore of the Port Stephens estuary.

The lowest point along the road is in the vicinity of the intersection with Michael Drive at around 1.7 m AHD. At this level, the road has 1% AEP flood immunity for existing conditions. Under increased design flood levels associated with climate change impacts for the nominal 2050 and 2100 planning conditions, a significant length of the road would be subject to inundation at the 1% AEP level. Similar to the other regional roads, the road is well overtopped by the Extreme Flood levels in excess of 3.5 to 4 m AHD.

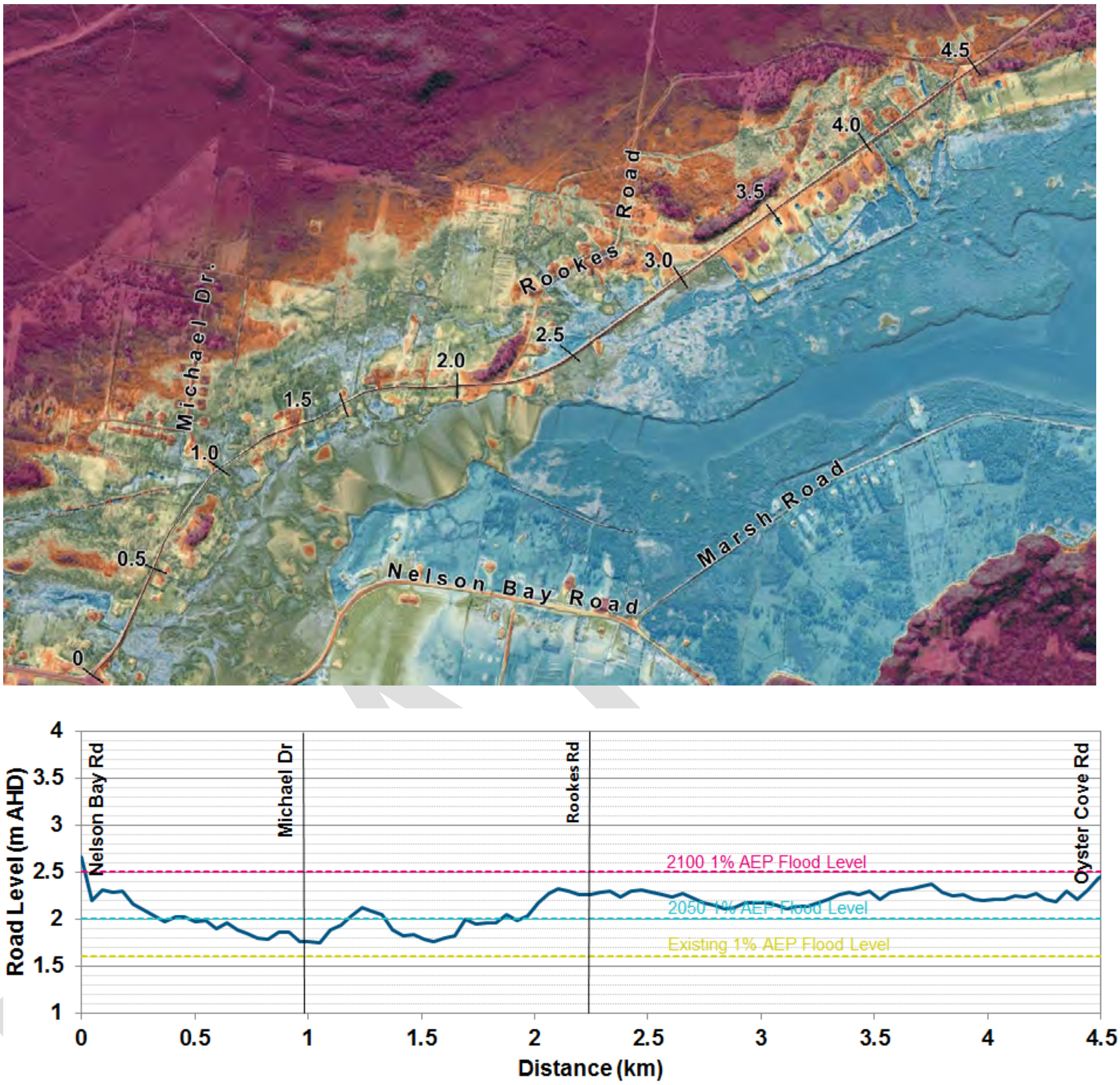


Figure 7-10 Lemon Tree Passage Road Profile

Medowie Road is noted as the other significant regional access road as shown in Figure 7-7. Medowie Road grades upward from around 2.5 m AHD from Nelson Bay Road to 11 m AHD at the intersection with Richardson Road to the north. Noting the peak flood levels discussed above, the existing road has 1% AEP flood immunity up to the 1% AEP 2100 planning condition level of 2.5 m AHD.

All of the key regional road routes have been identified as having 1% AEP flood immunity for existing design flood conditions on the Hunter River/Tilligerry Creek. For future design flood conditions incorporating climate change provisions, a number of routes are susceptible to inundation at the 1% AEP design level. Table 7-2 provides a summary of the approximate length of road subject to inundation at the 1% AEP design level for existing, 2050 and 2100 planning conditions. This provides an indication of the extent of road raising works that would be required to maintain 1% AEP flood immunity along each of the routes as the immunity is gradually reduced through climate change influence. This data may inform future capital works programs, however, in the context of the current Floodplain Risk Management Plan, there is no direct recommendation for road raising to address current flood risk. However, some road raising may opportunistically be undertaken as part of resurfacing/road upgrade works.

Table 7-2 Regional Road Inundation Summary – Length of Road Overtopped

Road	1% AEP Existing Condition	1% AEP +0.4 m SLR +20% Flow (2050 Condition)	1% AEP +0.9 m SLR +20% Flow (2100 Condition)
Nelson Bay Road	0 m	4500 m	8500 m
Cabbage Tree Road	0 m	1000 m	1500 m
Medowie Road	0 m	0 m	0 m
Richardson Road	0 m	0 m	0 m
Lemon Tree Passage Road	0 m	1500 m	4500 m

7.1.3 Lower Hunter Flood Mitigation Scheme

Following the major 1955 flood event in the Hunter River, the Lower Hunter Flood Mitigation Scheme was constructed. The existing Hunter River flood levees provide existing protection for lower order flood events (<5% AEP) for the floodplain areas in the vicinity of Tomago and Fullerton Cove.

The model configurations developed for the Williamtown-Salt Ash Flood Study include the representation of the levee system including appropriate cross drainage as applicable. Accordingly, the establishment of design flood conditions in the current study is based on the current levee configuration for both existing and future conditions.

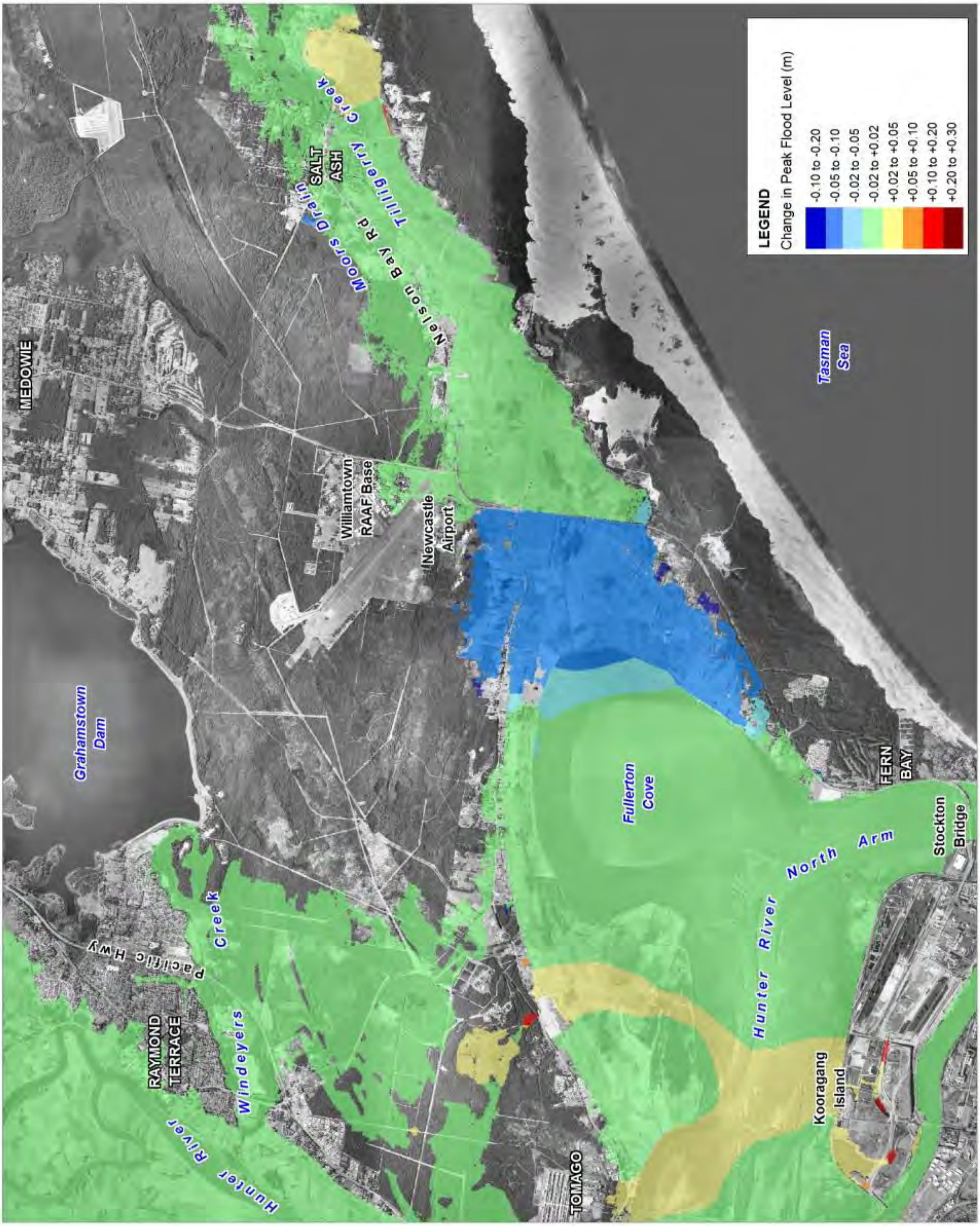
The scheme is managed by the NSW Office of Environment and Heritage. It is understood there are no formal plans for modifications to the existing flood levee configurations. However, it is important to recognise the potential influence of the existing levee system on the design flood behaviour in the Williamtown-Salt Ash study area. Accordingly, any future modification of the levee system, through either enhancement or decommissioning, would warrant a full review of impacts on Williamtown-Salt Ash flood conditions.

The alignment of the existing levee around Tomago and Fullerton Cove is shown in Figure 7-11. The crest levels vary along the levee profile, however, generally the crest elevation is of the order of 1.3 to 1.5 m AHD. The developed models have been applied to assess the potential impacts of changes in the current levee system representing a general raising or lowering of the full length of the levee.

Figure 7-11 Fullerton Cove Levee

The change in peak flood level through raising the Fullerton Cove Levee by 0.5 m is shown in Figure 7-12 and Figure 7-13 for the 1% AEP 2050 planning condition and 1% AEP 2100 planning condition respectively. The change in the 2050 condition provides for a minor decrease in flood levels (~-0.07 m) on the eastern side of the Fullerton Cove levee. The benefit does not extend beyond Nelson Bay Road which remains as the major hydraulic control for flows through to Tilligerry Creek. West of Fullerton Cove the simulation results show some minor increase on flood levels associated with the increase in levee height in this locality.

For the 1% AEP 2100 condition, Figure 7-13 shows a more extensive area of reduced peak flood levels downstream of the levee system extending beyond Nelson Bay Road into the broader Tilligerry Creek floodplain. The peak flood level reductions are only of the order of 0.04 m. The influence extends into the lower Tilligerry Creek floodplain under these conditions as Nelson Bay Road is overtopped to a greater degree thereby having a weaker hydraulic control.



Title:

Peak Flood Level Impact - Fullerton Cove Levee Raised 1% AEP +0.4m SLR + 20% flow scenario

Figure: 7-8

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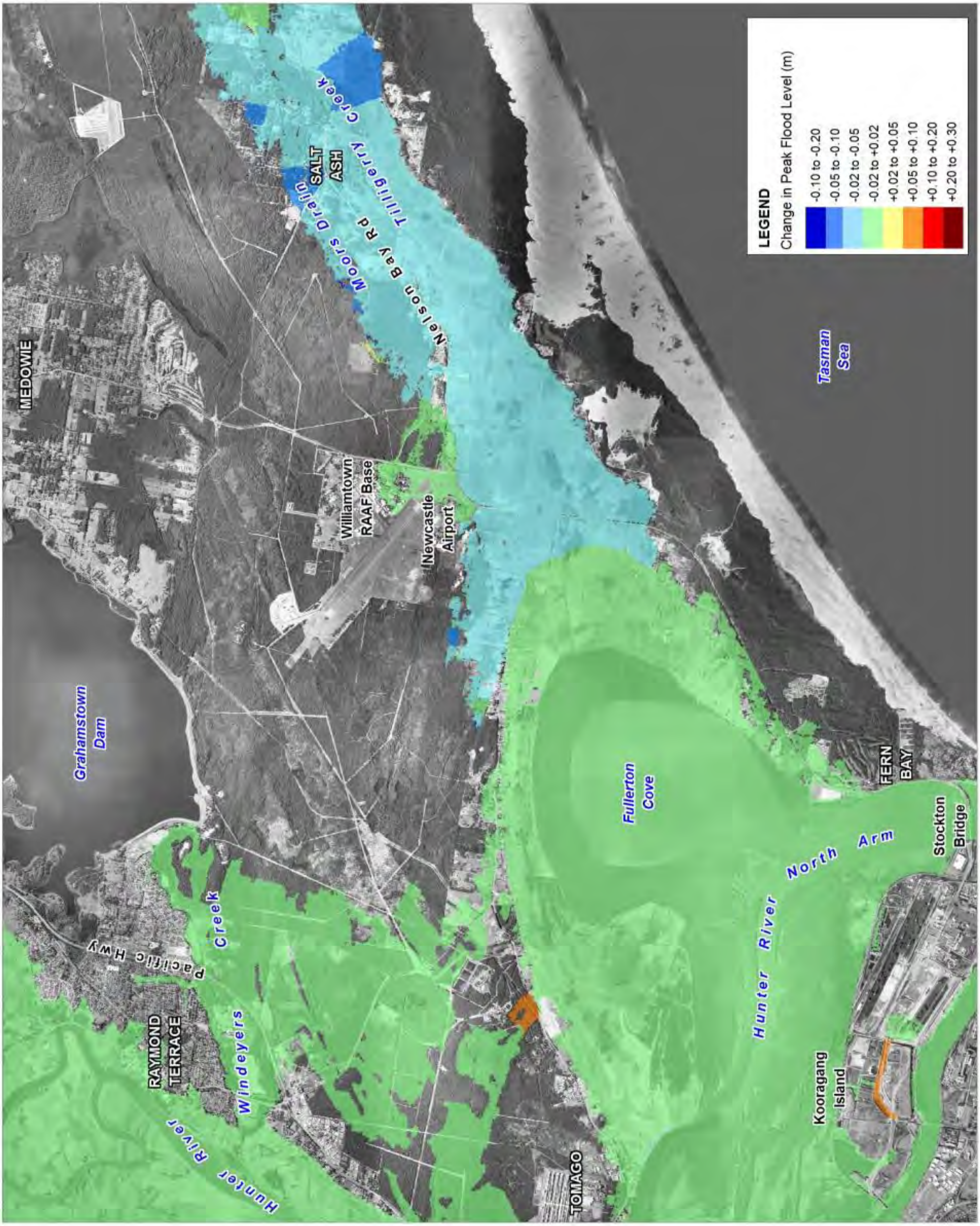

Title:

Peak Flood Level Impact - Fullerton Cove Levee Raised 1% AEP +0.9m SLR + 20% flow scenario

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The simulated raising of the Fullerton Cove levee has no significant influence on the peak flood levels in the broader Fullerton Cove and Hunter River North Arm floodplain for the 1% AEP 2100 condition. Even with a raised embankment, the level of overtopping of the levees under these flow conditions is significant, such that there is little hydraulic control on peak flood level conditions.

The change in peak flood level through lowering the Fullerton Cove Levee is shown in Figure 7-14 and Figure 7-15 for the 1% AEP 2050 planning condition and 1% AEP 2100 planning condition respectively. For the 2050 planning condition, lowering of the levee provides for a minor increase in peak flood levels downstream of Nelson Bay Road. The levee lowering provides for a redistribution of flow with increased flow over Nelson Bay and a corresponding reduction of flow in the Hunter River North Arm.

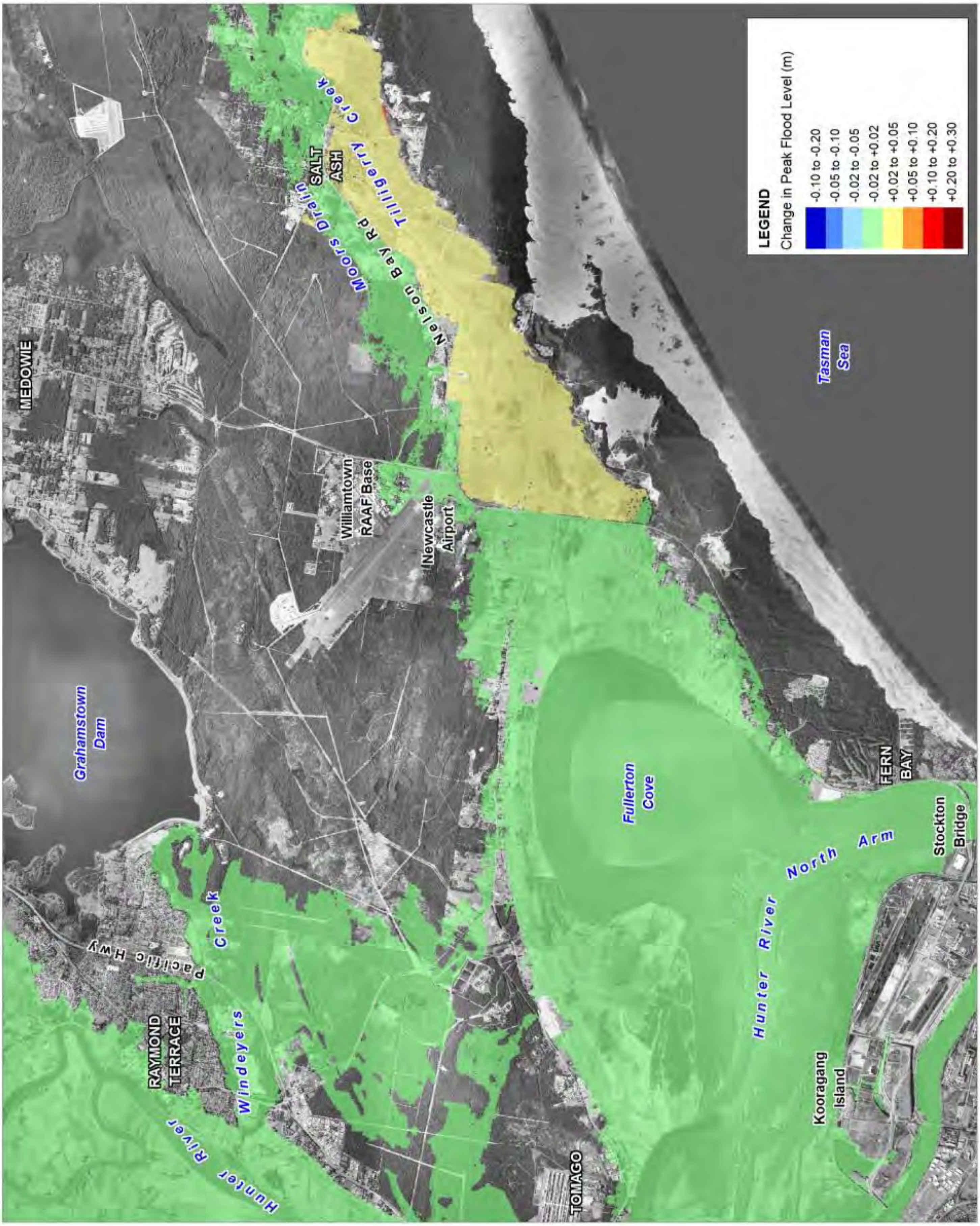
The redistribution of flow between the Nelson Bay Road overflow and the Hunter River North Arm is less significant for the higher flows of the 2100 planning condition. Accordingly, there is limited impact on the peak flood levels of the levee lowering for this magnitude event.

Without modification, the flood protection standard afforded by the existing levee will gradually reduce in line with increasing design flood levels associated with climate change influences. To this end, the frequency of overtopping of the levees under flood conditions will increase (approximate 5% AEP existing standard of protection). Further, the degree of overtopping in major flood events (e.g. 1% AEP) will be exacerbated, thereby increasing the redistribution of flow to Tilligerry Creek in particular as shown in Table 7-1.

The simulated impact of the Fullerton Cove levee modification options presented in Figure 7-12 to Figure 7-15 do not provide for significant changes in flood behaviour to consider as meaningful options to address future flooding risks. Other levee modification options are available such as different height configurations and new/additional alignments. However, at this stage the Nelson Bay Road embankment adjacent to Fullerton Cove remains the most significant control on peak flood level conditions and modifications to the road provide a greater opportunity to manage flooding.

Future climate change conditions may warrant reassessment of the levee function not just from a flood management perspective, but also ecological response in the broader Fullerton Cove/Lower Hunter River system. This area includes significant estuarine wetland environments and the influence of climate change will significantly change the current hydrological regimes. This is not just for flooding/catchment rainfall driven events, but also the regular tidal cycle, in which landward progression of the intertidal zone (and associated ecological response/community migration) under sea level rise scenarios may be impeded by fixed levees.

Accordingly there may be some future drivers for modification of the existing levee configurations and associated maintenance. In recognising the significance of the levee system in ongoing floodplain risk management for Williamtown - Salt Ash, the Plan provides for formal review in the event of any change in existing Plans of Management for the broader Hunter Valley Flood Mitigation Scheme.



Title:

Peak Flood Level Impact - Fullerton Cove Levee Lowered 1% AEP +0.4m SLR + 20% flow scenario

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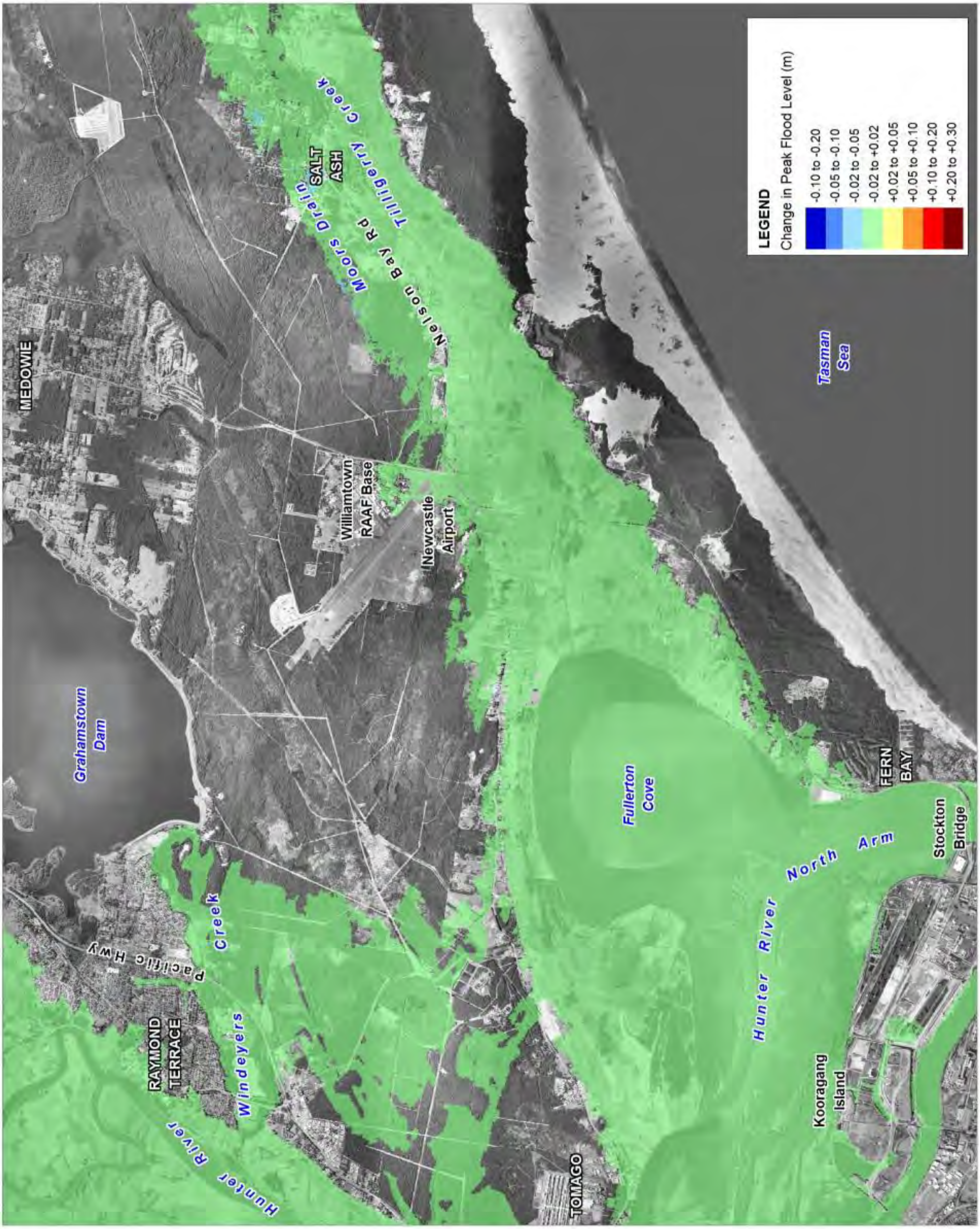

Title:

Peak Flood Level Impact - Fullerton Cove Levee Lowered 1% AEP +0.9m SLR + 20% flow scenario

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7.1.4 Salt Ash Flood Gate Modification

The Tilligerry Creek flood gates consist of four 1.8 m diameter circular pipes with one-way flap valves which prevent tidal inundation on the incoming tide, and allow water to drain out on the ebb tide. The floodgates provide an artificial tidal limit, preventing tidal exchange beyond the gates, thereby limiting tidal water ingress to the floodplain upstream. . The existing embankment forms part of a continuous levee control tying back in to Nelson Bay Road also providing some level of flood protection.

The design flood level profiles in Figure 4-5 showed 1% AEP flood levels in the Tilligerry Creek floodplain upstream of the flood gates to be significantly lower than the levels both upstream of Nelson Bay Road at Fullerton Cove and downstream of the flood gates. This part of the floodplain acts like a storage with water levels a function of the inflow volume of floodwater from the Hunter River inflows and local catchment contributions, and the outflow controlled by the flood gates. The peak flood level profiles for the 1% AEP design event show the flood gates would be closed at the peak flood condition with water levels in Tilligerry Creek downstream of the gates significantly higher than upstream. This condition holds for the 1% AEP 2050 condition, with albeit higher flood level attained upstream of the flood gates due to the higher inflow volumes. Accordingly, the current flood gate capacity does not have a major influence on the peak flood level. The capacity would have more influence however on the duration of inundation as the floodplain drains during periods when the gates are not tide locked.

For lower order local drainage events, the flood gate capacity will have some influence on the drainage of the agricultural lands upstream. The flood gates effectively provide a drainage function as part of the system of constructed drains used to remove stormwater from agricultural land. The influence of sea level rise in the Port Stephens estuary including the lower Tilligerry Creek will provide for gradual reduction in the performance of these outlets. The incidence and duration of the gates becoming “tide locked” will gradually increase, rendering the current configuration of culverts ineffective for draining the upstream areas. The influence of the tidal conditions on the local drainage function is discussed further hereunder.

The OEH coastal data network consists of some 188 tidal monitoring stations which are operated and maintained by NSW Public Works’ Manly Hydraulics Laboratory (MHL). MHL (2012) presents tidal plane and phase analysis for each of the monitoring stations that are part of network, including the sites in the Lower Hunter Estuary (e.g. Stockton Bridge, Hexham Bridge) and Port Stephens (e.g. Tomaree, Mallabula Point).

The Mallabula Point gauge is representative of tidal conditions in Tilligerry Creek. The tidal plane analysis for Mallabula Point as presented in MHL (2012) is presented in Table 7-3. The levels provided represent the average annual tidal planes recorded over a 20-year period from 1991 to 2010. The tidal plane trends over the 20-year analysis period are shown in Figure 7-16.

The Mean High Water Springs (MHWS) is representative of typical “every-day” high tide levels. The High High Water Solstices Springs (HHWSS) represent rarer high tides occurring approximately twice a year (King Tides)

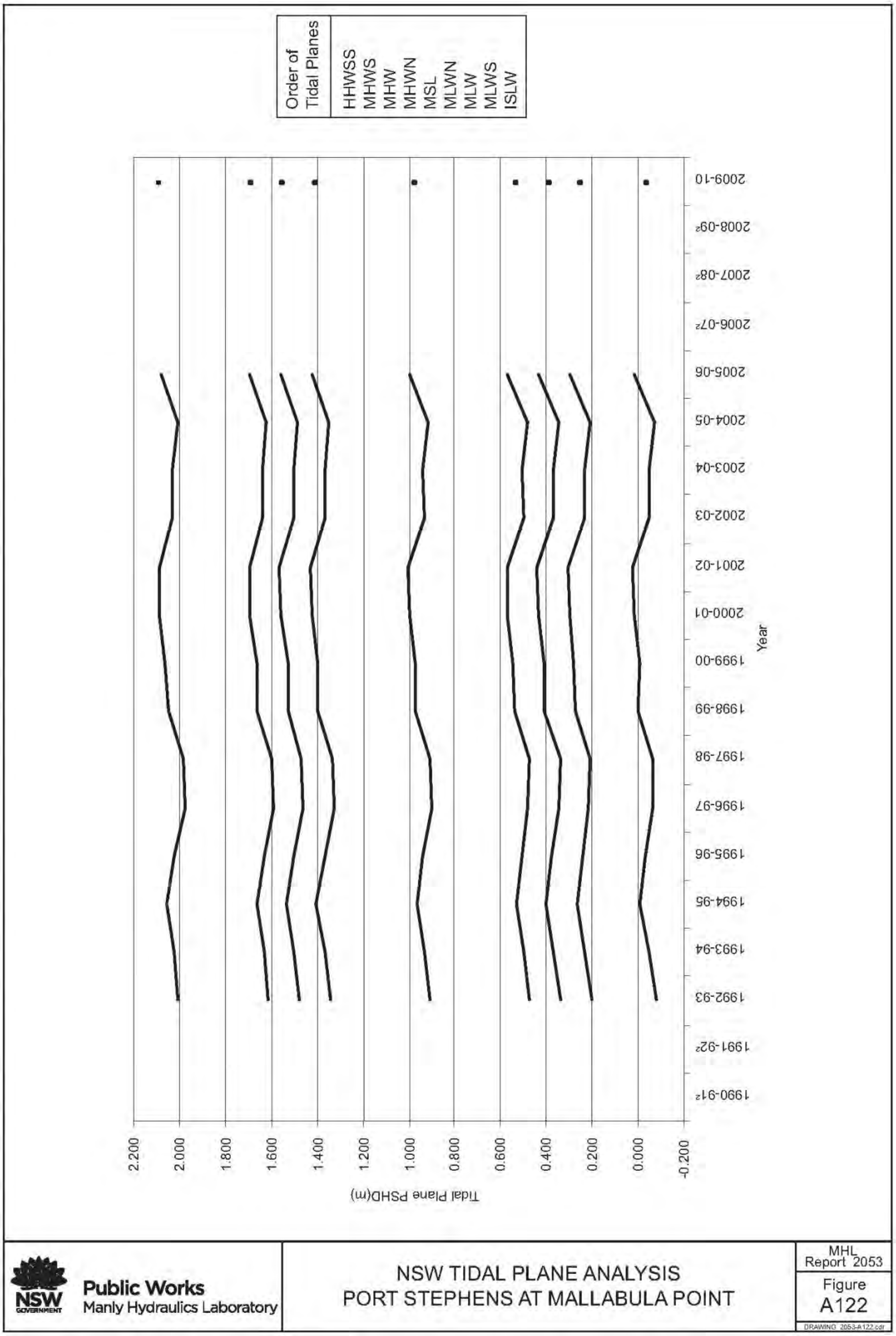


Figure 7-16 Tidal Plane Analysis at Mallabula Point (MHL, 2012

Table 7-3 Tidal Planes for Hunter River at Mallabula Point (MHL, 2012)

Tidal Plane	Water Level (m AHD)*
High High Water Solstices Springs (HHWSS)	1.08
Mean High Water Springs (MHWS)	0.69
Mean High Water (MHW)	0.56
Mean High Water Neaps (MHWN)	0.42
Mean Sea Level (MSL)	-0.01
Mean Low Water Neaps (MLWN)	-0.44
Mean Low Water (MLW)	-0.58
Mean Low Water Springs (MLWS)	-0.71
Indian Spring Low Water (ISLW)	-0.99

Note - * conversion to AHD from Port Stephens Height Datum (PSHD) = -0.949m (MHL, 2012)

The Salt Ash flood gates were constructed to manage the existing tidal regimes. Sea level rise will directly impact on these existing tidal regimes such that a 0.9 m sea level rise will provide for normal high tide levels of ~1.6 m AHD and King Tide levels of ~2.0 m AHD. Accordingly, the incidence of the gates becoming tide locked will increase in frequency and subsequently reduce the overall drainage performance. Even the local catchment contributions from relatively minor rainfall events may take significant time to drain.

Waterlogging and extended flooding duration of low lying floodplain areas is already identified by the community as a current issue which will be exacerbated under climate change influences. The susceptibility of these low lying areas is indicated in Figure 7-17. The image shows the existing ground levels, coloured in bands to represent an approximate inundation extent for a given level. The lowest parts of the floodplain can be seen to be below 0.5 m AHD. The limit of the coloured floodplain is at a level of 2.0 m AHD, noting this represents the King Tide level with a 0.9 m sea level rise. The 0.9 m sea level rise provides for a Mean Sea Level approaching 1.0 m AHD which would see water table levels above the existing ground surface for a large area of the floodplain.

The existing flood gate and drainage system performance has no real influence on major flooding conditions and accordingly there are no significant drivers from an immediate floodplain risk management perspective to modify the current arrangements. No modification works are recommended to address existing flood risk, however, the floodplain management study acknowledges the potential change in flood gate performance associated with progressive sea level rise and associated issues with general drainage.

Future modification of the existing structures and drainage system will need to be considered in climate change adaptation programs. This recognises a significant proportion of the existing floodplain may be inundated in regular tidal cycles or be unable to be effectively drained following rainfall.

7.1.5 Drainage System Management Plan

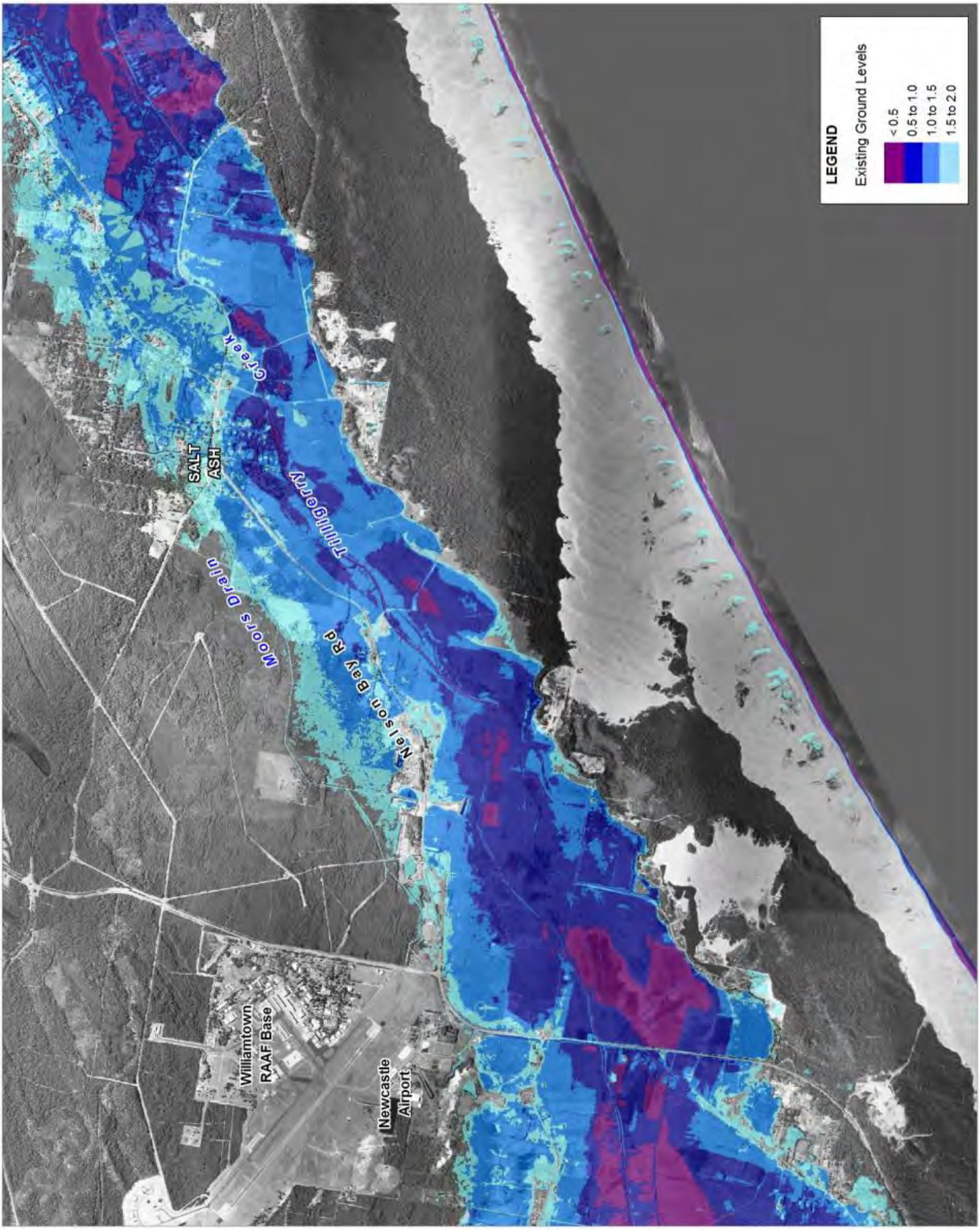
Effective management of the drainage system needs to go well beyond the flood gate performance and climate change adaptation. The community consultation has highlighted the drainage management as the most pressing issue for local residents. It is understood much of the current concern has arisen from the Williamtown RAAF site contamination and perceived impact of recent development on inundation and waterlogging.

There are potentially many facets to an overarching Management Plan. This may include investigation of issues such as:

- Local drainage capacity assessment and identification of potential upgrade/protection works such as local levees, drain augmentation, additional culverts upgrades etc.;
- Existing water quality and identification of pollutant/contaminant sources and potential treatment/containment measures;
- Riparian rehabilitation works such as revegetation, levee/channel reinstatement;
- Identification of Acid sulphate soil risk and appropriate management actions / controls;
- Opportunity / risks associated with tidal exchange;
- Climate change adaptation considering changes to the existing environment and appropriate land use planning;
- Drain and culvert maintenance requirements to manage vegetation and siltation impacts; and
- Impacts of cumulative development on hydrological regimes of the existing drainage networks and capacity constraints.

The above is by no means an exhaustive list, but rather highlights the multi-faceted nature that an effective Plan may take. Ultimately a scope will be driven by Council and community objectives and relative importance/urgency of particular issues. Of the above, the climate change adaptation is the key driver from the floodplain risk management perspective and to a lesser degree the local drainage capacity (low flow regimes). In this regard the Plan of Management may consider a broad range of management strategies to address short, medium and long-term objectives.

The Floodplain Risk Management Plan includes a recommendation for a Drainage System Management Plan to be prepared for the drainage systems of the Williamtown-Salt Ash floodplain areas.



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Low Lying Floodplain Inundation

Figure: 7-13

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7.1.6 Moors Drain

The Floodplain Risk Management Study has a focus on the mainstream flooding conditions in the study area driven by the interaction of Hunter River flooding, derived from upper catchment flows, and the tidal flooding from the Port of Newcastle and Port Stephens coastal boundaries. As previously discussed, the major flooding scenarios are driven by the transfer of Hunter River flow across Nelson Bay Road into the Tilligerry Creek floodplain. However, there are some local drainage issues which have also been highlighted through the community consultation, including the Moors Drain.

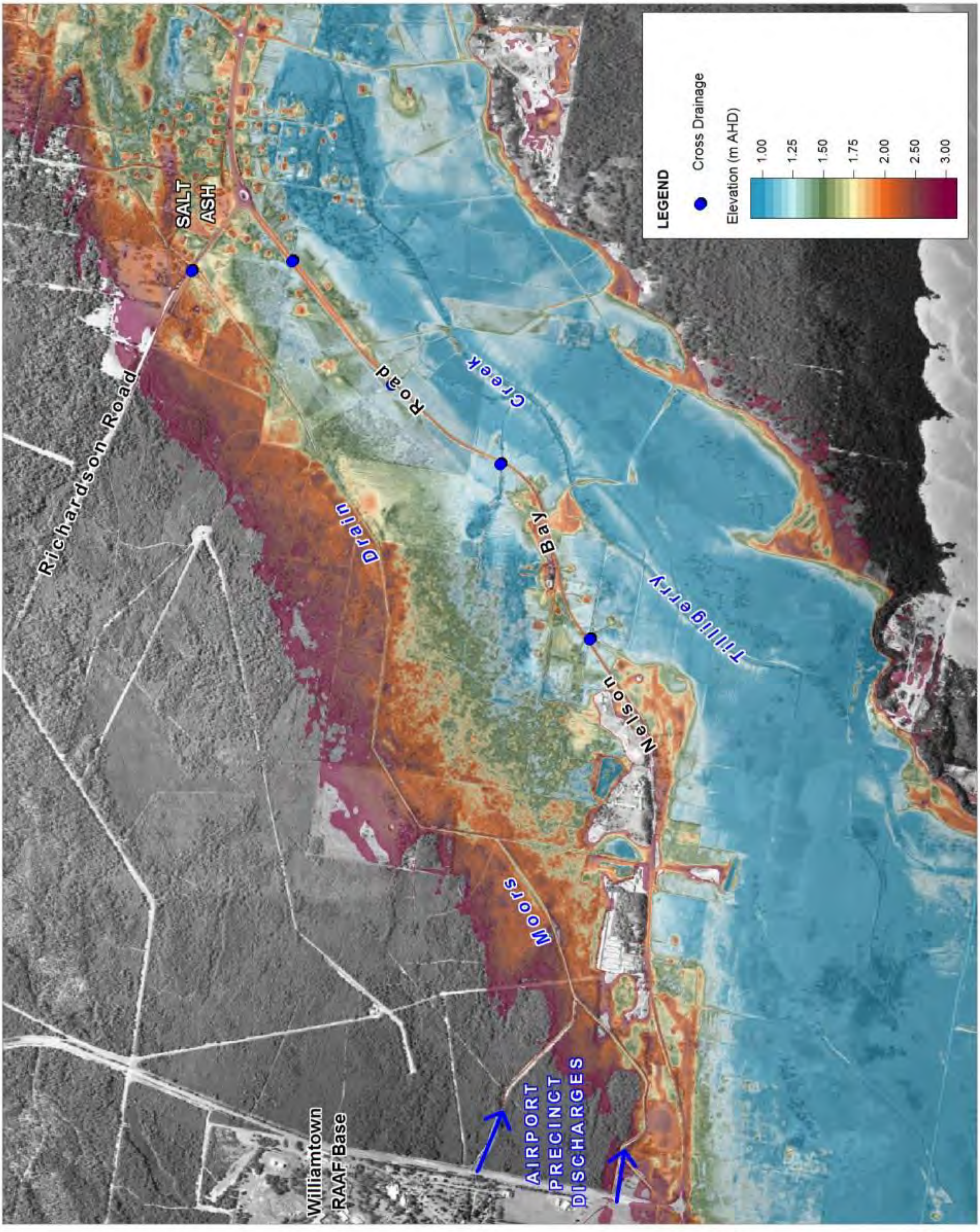
The Moors Drain is part of a network of local drainage channels constructed to provide drainage relief for the generally low-lying floodplain area. Other major drainage channels in the study area include Dawsons Drain, Fourteen Foot Drain and Ten Foot Drain. The Moors Drain is largely separated from the influence of Hunter River flooding under existing conditions, with its main catchment area including the Airport Precinct.

The local topography of the Moors Drain and floodplain area is shown in detail in Figure 7-18. The alignment of the drainage channel is generally along higher ground at the northern edge of the floodplain. The drainage channel largely services the catchment of the Airport Precinct with the key discharge points shown on Figure 7-18. Flows are conveyed within the drainage channel eventually discharging to the lower Tilligerry Creek system well downstream of Richardson Road.

As can be interpreted from local topography, flows exceeding the channel capacity will inundate the low-lying floodplain area to the south of the drainage channel bounded by Nelson Bay Road. Once out of the drainage channel there is limited opportunity for flow to re-enter the drain, but rather drained through other channels and into the Tilligerry Creek floodplain via cross drainage points in Nelson Bay Road. Survey data indicates the presence of some low bank elevations along Moors Drain, thereby increasing the propensity for spills in these locations.

The current study has not investigated in detail the capacity of the local drainage system, noting an investigation of this nature is at a significantly different resolution and scale to the mainstream flood modelling. However, it is noted that detailed drainage investigations have been undertaken for the Airport Precinct and would be referred to in considering local drainage capacity. Given the finite capacity of the existing drainage network, future developments in the Airport Precinct and changes in local catchment hydrology will be of concern for the Moors Drain. Existing Council development controls and approvals processes are the appropriate mechanisms for these issues to be addressed.

In the context of the Floodplain Risk Management Study, the climate change assessment has identified future flood risks for the Moors Drain. Under sea level rise scenarios, the performance of the Moors Drain in terms of local drainage relief will gradually be compromised as tailwater levels in the lower Tilligerry Creek back up through the drain. This represents a similar scenario to the current condition on Tilligerry Creek in which the flood gates prevents regular upstream tidal inundation. Accordingly, a similar flood gate arrangement may be required in the future for the Moors Drain. Table 7-3 provides a King Tide level of around 1.1 m AHD in Tilligerry Creek which is similar to the invert levels of the Moors Drain at Salt Ash. Accordingly, if sea level rise manifests at current projected levels, the drainage may be compromised in a relatively short timeframe.



Title:

Topography of the Study Area

Figure: **7-14**

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In the absence of flood gate protection, the Moors Drain is already at risk of inundation under tidal storm surge conditions. The 1% AEP flood level downstream of the Tilligerry Creek floodgates is approximately 1.6 m AHD for existing conditions, 2.0 m AHD for the 2050 condition and 2.4 m AHD for the 2100 condition. Accordingly, given the levels of the existing drainage channel and the general floodplain topography as shown in Figure 7-18, these storm surge conditions in Tilligerry Creek will inundate the Moors Drain floodplain and get progressively more severe with increasing sea levels.

A recommendation for a Management Plan for the local drainage systems has already been identified. Moors Drain would inherently be included in this as part of this local drainage network. Accordingly, the Floodplain Risk Management Study is not recommending specific structural management options for Moors Drain. However, a detailed Plan of Management would be expected to incorporate appropriate climate change adaptation strategies in addition to addressing local drainage capacity and water quality issues.

7.1.7 Airport Precinct

The Airport Precinct incorporates major transport infrastructure of regional significance with existing plans for further development and expansion of the site and associated business development. As previously noted, detailed investigations of the local drainage catchments have been conducted elsewhere as part of ongoing Airport planning. The flood risks associated with both the existing site and future development is considered in the context of major Hunter River flooding in the current study

The flood modelling and associated flood risk mapping undertaken has identified a significant increase in flood affectation within the Lower Hunter and Tilligerry Creek floodplain associated with potential climate change. However, the Airport Precinct is largely unaffected directly by these flooding conditions.

Figure 7-19 shows the mainstream flood inundation extent for the 1% AEP + 0.9 m sea level rise + 20% flow corresponding to the nominal 2100 planning condition. The majority of the Airport Precinct is outside the influence of the major flooding conditions incorporating the Hunter River flows and tidal storm surge influence. Accordingly, future development of the Airport Precinct would not be unduly constrained by mainstream flooding conditions up to the 1% AEP flood planning condition.

Future development would however need to consider the following:

- Changes in local catchment flood behaviour and external influence on the Moors Drain;
- Flood access via Nelson Bay Road (existing 1% AEP flood immunity but not for future planning horizons without road modifications);
- Flood impacts for development in mainstream flood extents including areas north of Cabbage Tree Road and eastern side of Nelson Bay Road; and
- PMF flood condition noting more extensive inundation across the locality.

Title:
Extent of Hunter River Influence on Airport Zone

Figure: **7-15**

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7.1.8 Broad Scale Redevelopment

The nature of flooding in some parts of the floodplain within the study area may present an opportunity for potential broad scale development. Development in this regard may include large scale filling of some floodplain areas to elevate the landform above design flood levels whilst providing suitable provisions for management of floodwaters and local drainage.

In identifying suitable areas for potential redevelopment, initial consideration can be given to the hydraulic categorisation of the floodplain as discussed in 4.6.1. Hydraulic categorisation is one of the tools used to identify flood behaviour and risk. The categorisation is not used to assess individual developments, but rather to give a catchment-scale overview of which areas may be appropriate for various types of land use and accordingly can be used to inform future land use planning.

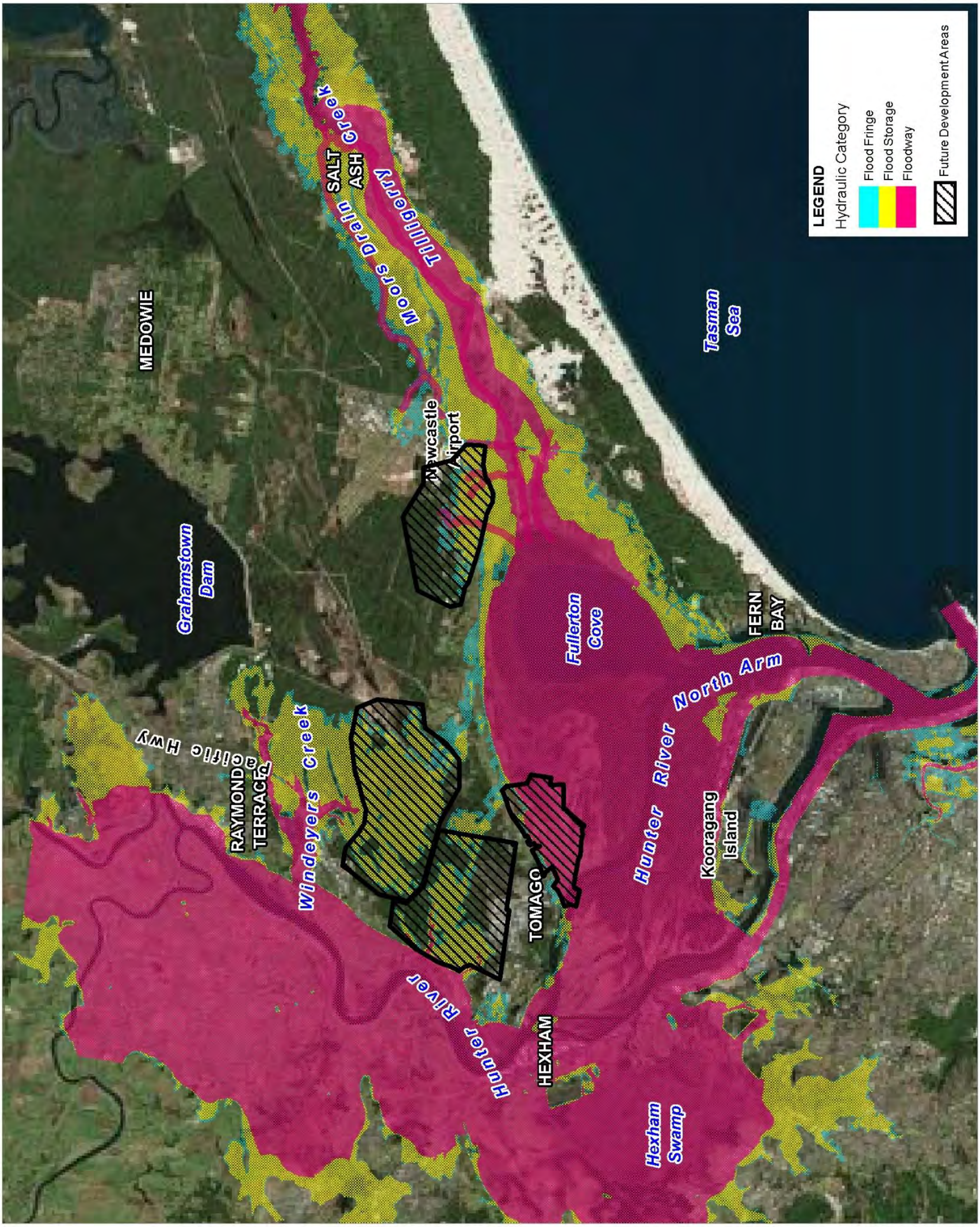
With regard to the hydraulic categorisation of the floodplain, typically the flood fringe areas are more suitable for development in which filling or blocking of these areas is expected to have no significant effect on the flood pattern or flood levels. In areas identified as flood storage, i.e. areas that are important in the temporary storage of the floodwater during the passage of the flood, substantially filling or leveeing of these areas is likely to result in elevated water levels and/or elevated discharges. Floodway areas are typically “no-go” areas for development given the important function of flood conveyance.

The hydraulic category mapping for the 1% AEP design flood conditions is provided in Appendix A. The majority of the study area floodplain is either flood storage or floodway area, particularly within the broader Hunter River and Tilligerry Creek floodplain areas. Typically the only extensive flood fringe areas are the local catchment runoff areas elevated above the mainstream flood extents. In this context therefore, there would appear limited broad scale development opportunity within the main floodplain areas of the Hunter River and Tilligerry Creek.

Following initial discussions with Council, the following areas were identified for further consideration in the context of future land development:

- Cabbage Tree Road – area north of Cabbage Tree Road including local drainage catchment areas (e.g. Dawsons Drain);
- Tomago Road – area adjacent to Tomago Road around Fullerton Cove. There are existing development approvals in this location including the WesTrac Facility and Northbank Enterprise Hub;
- Hunter Corporate Park – current development proposal between Tomago Road and the Pacific Highway in the current Tomago Aluminium site; and
- Windeyers Creek – a large proportion of this area lies within the direct backwater influence of the Hunter River.

These general areas are identified in Figure 7-20 with reference to the adopted hydraulic categorisations for the floodplain. The WesTrac and Northbank sites on the southern side of Tomago Road are the only areas with current development approvals.



Title:

Potential Development Areas and Floodplain Hydraulic Classification (1% AEP 2100 Condition)

Figure: 7-20

Rev: A

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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Investigated in isolation, these areas may show some potential for future redevelopment (including large scale filling/earthworks) with limited impact on existing flood conditions. This is of course subject to scale and extent of potential footprints. It is not the intention of the Floodplain Risk Management Study to define potential development footprints. A typical flood impact investigation may iterate a number of development scenarios to optimise a design footprint with regard to flood impacts. Further, there are many other land use planning considerations that need to be taken into account in defining appropriate development within the floodplain. The potential flood impact of individual developments is presented in Appendix E.

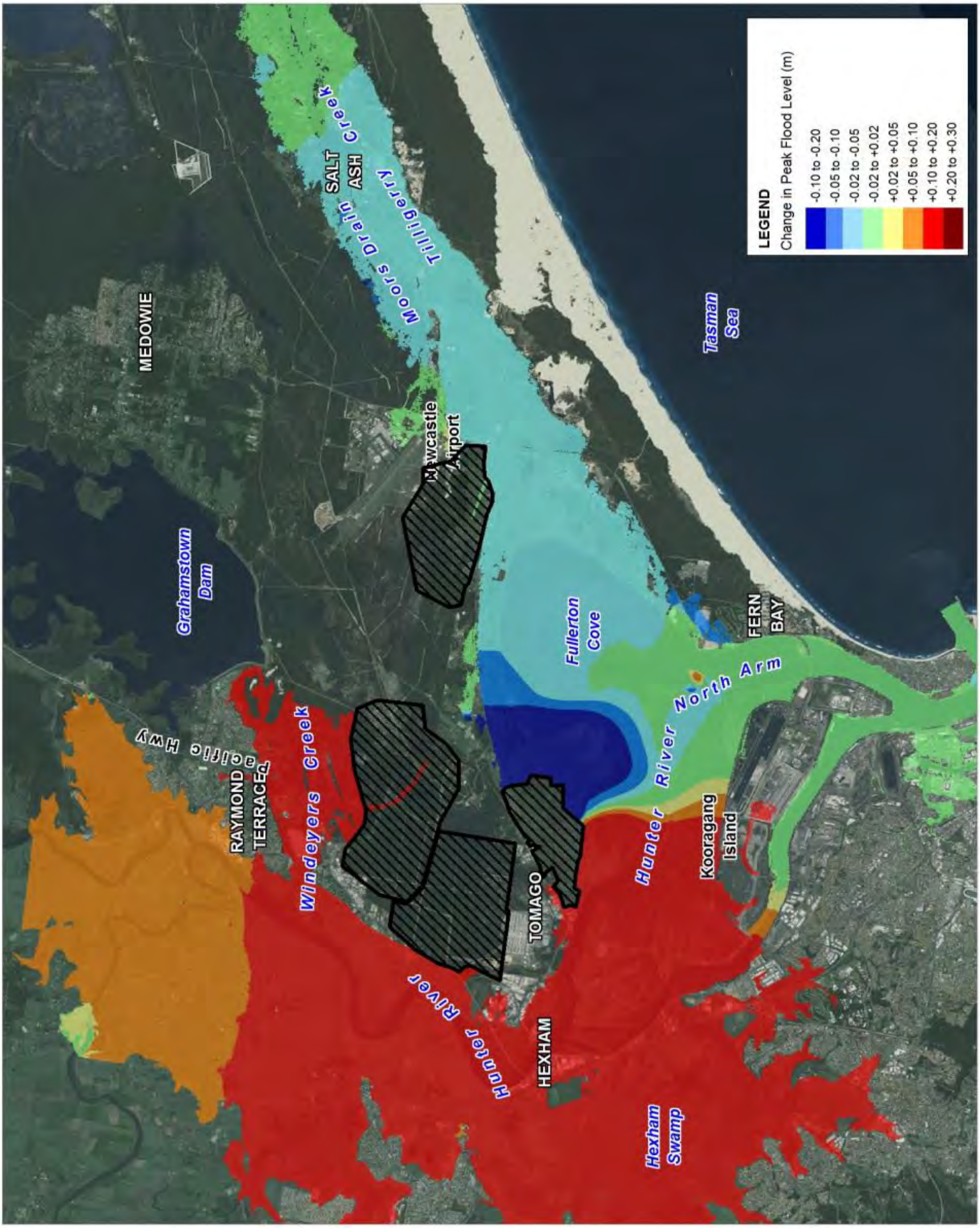
Notwithstanding any limited impact of an individual development, in assessing future development potential within the floodplain involving broad scale filling and loss of flood storage, consideration needs to be given to the cumulative impact of all potential development. The accumulation of incremental flood impacts borne out of individual developments can result in a significant change in overall flood behaviour for ultimate or total development scenario compared to existing conditions.

The developed models have been applied to simulate the change in peak flood levels across the Lower Hunter floodplain under a cumulative development scenario incorporating all of the areas identified in Figure 7-20. The change in peak flood level through filling all of the sites is shown in Figure 7-21 for the 1% AEP 2100 planning condition. Note all of the area is assumed to be raised above the 1% AEP flood level. Figure 7-21 indicates the potential for significant increases in peak flood levels due to the cumulative impact of development. Development in flood prone land can impact on flood levels through a redistribution of flow and loss of temporary flood storage. The development scenario shown provides a combination of these impacts. The distribution of the flood impacts shown in Figure 7-21 would be of concern considering both the potential magnitude and geographical extent of impact.

Some potential development areas will have less of an incremental impact than others and accordingly may be more suitable for potential development. The current study has specifically not provided commentary on the appropriateness or otherwise of individual development areas. This is in recognition of the importance of the assessment of cumulative development on the Lower Hunter floodplain conditions.

For the Lower Hunter River floodplain, a cumulative impact assessment would also need to consider future development within the Newcastle LGA. Large scale floodplain works undertaken in either LGA has the potential to impact on flood conditions across the LGA boundaries and also incremental development may unduly constrain other parts of the floodplain or increase flood risks. Whilst a preliminary assessment of cumulative development was undertaken in the Newcastle City-wide Floodplain Risk Management Study and Plan, this has not translated into a regional strategy for future development.

Accordingly, there is no over-arching strategy in place to determine which parcels of land or future development configurations are most appropriate. Some development areas on the edge of the floodplain may be more appropriate for future development from flood emergency access and recovery considerations for example. The flood impact assessment is only one component of identifying a future regional development strategy which will have other economic and social drivers.



Title:

Peak Flood Level Impact - Future Development
1% AEP +0.9m SLR + 20% flow scenario

Figure: **7-17**

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A coordinated flood impact assessment is recommended comprising a full cumulative development assessment with consideration of regional development opportunities across the Lower Hunter River floodplain incorporating the Port Stephens and Newcastle LGAs. Such an investigation is likely to consider broader regional land use planning and identify future development areas within the floodplain that duly considers overall flood risk and potential impacts under an ultimate development scenario. The outcomes of this cumulative impact assessment would further inform future LEP and DCP amendments (e.g. rezoning, development controls such as fill limitations), and regional planning.

7.2 Property Modification Measures

7.2.1 Planning and Development Controls

Land use planning and development controls are key mechanisms by which Council can manage flood-affected areas within the Williamtown / Salt Ash area. Such mechanisms will influence future development (and redevelopment) and therefore the benefits will accrue gradually over time. Without comprehensive floodplain planning, existing problems may be exacerbated and opportunities to reduce flood risks may be lost.

As discussed in Section 6, Council currently has a number of land use planning and development controls in place to manage flood-affected areas within the Port Stephens LGA. No key changes to existing planning and development controls are considered to be required for the Williamtown Salt Ash study area. However, various flood risk mapping outputs updated for the current study are recommended to be adopted by Council and used in the development assessment process.

It is recommended that the design 1% AEP flood level conditions for planning purposes be based on the updated design flood results established in the current study. These results incorporate the updated Flood Frequency Analysis to define Hunter River inflows, localised model improvements (e.g. topography, culverts) and updated climate change analysis consistent with Councils Flood Planning policies.

In adopting the revised flood condition, associated flood risk mapping outputs for the 1% AEP event including design flood conditions (peak water level, depth and velocity), Flood Planning Area, hydraulic category (floodway, flood storage and flood fringe definition) and flood hazard mapping have been updated for Council use.

7.2.2 Flood Planning Levels

Council has adopted the 1% AEP design event for 2100 conditions (incorporating 20% increase in flow and 0.9 m sea level rise) as the basis for setting Flood Planning Levels. Section 4.5 provides detail of the increasing flood risk with climate changes influences. For much of the study area, the 2100 planning condition represents a significant change from existing design flood conditions. This is particularly the case for the Tilligerry Creek floodplain downstream of Nelson Bay Road at Fullerton Cove. As previously noted, the flooding conditions in the Tilligerry Creek floodplain are controlled by the volume of overtopping of Nelson Bay Road from Hunter River flows.

The design flooding conditions across Nelson Bay Road for existing and climate change scenarios was summarised in Table 7-1, demonstrating the significant overtopping for the 2100 planning event.

As the principal control on Hunter River flows to Tilligerry Creek, options for raising and lowering of the Nelson Bay Road profile was considered in Section 7.1.1.

Figure 7-3 showed the change in design 1% AEP 2100 condition flood levels through raising of Nelson Bay Road. In this case, raising of Nelson Bay Road provides a barrier to Hunter River floodwater flowing through Tilligerry Creek. A significant reduction in design peak flood levels downstream of Nelson Bay Road through to Salt Ash is possible through raising Nelson Bay Road. There is a corresponding increase in flood levels for an area in Fullerton Cove upstream of Nelson Bay Road.

The progressive raising of Nelson Bay Road to maintain flood immunity at the 1% AEP design level will be required as part of combating the influence of climate change. In raising the road there is the opportunity to further restrict the flow of Hunter River overflows into Tilligerry Creek, or provide the appropriate scale of cross drainage to maintain the flow distribution for the current road configuration.

This presents Council with a Strategic Planning issue in that future flood planning is directly linked to the configuration of future upgrades to Nelson Bay Road. There is an opportunity to reduce flood risk in the Williamtown and Salt Ash localities (and further downstream along Tilligerry Creek). This may be a long term preferential outcome in conjunction with managing the areas upstream in Fullerton Cove that may be adversely impacted. It is important to recognise also that climate changes influences may not stop at the 2100 planning horizon, and that strategic planning must consider the future landscapes beyond this timeframe.

The potential for climate change impacts increasing flood risk in the future presents immediate challenges for floodplain management in Williamtown-Salt Ash. Many of the floodplain management options in addressing flood risk to existing and future property are dependent on the long-term viability of continued occupation of the floodplain in these areas. Through ongoing approval of development in flood risk areas identified in the study area and investment (public and private) in flood protection measures there is the inherent assumption that development in these flood prone areas has a viable future.

However, under climate change influences, the continued habitation and redevelopment of parts of the floodplain will become increasingly difficult to sustain or require more onerous controls. With increasing flood risk, the provision and maintenance of services and infrastructure may become increasingly expensive or impractical.

In the longer term, it is expected that a strategic plan will be required to guide the development of the Williamtown-Salt Ash study area. There are very complex issues with considerable social implications requiring extensive consultation with the community and detailed supporting investigations of social, economic and environmental issues. Depending on the rate at which sea level rise impacts manifest, implementation of adaptation plans may not be necessary for some years. Whilst such a decision does not need to be made immediately, Council should be preparing for such an ultimatum in the near future (within the next 10 years or so, or as the realities of sea level rise start to manifest). Nevertheless, appropriate planning should be commenced immediately to provide sufficient time to develop site specific adaptation plans and develop funding models.

It is recommended that Council pursue the development of a Strategic Climate Change Adaptation Plan for the Williamtown-Salt Ash study area. This will be required to inform some of the floodplain management options considered in the current study such as changes to Nelson Bay Road (and other routes), flood gate upgrades and management of the local drainage system.

7.2.3 Local Land Filling

Filling of flood prone land is an option to remove or reduce the flood affectation on a site, typically to provide for development potential. With any development on the floodplain there is potential for significant changes to existing flood conditions through:

- Redistribution of flow arising from works on the floodplain;
- Concentration discharges and subsequent impact on downstream areas; and
- Increase in flood levels through impedance of overland flow paths and loss of temporary flood storage.

Section 7.1.8 discussed broad scale redevelopment across the study including some recent major developments. Evident in the results also presented in Appendix E is the potential for significant changes in design flood conditions through filling of floodplain areas.

Council's existing DCP has some qualitative controls in regards to filling related to the flood hazard categories as presented in . These controls are summarised below.

All Flood Hazard Categories

*Fill should not substantially impede the flow of floodwater, and must not contribute to flooding or ponding of water on other propertie*s.

Low Hazard Floodway

Use of fill is not supported.

Low Hazard Flood Storage

Use of fill is not supported unless accompanied by a flood report.

High Hazard Floodway

New buildings or structures and fill are not supported unless accompanied by a report.

Note: Development within a floodway is not encouraged. An application may only be considered where it demonstrated to have specific community needs/benefits, which does not relate to the provision of housing.

High Hazard Flood Storage

New residential and fill are not supported unless accompanied by a flood report and a flood emergency response plan.

No controls related to filling are included for flood fringe areas.

Typically development controls seek to limit any development in nominated floodway areas. Floodways by definition are those areas of the floodplain where a significant discharge of water occurs during floods. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels. Accordingly, opportunities for extensive development in floodway areas would be limited.

The existing controls are qualitative in nature and do not provide any definitive guidance on limits of fill volumes, quantification of impacts etc. The existing controls do however appropriately trigger the requirement for an assessment (via a flood report) of the impact of filling within existing flood storage and floodway areas.

Consideration has been given in the current study to defining more quantitative fill controls. Some examples of these in DCPs of other Councils include limits on volume of fill on either a cubic metre volume basis or as a percentage of existing flood storage on a lot.

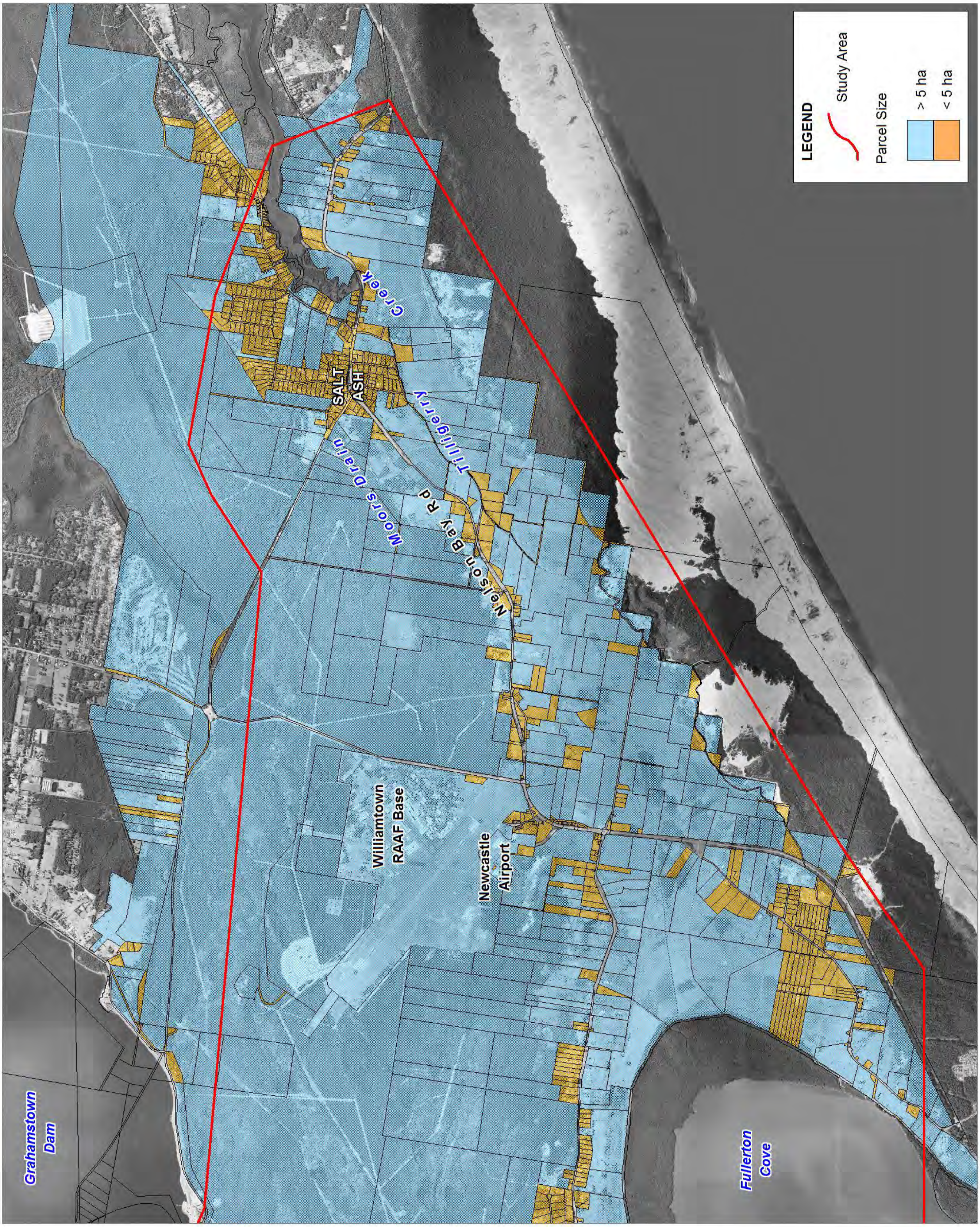
The classification of flood fringe, storage and floodway areas around Fullerton Cove and Tilligerry Creek floodplain was shown in Figure 4-7 (refer to Appendix A for broader floodplain extent). The majority of inundated area at the 1% AEP 2100 planning condition is comprised of floodway or flood storage, with limited flood fringe at the floodplain extents. Accordingly, most affected area or lots would be subject to limitations on filling as per the controls discussed above.

The current lot distribution in the study area provides for typically large scale lots. This is particularly the case in the Tilligerry Creek and Fullerton Cove floodplain areas. Figure 7-22 presents a distribution of the relative lot sizes above and below a nominal 5 ha area.

As shown in Figure 7-22, most floodplain area is covered by lot sizes more than 5 ha. Many of the remaining lots are still of relatively large size, with only the higher density residential development at Salt Ash providing for smaller residential scale lots.

The large lot sizes typically within the floodplain mean that even relatively small percentage fill limits based on area represent a substantial volume of filling. Large scale filling in the existing floodplain is not considered appropriate given the potential impact of lost floodplain storage volume. Large scale filling would also provide for a redistribution of flow and likely therefore to impact directly on neighbouring properties. The potential impacts of large scale lot filling are difficult to estimate given the flow redistribution will be dependent on the location and configuration of a fill platform.

A smaller scale of filling, somewhat representative of a fill platform for a residential dwelling, is unlikely to have significant impacts in terms of loss of floodplain storage. The cumulative volume of a typical building pad on each cadastral parcel represents only a small proportion of the total floodplain storage volume. However, whilst unlikely to require development controls from a flood storage perspective, the impact of any filling on the floodplain will need to be considered for its potential for a local redistribution of flow, and impacts on neighbouring lots. As noted, this will be dependent on the location and configuration of the development and proximity to other property boundaries and infrastructure. Accordingly, Council's existing triggers in the DCP for a flood assessment report to support a development application remains appropriate.



Title:
Cadastre Parcel Size

Figure:
7-22

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7.2.4 Flood Proofing

Flood proofing refers to the design and construction of buildings with appropriate water resistant materials such that flood damage is minimised should the building be inundated. Flood proofing is more effectively achieved during construction with appropriate selection of materials and design. Council's Development Control Plan already includes requirements for flood proofing of buildings for new development. However, there are a number of non-structural options that can be retrofit to existing property to help reduce flood damage including changes to joinery and fittings, floor coverings and electrical services.

These measures would be applicable for all new developments in this area and redevelopment of existing property. These measures are seen as an effective measure for much of the existing property constructed across natural overland flow paths. Whereas the expense of house raising provides for minimal return in terms of loss reduction compared to the capital expense, flood proofing measures on an individual property scale can be effective in reducing flood damages for a significantly lower cost.

The extent of damage, cost of repairs, inconvenience and cleaning required following a flood event will depend on many factors including depth and velocity of water, period of inundation, amount of debris and silt in floodwater, and type of materials and construction. If floodwaters cannot be excluded from a property through other measures, flood proofing may provide a direct benefit in terms of reduced economic damages and social disruption.

Property owners would be expected to undertake works at their own convenience. A public awareness campaign may help to inform the community of flood proofing measures, and could be supplemented with individual building inspections and property owner interviews. Encouragement to make a property more flood-resilient can be linked to the recommended Community Awareness Program.

Direct consultation with landholders with potential for house raising/flood proofing must be undertaken initially to establish the level of support, with explanation of:

- conditions of any subsidy offer (to be determined);
- susceptibility of the house to flooding (following confirmation of floor levels);
- anticipated benefits of raising the floor level or flood proofing house; and
- potential funding arrangements.

7.2.5 House Raising

Voluntary house raising is aimed at reducing the flood damage to houses by raising the habitable floor level of individual buildings above an acceptable design standard, typically the Flood Planning Level (i.e. 1% AEP Flood Level +0.5 m). Voluntary house raising generally only provides a benefit in terms of reduced economic damages but does not eliminate the risk. Larger floods than the design flood (used to establish minimum floor level) will still provide building damages and the option does not address personal safety aspects. These risks are still present as the property and surrounds are subject to inundation.

Only a limited number of existing residential properties (14) have been identified with floor levels below the 1% AEP flood level. Of these 14 properties, only 3 are a timber or clad on pier type construction, noting that slab on ground and brick type construction is typically unsuitable for house raising. Two of the properties are located in Raymond Terrace in the Windeyers Creek catchment, thereby affected by the backwater influence of the Hunter River. The other property is located in Salt Ash with an above floor flooding depth of only ~0.02 m.

Additionally, house raising in the study area may not be effective given:

- Houses that can be raised may be approaching the end of their useful life;
- Rebuilding rather than renovations may be more cost-effective and potentially the preferred option of landholders;
- Flood proofing existing property provides a cheaper alternative.

The number of residential properties identified at risk of above floor flooding for the 1% AEP 2050 planning condition increases to 46 as noted in Table 5-2. Again, it is noted that only 17 of these properties are a timber/clad house on pier type construction. Accordingly, even for the future condition the number of suitable properties for a VHR scheme is limited. The 2050 planning condition includes climate change provisions of 10% increase in flow for the Hunter River and a sea level rise allowance of 0.4 m.

The viability of a house raising scheme is dependent on establishing a suitable funding model and the uptake of the scheme given that it is on a voluntary basis. Further investigation may be undertaken to establish the level of landowner support and therefore uptake potential, to assess the merit of including a Voluntary House Raising scheme in future revisions of the Floodplain Risk Management Plan. The requirement for and viability of a house raising scheme is likely to increase with climate change influences. However, given the timeframes involved, it is considered that future flood risk would be more effectively managed through redevelopment.

Given limited need under existing flood conditions for a VHR scheme, it is recommended that the opportunity/requirement for a scheme is reinvestigated in a 5 year timeframe or following significant updates in climate challenge knowledge as we progress towards the 2050 planning horizon.

7.3 Response Modification Measures

7.3.1 Flood Warning

The Bureau of Meteorology (BoM) prepares and disseminates flood forecasts and warnings and information to the public in close cooperation with state, territory and local government agencies and other stakeholders. Users of flood warning services include emergency management agencies and members of the public, particularly those in flood-prone areas. More detailed local interpretation of BoM flood warning products and information is provided directly to the public by flood response agencies. BoM warning products include early alerts to the possibility of flooding through a flood watch product, with site-specific forecasts of river height and the expected impact in terms of minor, moderate or major flooding in specific river basins.

Where dedicated flood forecasting systems have not been installed, more generalised products are issued on a regional basis. However, there are several general warning services provided by the Bureau of Meteorology (BoM) including:

- **Severe Thunderstorm Warnings –** typically provide 0.5 to 2 hours notice. These short range forecasts are issued by the Bureau's severe weather team and are based upon radar, data from field stations, reports from storm spotters as well as synoptic forecasts.
- **Severe Weather Warnings –** for synoptic scale events that cause a range of hazards, including flooding. Examples of synoptic scale events are the deep low pressure systems off the NSW coast that often result in significant flooding in eastern catchments.
- **Flood Watches –** typically provide 24-48 hour notice. These are issued by the NSW Flood Warning Centre providing initial warnings of potential flooding based upon current catchment conditions and future rainfall predictions.

There is no formal flood warning service specific for the Williamtown-Salt Ash area; however, a flood warning network is established on the Lower Hunter River providing for official **Flood Warning** notifications. A Flood Warning is a gauge specific forecast of actual or imminent flooding. Flood Warnings specify the river valley, the locations expected to be flooded, the likely severity of flooding and when it will occur.

The issuing of flood warnings in the broader Lower Hunter region is the responsibility of the Lower Hunter Division of the State Emergency Services (SES). At present flood warnings and estimates of the time of arrival of the flood peak are based on floodwater levels at gauges located upstream at Raymond Terrace and Maitland on the Hunter River, Gostwyck Bridge on the Paterson River and Mill Dam Falls on the Williams River. Typically, water levels at these gauges are communicated to the Lower Hunter headquarters of the SES, where they are compared with stage hydrographs for recorded floods. Unfortunately, the SES does not give flood level projections for areas downstream of Raymond Terrace due to the potential influence of the tide on peak flood levels.

Flood classifications in the form of locally-defined flood levels are used in flood warnings to give an indication of the severity of flooding (minor, moderate or major) expected. These levels are used by the NSW State Emergency Service (SES) and the Australian Government Bureau of Meteorology (BoM) in flood bulletins and flood warnings. The flood classification levels are described by:

- **Minor flooding**: flooding which causes inconvenience such as closing of minor roads and the submergence of low-level bridges. The lower limit of this class of flooding, on the reference gauge, is the initial flood level at which landholders and/or townspeople begin to be affected in a significant manner that necessitates the issuing of a public flood warning by the BoM.
- **Moderate flooding**: flooding which inundates low-lying areas, requiring removal of stock and/or evacuation of some houses. Main traffic routes may be flooded.
- **Major flooding**: flooding which causes inundation of extensive rural areas, with properties, villages and towns isolated and/or appreciable urban areas flooded.

The SES classifies minor, moderate and major flooding according to the gauge height values at recording water level gauges as detailed in Table 7-4 .

Table 7-4 Flood Classification Levels for Hunter River

Gauge	Flood Classifications (gauge readings in m AHD)		
	Minor	Moderate	Major
Raymond Terrace[1]	2.5	3.1	3.5
Hexham Bridge[2]	1.9	2.9	3.8
Stockton Bridge[2]	1.2	1.3	1.7

1) NSW State Flood Plan, March 2015, NSW Government

2) NSW State Flood Plan, June 2008, NSW Government

It is noted that the flood classifications for Hexham Bridge and Stockton Bridge are not included in the 2015 update of the State Flood Plan with the values in Table 7-4 from the 2008 document. It is understood that the recent State Flood Plan has not incorporated the Hexham Bridge and Stockton Bridge classifications given that the SES does not give flood level projections for areas downstream of Raymond Terrace due to the potential influence of the tide on peak flood levels.

The NSW State Flood Plan notes target warning lead time at Raymond Terrace of 6 hours for levels in excess of 2.5 m AHD (minor flooding) and 18 hours for levels in excess of 3.5 m AHD (major flooding). Design flood levels at Raymond Terrace were presented in Table 4-1. The major flood level classification as above falls between the 5% AEP and 2% AEP flood levels of 3.2 m AHD and 4.1 m AHD respectively

There is no telemetered flood forecasting and warning system in existence for the downstream reaches of the Lower Hunter including the Fullerton Cove area. Nevertheless, the flooding condition in the Williamtown-Salt Ash study area is intrinsically linked to broader Hunter River flood behaviour. Accordingly, there is opportunity to enhance the existing flood warning system on the Hunter to link flood warning services for the study area to existing gauge locations such as Raymond Terrace, Hexham Bridge and Stockton Bridge.

The current study has established specific flood warning trigger levels and timings for Williamtown-Salt Ash linked to the existing Raymond Terrace, Hexham Bridge and Stockton Bridge water level gauges. The additional data in concert with the official Hunter River flood warning system should be used to establish appropriate flood warning and response triggers for the study area and update of Local Flood Plans accordingly.

Figure 7-23 shows the relative design flood water levels at Raymond Terrace, Hexham Bridge and Stockton Bridge, corresponding to the existing water level gauges on the Lower Hunter River. The design flood water levels upstream of Nelson Bay Road at Fullerton Cove are shown for reference also, given that major flooding in the Tilligerry Creek system is controlled by the road overtopping at this location.

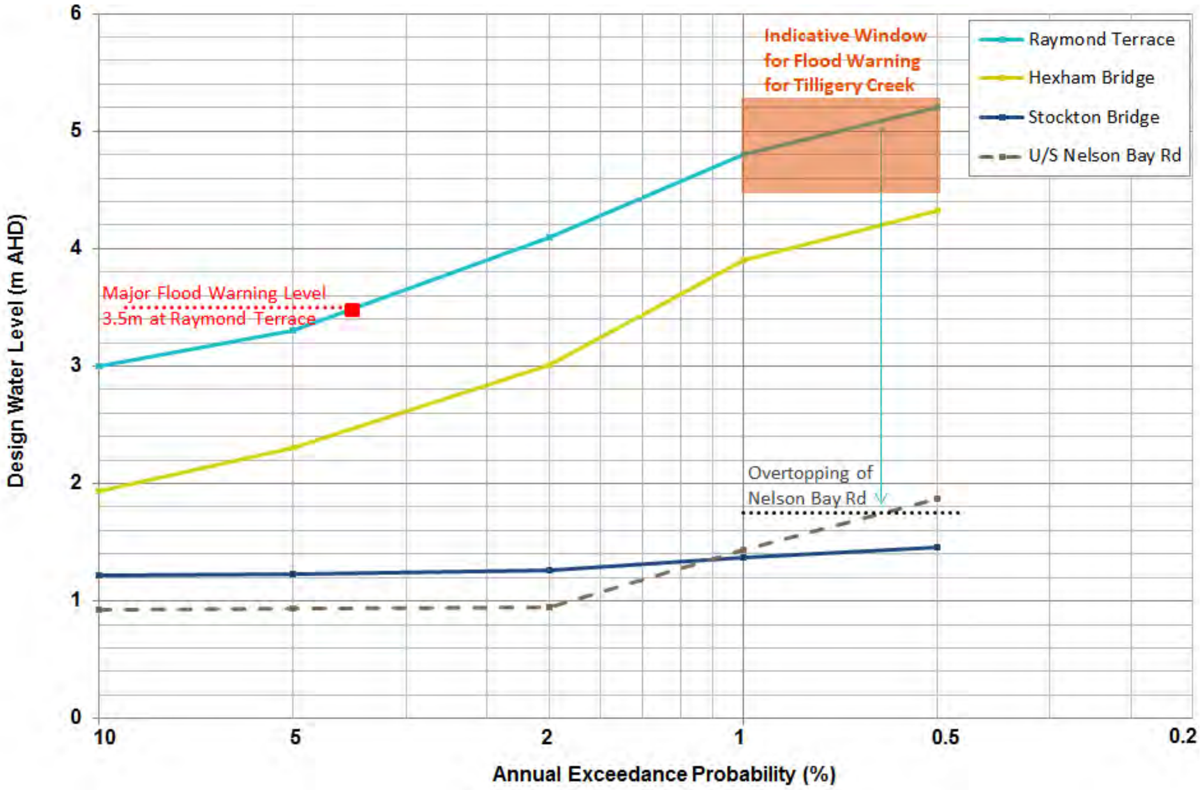

Figure 7-23 Design Flood Levels at Lower Hunter Gauges

The flood magnitude at the major flood warning level at Raymond Terrace does not provide any significant flood risk for the Williamtown-Salt Ash area. As previously noted, major flooding in the Tilligery Creek system from Hunter River flows only occurs via overtopping of Nelson Bay Road. This overtopping is only expected to occur with major flows in the Hunter River system corresponding to peak flood levels at Raymond Terrace in excess of 5 m AHD. Accordingly, an initial major flood warning for water level in excess of 3.5 m AHD at Raymond Terrace would not specifically require a direct flood warning for the Williamtown-Salt Ash area.

An indicative flood warning window is shown in Figure 7-23 representing a stage range at Raymond Terrace in which rising flood water levels may pose a risk of overtopping of Nelson Bay Road at Fullerton Cove. Flood level forecasts of in excess of 4.5 m AHD at Raymond Terrace may be an appropriate trigger level for more direct flood warning to be disseminated to the Williamtown-Salt Ash area.

It is noted that the indicative flood warning window is in the range of flooding in excess of a 1% AEP design magnitude at Raymond Terrace. Accordingly, specific flood warnings for Williamtown-Salt Ash would only be expected for high flood event conditions well in excess of the major flood warning trigger level at Raymond Terrace. These trigger levels have not been reached in the Hunter River since the 1955 event and as such there has not been a large enough event since 1955 that provided for overtopping of Nelson Bay Road at Fullerton Cove.

7.3.2 Emergency Response

The State Emergency Service (SES) has formal responsibility for emergency management operations in response to flooding. Other organisations normally provide assistance, including the Bureau of Meteorology, council, police, fire brigade, ambulance and community groups. Emergency management operations are usually outlined in a Local Flood Plan (LFP).

Information contained in the LFP is largely derived via local knowledge, historical record and completed flood studies. The SES follows the LFP, using information from Flood Intelligence and BoM's predictions, to respond in actual flood events.

It is important that the SES Plan incorporates all relevant technical data and specific community vulnerabilities (including addresses of areas at highest risk) that have been determined through the Floodplain Risk Management process. Provision of this data is particularly important with regard to those areas that are potentially to above floor flooding or where key transport routes are subject to closure.

For onset of flooding within the Williamtown-Salt Ash locality which is only initiated in the significantly larger flood events, it would not be realistic to expect the SES to be able to undertake much in the way of emergency response for several reasons:

- The SES is principally a volunteer organisation and the time required to mobilise personnel could exceed the warning time available on initiation of overtopping of Nelson Bay Road at Fullerton Cove;
- A major flood event in the Williamtown-Salt Ash area is driven by broader Hunter River flooding and therefore likely to coincide with major flooding of other communities in the Hunter Region, further stretching already limited emergency response resources;
- Some of the principal roads within the region are cut in major floods making access difficult for mobilising or responding; and
- There is generally insufficient time to undertake tasks such as sandbagging or evacuation to reduce impacts on property or people.

For some major flooding situations, the SES's role in flooding may be limited to assisting with recovery after the event. That is not to say that the SES Flood Emergency Plan will not in some measure mitigate the impacts of flooding. What it does mean is that they cannot be relied upon alone to provide an appropriate level of protection, particularly the protection of lives. In the rapid onset of a flood, individuals and groups of people must essentially take appropriate actions to protect themselves. Occupants of premises within the flood prone areas should be encouraged to have private flood emergency response plans.

A summary of the emergency response updates to be incorporated in the Plan include:

- Update of Local Flood Plan – in consultation with SES utilising updated Flood Study information and cross linkage to monitoring sites and local property databases:
    - Design flood mapping
    - Property database and inundation statistics

  - Key levels at monitoring locations (event references - design and historical)
  - Evacuation arrangements
  - Recovery Plans
- Road closures
  - Clear roles of responsibility during flood
  - Warning issue and dissemination
  - Activation of road closures and corresponding operational safety measures
- Community / Personal Flood Action Plans – in recognition of the potential for limited external support and requirement for self-help.

The concept of a "Community Flood Emergency Response Plan" should be explored. The Plan would provide information regarding evacuation routes, refuge areas, what to do/not to do during a flood event etc. If such a plan is developed and embraced at a community level, the self-sufficiency in terms of flood response would maximise potential for effective emergency response and a non-reliance on formal emergency services. Council and the SES would be expected to have a key role in developing the CFERP for the vulnerable areas of Williamtown and Salt Ash.

7.3.3 Community Awareness

Raising and maintaining flood awareness provides residents with an appreciation of the flood problem and what measures can be taken to reduce potential flood damage and to minimise personal risk during future floods.

The basic objectives of the community awareness program are to:

- Make people aware they are living / working in a flood zone;
- Receiving, understanding and reacting to flood warnings; and
- Appropriate actions - e.g. protecting property, vehicular and pedestrian access during flood time.

Community awareness is an on-going process and there is also the inherent danger of complacency between events. A lack of general community awareness may also be exacerbated by new residents in the area having little knowledge or appreciation of flood risk. This would also apply to any transient population (e.g. holidaymakers) who may be in the locality at a time of major flood.

There are numerous mechanisms to inform the community, such as.

- Flood mapping availability (Council website) – Consolidation of the recent flood risk mapping, flood data and flood damages database prepared during the floodplain risk management study into Council's computer based GIS system. This will provide Council with valuable flood information that can be easily retrieved, and which will form the basis of information that can be supplied to the public when requests are made, or on a periodic basis.
- Section 149 certificates or Flood certificates – Consideration could be given to providing information on the flood risk and the flood levels that apply to a particular property on a special

flood certificate. These certificates could be appended to the Section 149(5) certificates; provided whenever flood information is requested for a property; or provided on a regular basis to all residents in the study area.

- Flood information page on community websites – this can include links to BoM rainfall and flood warning pages, a how to guide in understanding and reacting to flood warnings. This may be extended to other media including community newsletters/publications with Council providing regular input regarding flood awareness/preparedness, commemoration of historic events etc.
- Undertake a formal flood education, awareness and resilience program. Education is required to build a flood-resilient community who is prepared for flooding and able to respond to and recover from actual flooding. There are few planning or administrative barriers that would delay the development and implementation of a community education plan. Education and flood awareness should be a key role for combat agencies such as the SES, with Council having a key supporting role to play in assisting SES with the technical elements of flood characteristics of overland flooding in the catchments.

Given the relatively low incidence of flood affectation to existing property within the Williamtown-Salt Ash area, an extensive community education and awareness program would be of little value. A more targeted approach could be employed focusing on the identified flood affected properties.

PART B – FLOODPLAIN RISK MANAGEMENT PLAN

8 Williamtown Salt Ash Floodplain Risk Management Plan

8.1 Introduction

The Williamtown Salt Ash Floodplain Risk Management Plan (the FRM Plan) has been developed to direct and co-ordinate the future management of flood prone lands within the Williamtown / Salt Ash area. The FRM Plan sets out a strategy of actions and initiatives that are to be pursued by Council, agencies and the community in order to adequately address the risks posed by flooding. Development of the FRM Plan has been guided by the NSW Government's Floodplain Development Manual (2005).

The outcomes of the Floodplain Risk Management Study provide the basis for this FRM Plan, containing an appropriate mix of management measures and strategies, to help direct and coordinate the responsibilities of Government and the community in undertaking immediate and future flood management works and initiatives.

The floodplain management measures and strategies that are recommended for inclusion in the FRM Plan are summarised below.

8.2 Recommended Measures

8.2.1 Flood Modification Measures

Nelson Bay Road Upgrades

Nelson Bay Road is the principal flood access route through the study area. It is presently elevated well above the floodplain and typically provides for existing 1% AEP flood access. The existing flood immunity of the road will gradually decrease with progressive climate change impacts increasing design peak flood level conditions. Whilst not specifically requiring immediate works, road upgrades may be undertaken in association with regular maintenance programs (e.g. resurfacing) to provide progressive lifting of the existing road surface profile and maintain appropriate flood immunity.

In addressing local and regional flood access, investigation of a consistent flood immunity for roads based on the adopted road hierarchy is recommended.

Estimated Cost **– to be confirmed (future works)** Responsibility **– Council/RMS** Priority – **Low**

Salt Ash Flood Gate Modification

The existing flood gate and levee arrangement limits tidal water ingress to the floodplain upstream. The existing arrangement has limited control on peak flood level conditions, particularly in relation to Hunter River derived flooding. No modification works are therefore recommended to address existing flood risk. However, the floodplain management study notes the potential change in flood gate performance associated with progressive sea level rise. Accordingly, future modification of the existing structures will need to be considered in climate change adaptation programs.

It is recommended an initial investigation be undertaken to identify the required upgrade works and the timing/triggers for construction to enable future works planning. This may be incorporated in a broader climate change adaptation study for the locality.

Estimated Cost **– to be confirmed (future works)** Responsibility **– Council** Priority – **Low**

Hunter River Levee Review

The existing Hunter River flood levees provide existing protection for lower order flood events (<5% AEP) for the floodplain areas in the vicinity of Tomago and Fullerton Cove. Existing and future design flood conditions established in the current study are based on the current levee configurations. Ongoing floodplain risk management for Williamtown and Salt Ash needs to consider potential changes in the configuration or maintenance of these levees that may have an influence on design flood conditions in the study area. Future climate change conditions may warrant reassessment of the levee function, not just from a flood management perspective, but also ecological response in the broader Fullerton Cove/Lower Hunter River system which includes significant wetland areas. An initial review from a Williamtown – Salt Ash floodplain risk management perspective may be considered as an initial phase to a broader Plan of Management for the levee system. It is noted that the responsibility for the levee system lies with the Office of Environment and Heritage. Accordingly, Port Stephens Council is a stakeholder (as is City of Newcastle and Maitland City Council) in this potential management option rather than having primary responsibility.

Estimated Cost **– low ($30K)** Responsibility **– OEH** Priority – **Medium**

Preparation of Local Drainage Strategies

Acknowledging the principal concerns of the community raised during the consultation process, recommendation is made to prepare a Management Plan for the local drainage systems. From the floodplain risk management perspective, this is driven by the need for appropriate adaptation plans to be prepared to address increasing flooding under future climate change conditions. There are associated issues relating to local low flow drainage regimes including limited existing capacity, incidence of waterlogging and extended flooding durations, and impact of development on increased runoff. A more holistic Management Plan would also consider other issues related to water quality and environmental issues.

Estimated Cost **– med ($50-100K)** Responsibility **– Council** Priority – **High**

8.2.2 Property Modification Measures

Land Use Planning and Development Controls

Land use planning and development controls are key mechanisms by which Council can manage flood-affected areas within the study area. Such mechanisms will influence future development (and redevelopment) and therefore the benefits will accrue gradually over time. No key changes to existing planning and development controls are considered to be required for the study area. However, various flood risk mapping outputs updated for the current study are recommended to be adopted by Council and used in the development assessment process.

- Council adoption of the revised 1% AEP flood condition (incorporating climate change provisions) derived through updated modelling undertaken as part of the Floodplain Risk Management Study. Council apply FPLs on the basis of updated flood modelling results developed in the current study.

- Council adoption of the flood risk mapping associated with the 1% AEP flood event incorporating design flood conditions, Flood Planning Area, hydraulic category (floodway, flood storage and flood fringe definition) and flood hazard. These maps are to effectively form a referenced component of the LEP2014 and DCP2014.

Estimated Cost **– low (staff costs)** Responsibility **– Council** Priority – **High**

Flood Proofing

Flood proofing refers to the design and construction of buildings with appropriate materials (i.e. material able to withstand inundation, debris and buoyancy forces) so that damage to both the building and its contents is minimised should the building be inundated during a flood. Flood proofing can be undertaken for new buildings or be retrofitted to existing buildings. Generally these works would be undertaken on a property by property basis at no cost to Council.

Council's Development Control Plan already includes requirements for the use of flood compatible building components for new development in the floodplain. However, there are a number of non-structural options that can be retrofit to existing property to help reduce flood damage including changes to joinery and fittings, floor coverings and electrical services.

A public awareness campaign may help to inform the community of flood proofing measures, and could be supplemented with individual building inspections and property owner interviews. Encouragement to make a property more flood-resilient can be linked to the recommended Community Awareness Program.

Estimated Cost **– low ($5K)** Responsibility **– Landowner** Priority – **Medium**

Voluntary House Raising

Raising floor levels of individual properties where practical to elevate habitable floor levels to required levels above the flood planning level. Not all houses are suitable for raising. Houses of brick construction or slab on ground construction are generally not suitable for house raising due to expense and construction difficulty. Generally, this technique is limited to structures constructed on piers. This scheme has been recommended for further investigation within the Plan to identify suitable properties and funding. The current predictions for sea level rise may further improve the viability of such a scheme in the future. A house raising program may form part of a broader climate change adaptation strategy for the study area.

Estimated Cost **– low ($10K)** Responsibility **– Council/Landowner** Priority – **Low**

Strategic Planning for Future Development

The study investigated a number of potential large scale redevelopment areas within the Port Stephens LGA. Investigated in isolation, a number of these areas show potential for future redevelopment (including large scale filling/earthworks) with limited impact on existing flood conditions. However, a more coordinated flood impact assessment is recommended comprising a full cumulative development assessment with consideration of regional development opportunities across the Lower Hunter River floodplain incorporating the Port Stephens and Newcastle LGAs. Such an investigation is likely to consider broader regional land use planning and identify future development areas within the floodplain that duly consider overall flood risk and potential impacts under an ultimate development scenario. The outcomes of this cumulative impact assessment would further inform future LEP and DCP amendments (e.g. rezoning, development controls such as fill limitations).

Estimated Cost **– medium ($50K)** Responsibility **– Council/City of Newcastle** Priority – **High**

Climate Change Adaptation Strategy for Williamtown-Salt Ash

The extent and severity of flooding in the Tilligerry Creek floodplain is controlled by the transfer of Hunter River floodwater across Nelson Bay Road. In raising Nelson Bay Road to combat climate change influence and maintain road flood immunity as a potential flood management measure, there is an opportunity to modify the flood behaviour to provide significant flood risk reductions in the Williamtown-Salt Ash localities under future climate conditions. Strategic planning studies in both a local and regional planning context is recommended to identify a long-term position on the future landscape of the Williamtown-Salt Ash locality under future climate change scenarios. Flood risk management options considered in the current study would be considered as part of local adaptation plans and updated accordingly.

Estimated Cost **– high ($100K)** Responsibility **– Council** Priority – **High**

8.2.3 Response Modification Measures

Flood Warning Arrangements

The issuing of flood warnings in the region is the responsibility of the Lower Hunter Division of the State Emergency Services (SES). At present flood warnings and estimates of the time of arrival of the flood peak are based on floodwater levels at gauges located upstream including Singleton, Greta, Maitland and Raymond Terrace. The current study has established specific flood warning trigger levels and timings for Williamtown-Salt Ash linked to the existing Raymond Terrace, Hexham Bridge and Stockton Bridge water level gauges. The additional data in concert with the official Hunter River flood warning system should be used to establish appropriate flood warning and response triggers for the study area and update of Local Flood Plans accordingly. It is recommended this be incorporated in the implementation of a real-time Flood Forecasting Tool based on the Bureau of Meteorology flood warnings at river gauges.

Estimated Cost **– low ($50K)** Responsibility **– Council/SES** Priority – **High**

Emergency Response

The key improvements to emergency response considered in the current study is the update of Local Flood Plans to incorporate the flood intelligence data borne out of the revised understanding of catchment flooding conditions. This data includes the updated flood modelling, property inundation and flood damages analysis.

It is important that the SES Plan incorporates all relevant technical data and specific community vulnerabilities (including addresses of areas at highest risk) that have been determined through the Floodplain Risk Management process. Updates to the Local Flood Plan would be expected to build upon the following flood intelligence data:

- Update of linkage to flood warning/gauge sites and local property database
- Key levels at gauge locations with references to design and historical events
- Updated flood mapping showing flood depth and inundation extents and flood hazard categories for a range of events.
- Property database and inundation statistics
- Potential evacuation requirements
- Post flood recovery services

Recommendation is to review of flood emergency planning and update of Local Flood Plan utilising updated flood intelligence.

Estimated Cost **– low (staff costs)** Responsibility **– Council/SES** Priority – **High**

Improved flood awareness

Raising and maintaining flood awareness will provide the community with an appreciation of the flood problem and what can be expected during flood events. An ongoing flood awareness program should be pursued through collaboration of the SES and Council (e.g. FloodSafe program specific for the study area). The focus of this program should encourage landowners to develop their own Flood Plan for appropriate emergency response in lieu of reliance on Emergency Services as noted above.

Estimated Cost **– low ($20K)** Responsibility **– Council/SES** Priority – **High**

8.3 Funding and Implementation

The timing of the implementation of recommended measures will depend on the available resources, overall budgetary commitments of Council and the availability of funds and support from other sources. It is envisaged that the FRM Plan would be implemented progressively over a 2-5 year time frame. Implementation of measures may be achieved sooner given that most measures do not require significant expenditure, however, although will need to be incorporated in Council's capital works program.

There are a variety of sources of potential funding that could be considered to implement the Plan. These include:

(1) Council funds;

(2) Section 94 contributions;

(3) State funding for flood risk management measures through the Office of Environment and Heritage; and

(4) State Emergency Service, either through volunteered time or funding assistance for emergency management measures.

State funds are available to implement measures that contribute to reducing existing flood problems. Funding assistance is likely to be available on a 2:1 (State:Council) basis. Although much of the FRM Plan may be eligible for Government assistance, funding cannot be guaranteed. Government funds are allocated on an annual basis to competing projects throughout the State. Measures that receive

Government funding must be of significant benefit to the community. Funding is usually available for the investigation, design and construction of flood mitigation works included in the floodplain management plan.

8.4 Plan Review

The FRM Plan should be regarded as a dynamic instrument requiring review and modification over time. The catalyst for change could include new flood events and experiences, legislative change, alterations in the availability of funding, or changes to the area's planning strategies.

A thorough review every 5 years is warranted to ensure the ongoing relevance of the FRM Plan.

Table 8-1 Recommended Floodplain Risk Management Plan

ID	Action	Estimated Cost	Responsibility	Priority
1	Undertake Nelson Bay Road upgrade works road raising and culvert upgrades (note this may be progressive works in response to incremental climate change impacts)	t.b.c. (future works program)	RMS	Low
2	Investigation of consistent flood immunity for roads based on the adopted hierarchy and install flood indicator signs as appropriate	$50k	Council	Low
3	Upgrade Salt Ash flood gate and levee as required (note this may be progressive works in response to incremental climate change impacts)	t.b.c. (future works program)	Council	Low
4	Review of Hunter River Levee Scheme in providing ongoing function for Williamtown-Salt Ash flood control	$30k	Council / OEH	Medium
5	Update planning and development controls including flood risk mapping	Staff costs	Council	High
6	Investigate voluntary house raising program (limited properties)	$20k	Council / Landowner	Medium
7	Improved flood awareness through issue of flood information and community flood emergency response planning	$20k	Council / SES	High
8	Update of Local Flood Plans with current design flood information and intelligence	Staff costs	Council / SES	High
9	Implement a real-time flood forecasting tool based on BoM flood warnings at river gauges system	$50k	Council / SES	High
10	Preparation of a Regional Floodplain Development Strategy incorporating cumulative development flood impact assessment	$50k	NSW Planning / Port Stephens / Newcastle Councils	High
11	Preparation of a local drainage studies including climate change considerations	$50 - $100k	Council	High
12	Preparation of a Climate Change Adaptation Strategy for Williamtown-Salt Ash to define long term development directions	$100 - $200k	Council	High

Property owners with flood affectation may also be encouraged to undertake flood proofing works at their own costs and convenience. The public awareness campaign may help to inform the community of flood proofing measures, and could be supplemented with individual building inspections and property owner interviews.

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Appendix A Design Flood Mapping

Design Flood Inundation Extent, Peak Flood Level Contours and Peak Flood Depth

Figure A1 – 5% AEP Event Existing Conditions

Figure A2 – 2% AEP Event Existing Conditions

Figure A3 – 1% AEP Event Existing Conditions

Figure A4 – 0.5% AEP Event Existing Conditions

Figure A5 – PMF Event Existing Conditions

Figure A6 – 1% AEP Event 2100 Planning Condition (1% AEP+0.9mSLR+20%Flow)

Hydraulic Categories

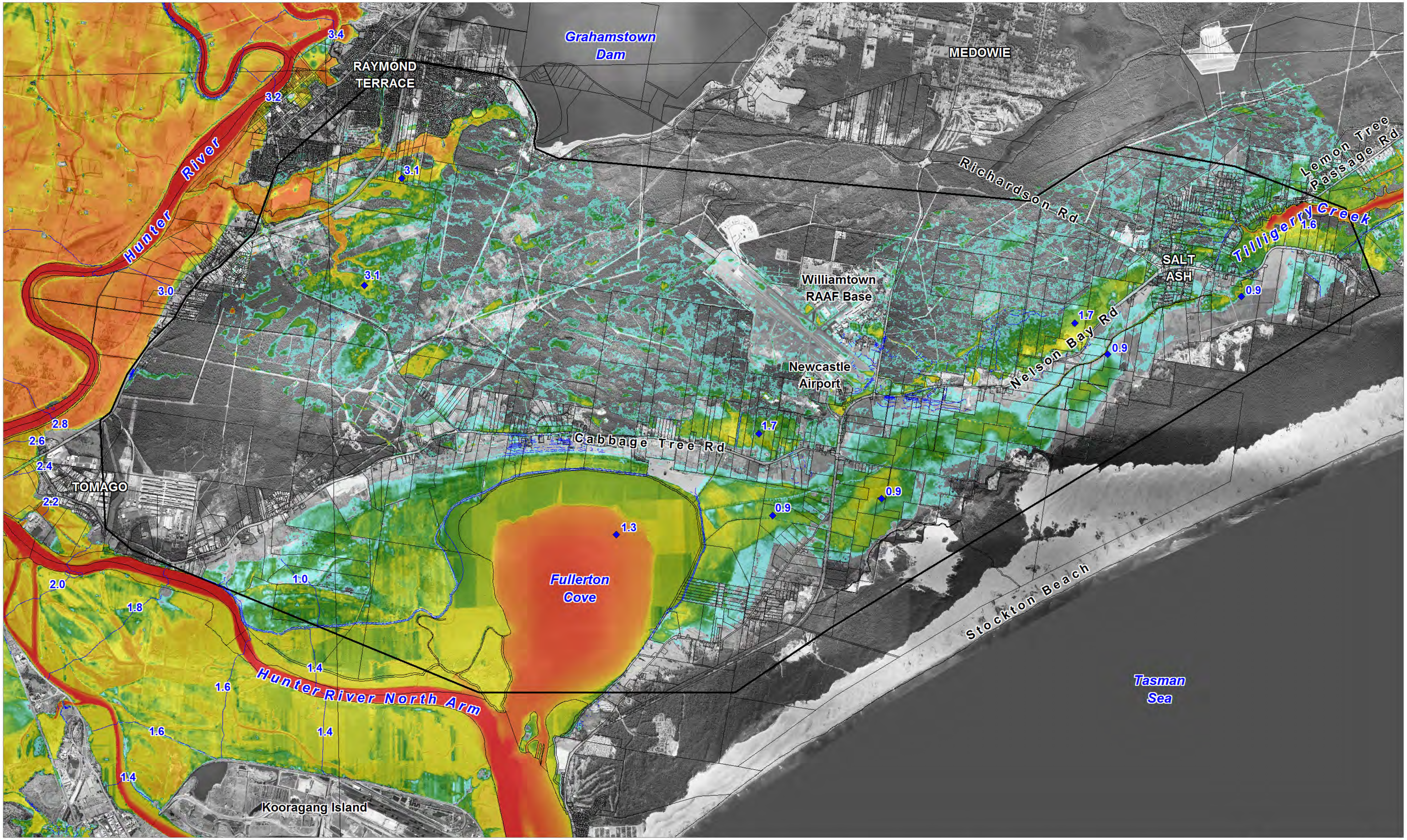
Figure A7 – 1% AEP Event 2100 Planning Condition

Figure A8 – PMF Event Existing Conditions

Hazard Categories

Figure A9 – 1% AEP Event 2100 Planning Condition

Figure A10 – PMF Event Existing Conditions



LEGEND

Peak Flood Depth (m)

- 0.2 lower depths mapped as same colour
- 0.5
- 1.0
- 2.0
- 4.0 higher depths mapped as same colour

2.5 Water Level Spot Height (mAHD)

2.5 Water Level Contour (mAHD)

Study Area

Title:

5% AEP Design Event - Modelled Flood Depths and Levels Existing Conditions

Figure: **A-1**

Rev: **A**

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 1.25 2.5km

Approx. Scale

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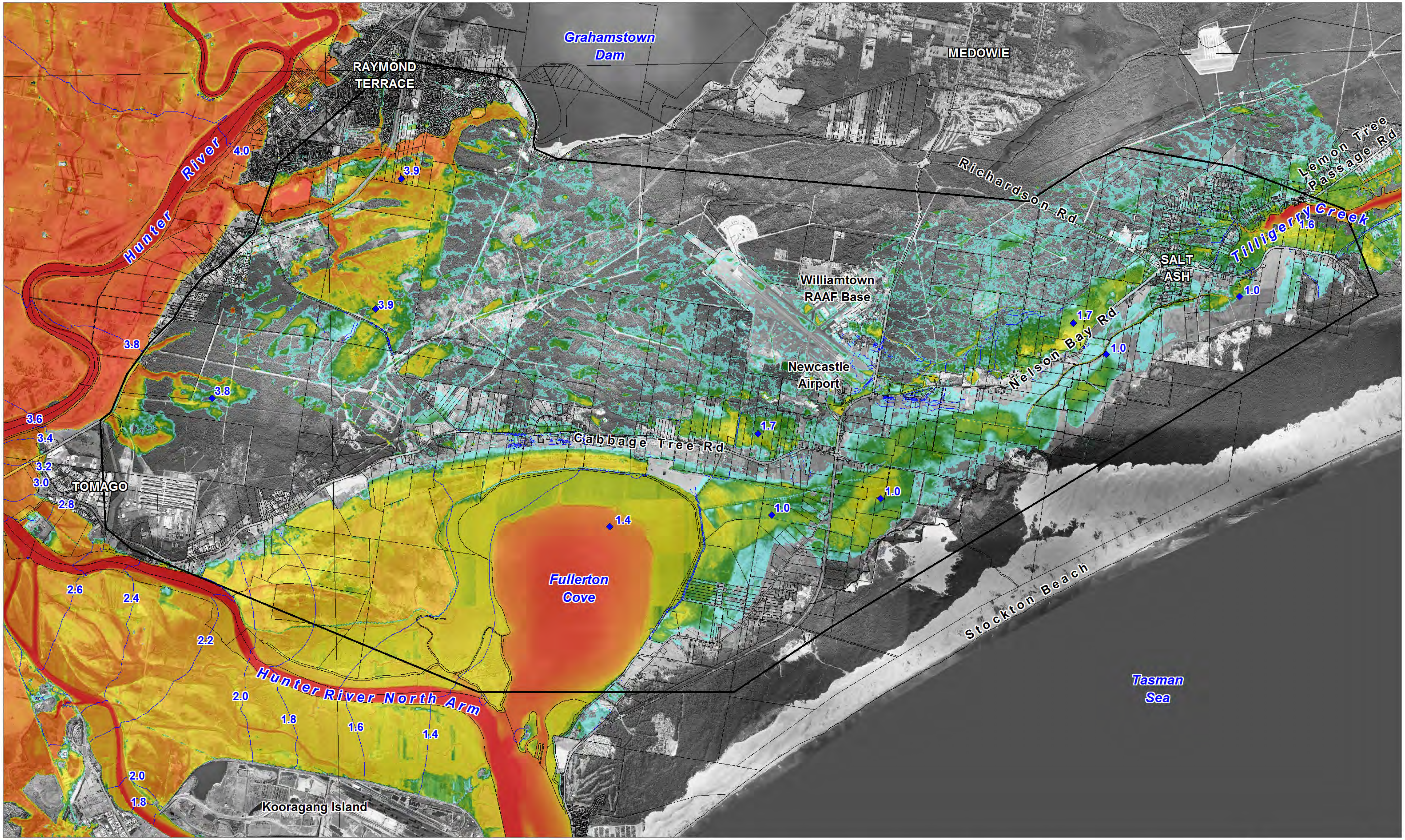

LEGEND

Peak Flood Depth (m)

- 0.2 lower depths mapped as same colour
- 0.5
- 1.0
- 2.0
- 4.0 higher depths mapped as same colour

2.5 Water Level Spot Height (mAHD)

2.5 Water Level Contour (mAHD)

Study Area

Title:

2% AEP Design Event - Modelled Flood Depths and Levels Existing Conditions

Figure: **A-2**

Rev: **A**

N

0 1.25 2.5km

Approx. Scale

BMT WBM

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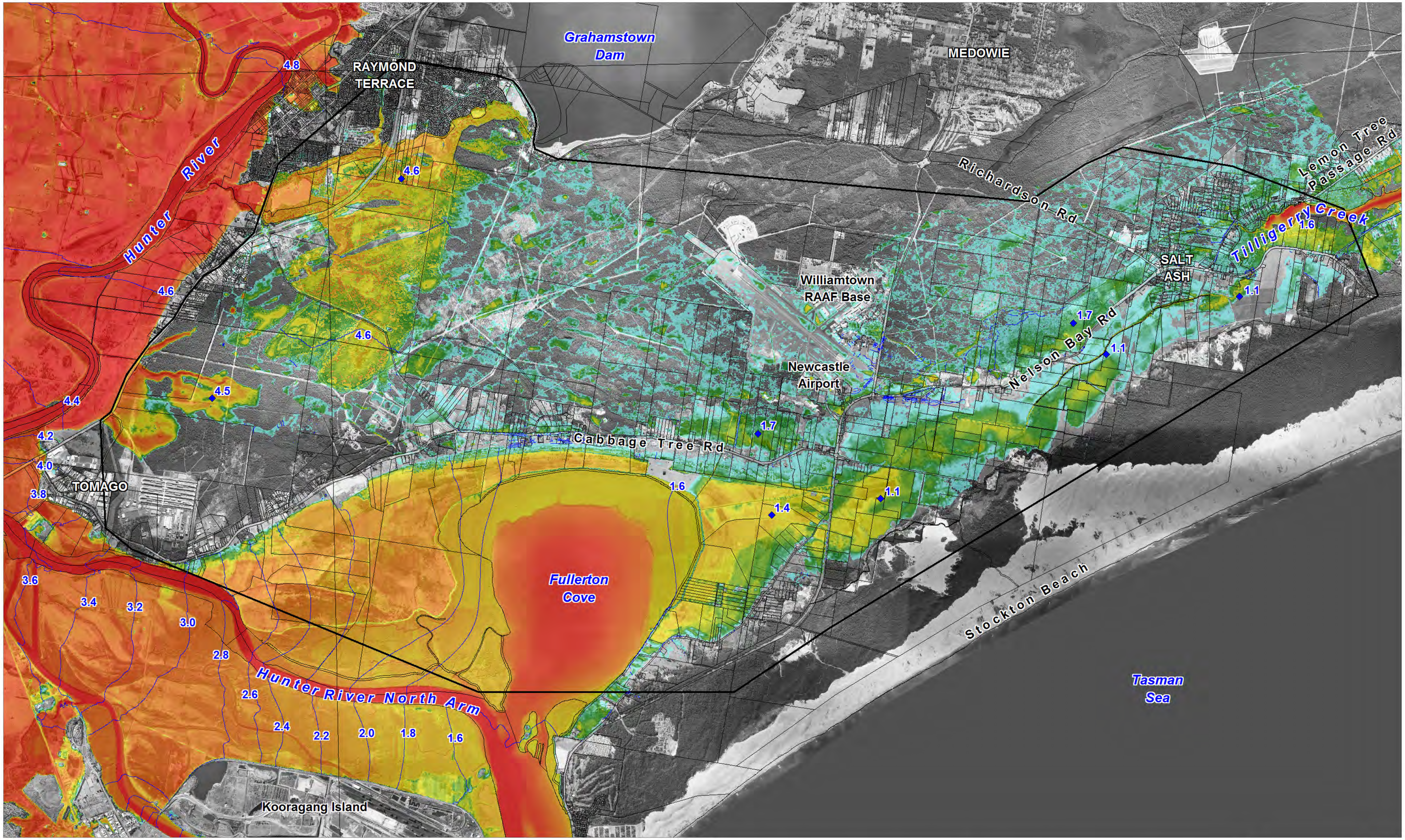

LEGEND

Peak Flood Depth (m)

- 0.2 lower depths mapped as same colour
- 0.5
- 1.0
- 2.0
- 4.0 higher depths mapped as same colour

2.5 Water Level Spot Height (mAHD)

2.5 Water Level Contour (mAHD)

Study Area

Title:

1% AEP Design Event - Modelled Flood Depths and Levels Existing Conditions

Figure: A-3

Rev: A

N

0 1.25 2.5km

Approx. Scale

BMT WBM

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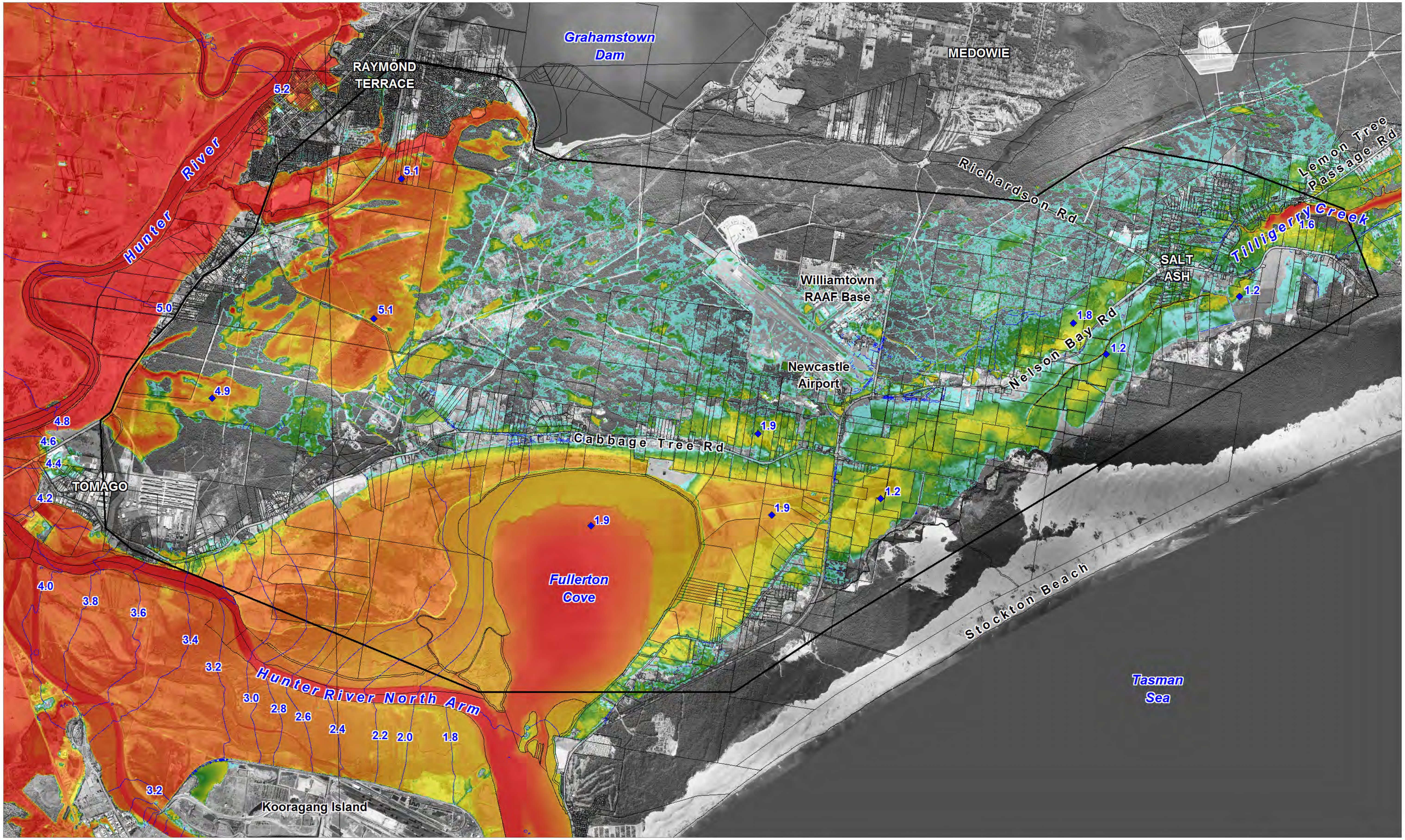

LEGEND

Peak Flood Depth (m)

- 0.2 lower depths mapped as same colour
- 0.5
- 1.0
- 2.0
- 4.0 higher depths mapped as same colour

2.5 Water Level Spot Height (mAHD)

2.5 Water Level Contour (mAHD)

Study Area

Title:

0.5% AEP Design Event - Modelled Flood Depths and Levels Existing Conditions

Figure: **A-4**

Rev: **A**

N

0 1.25 2.5km

Approx. Scale

No Window

www.bmtwbm.com.au

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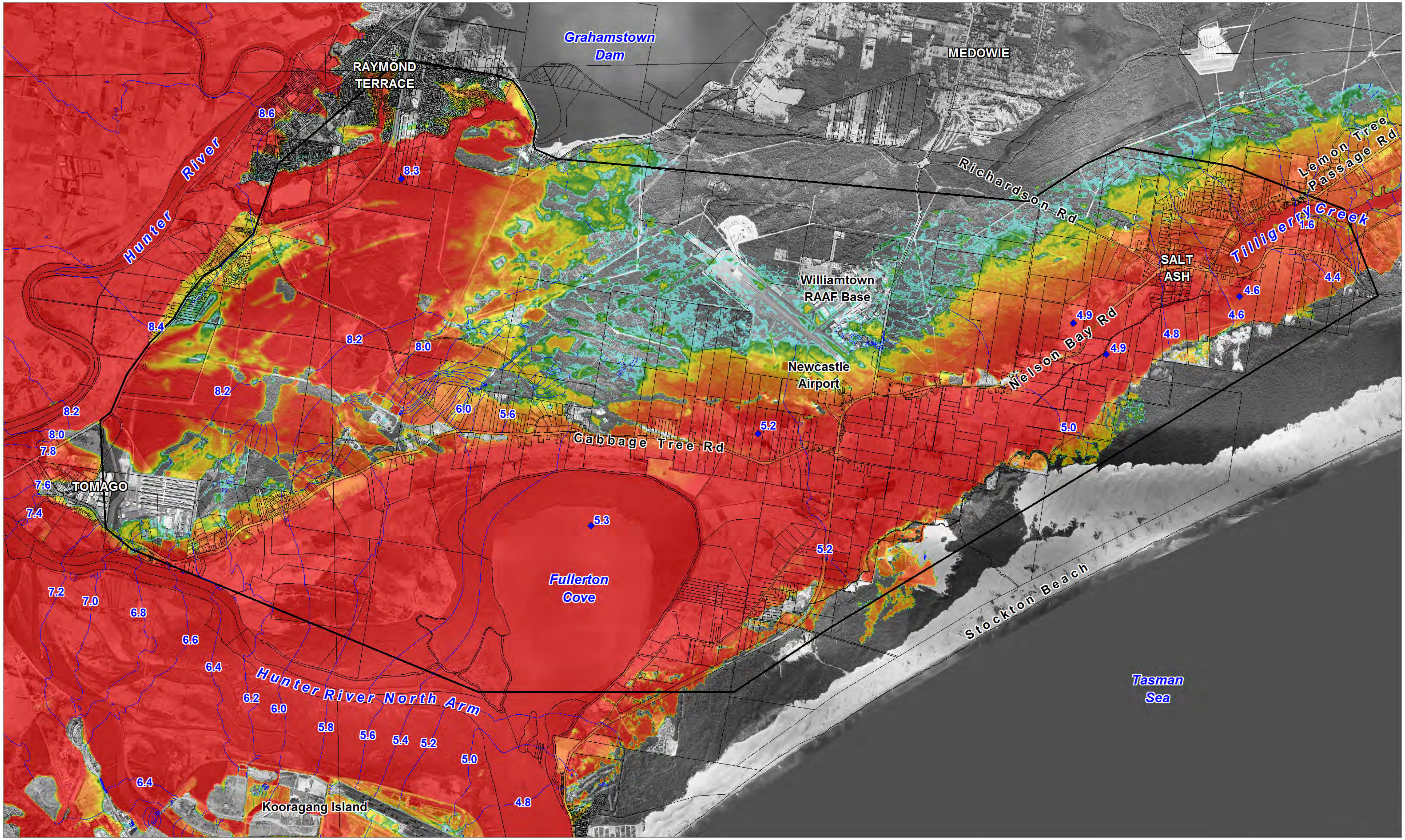

LEGEND

Peak Flood Depth (m)

- 0.2 — lower depths mapped as same colour
- 0.5
- 1.0
- 2.0
- 4.0 — higher depths mapped as same colour

2.5 Water Level Spot Height (mAHD)

2.5 Water Level Contour (mAHD)

Study Area

Title:

PMF Design Event - Modelled Flood Depths and Levels Existing Conditions

Figure: **A-5**

Rev: **A**

N

0 1.25 2.5km

Approx. Scale

BMT WBM

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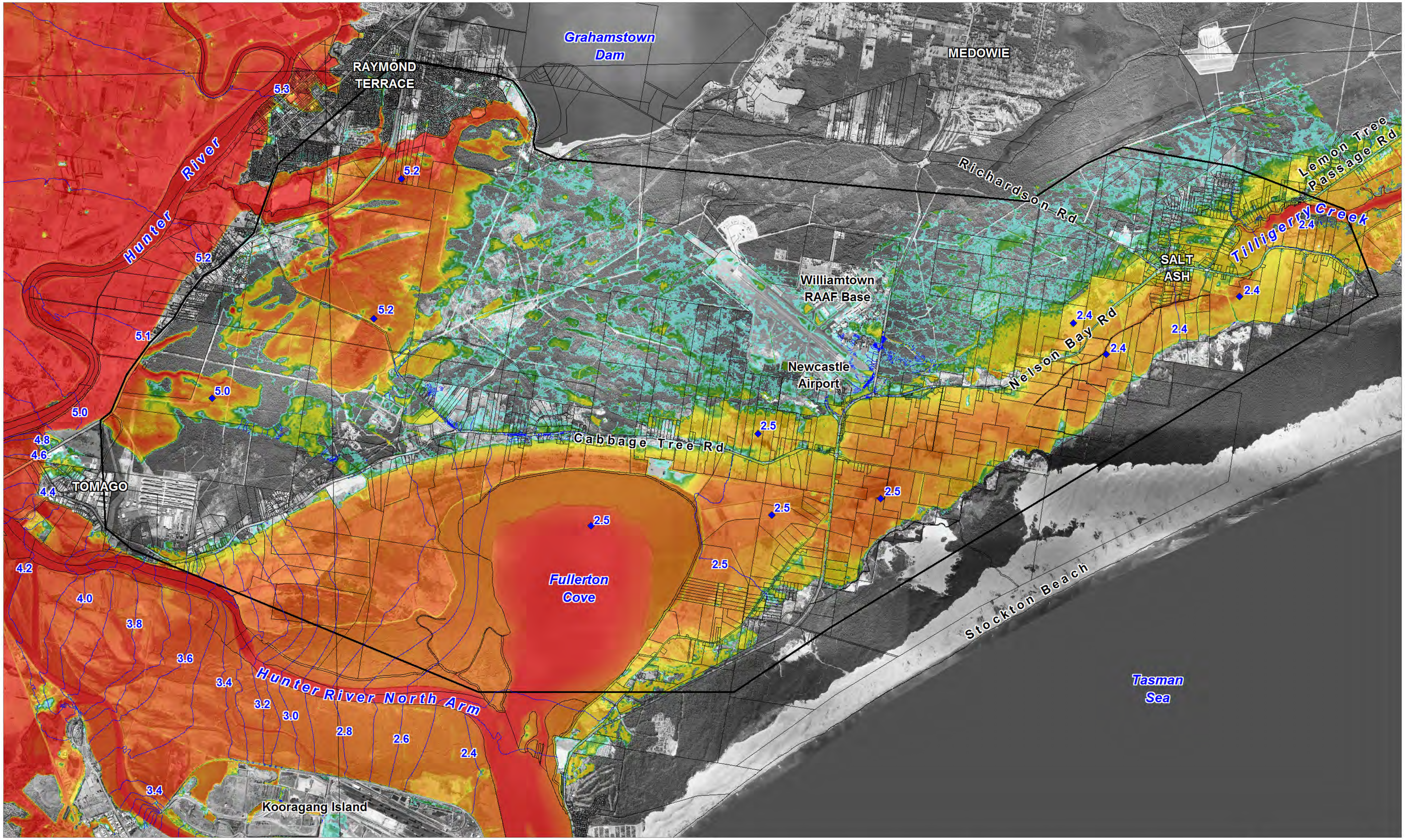

LEGEND

Peak Flood Depth (m)

- 0.2 lower depths mapped as same colour
- 0.5
- 1.0
- 2.0
- 4.0 higher depths mapped as same colour

2.5 Water Level Spot Height (mAHD)

2.5 Water Level Contour (mAHD)

Study Area

Title:

1% AEP Design Event - Modelled Flood Depths and Levels 2100 Planning Condition: +0.9m Sea Level Rise + 20% Flow

Figure: **A-6**

Rev: **A**

N

0 1.25 2.5km

Approx. Scale

BMT WBM

www.bmtwbm.com.au

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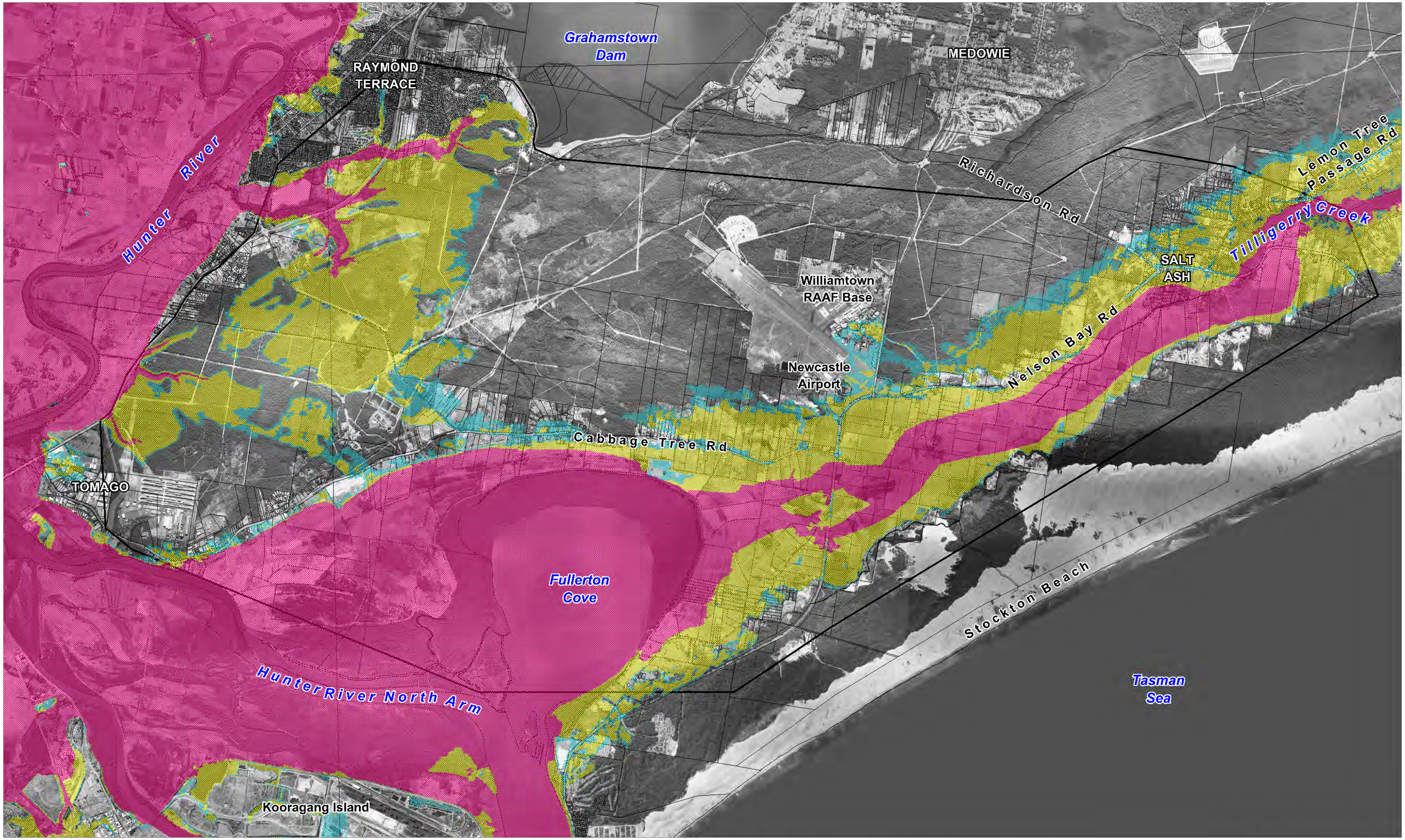


LEGEND

Hydraulic Category

- Flood Fringe
- Flood Storage
- Floodway
- Study Area

Title:

1% AEP Design Event - Hydraulic Categories
2100 Planning Condition: +0.9m Sea Level Rise +20% Flow

Figure: **A-7**

Rev: **A**

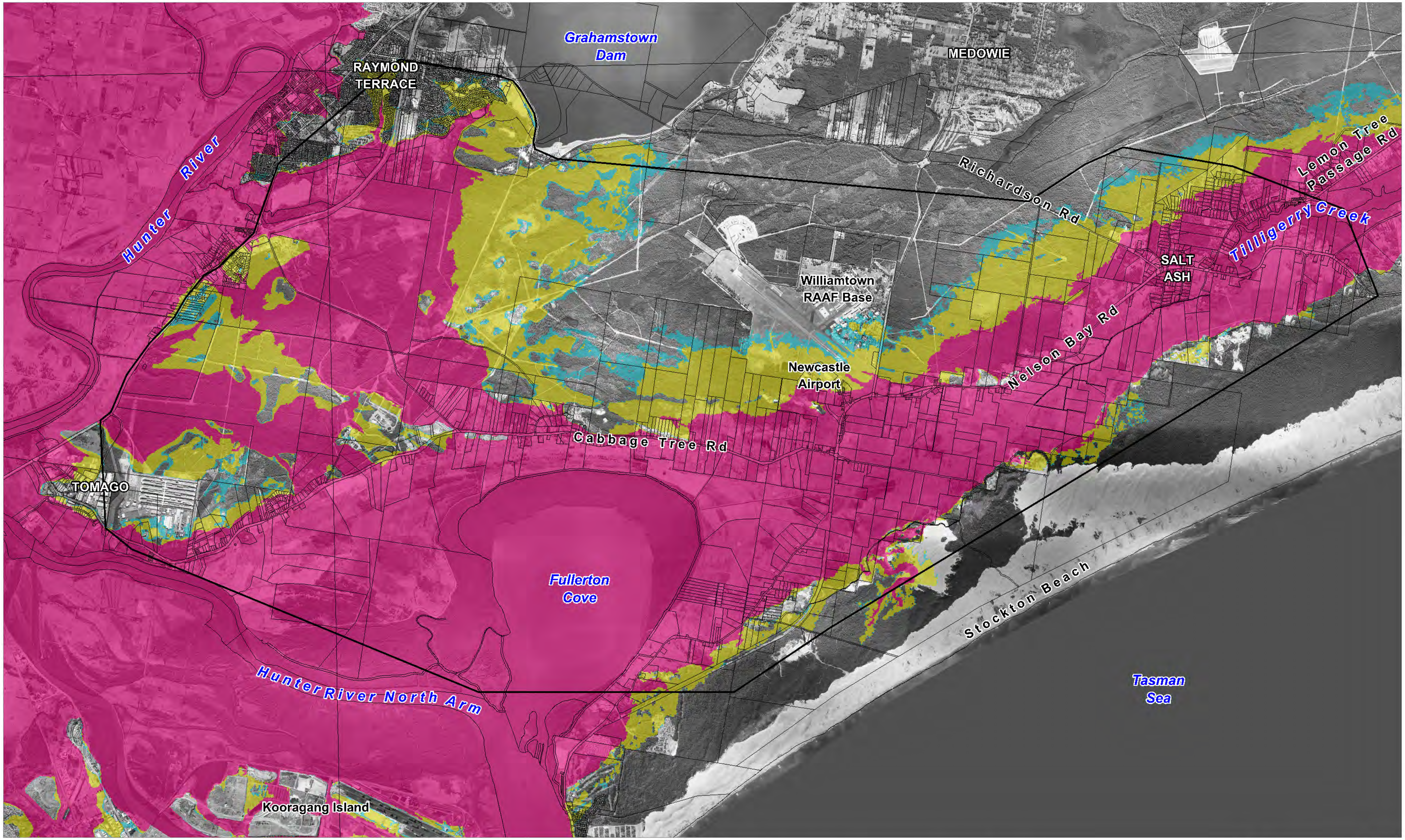
BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 1.25 2.5km
Approx. Scale

BMT WBM
www.bmtwbm.com.au

Filepath : K:\N20209_Williamtown_Salt_Ash_FRMSP\MapInfo\Workspace\1%AEP_2100_hc.WOR



LEGEND

Hydraulic Category

- Flood Fringe
- Flood Storage
- Floodway

Study Area

Title:

PMF Design Event - Hydraulic Categories

Figure: **A-8**

Rev: **A**

N

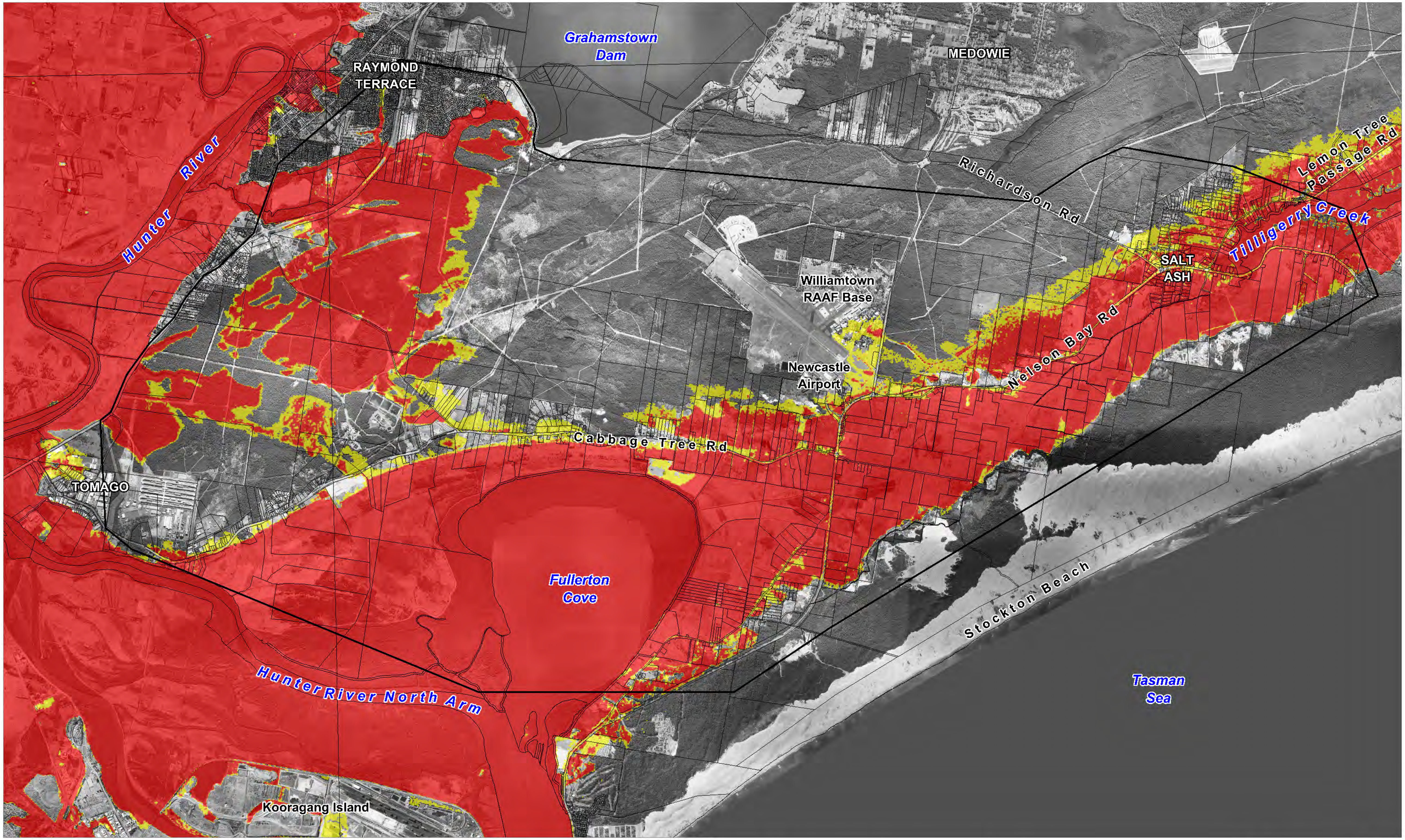
0 1.25 2.5km

Approx. Scale

BMT WBM

www.bmtwbm.com.au

Filepath : K:\N20209_Williamtown_Salt_Ash_FRMSP\MapInfo\Workspace\PMF_hc.WOR



LEGEND

Hazard Category

High Hazard

Low Hazard

Study Area

Title:

1% AEP Design Event - Hazard Categories
2100 Planning Condition: +0.9m Sea Level Rise +20% Flow

Figure: **A-9**

Rev: **A**

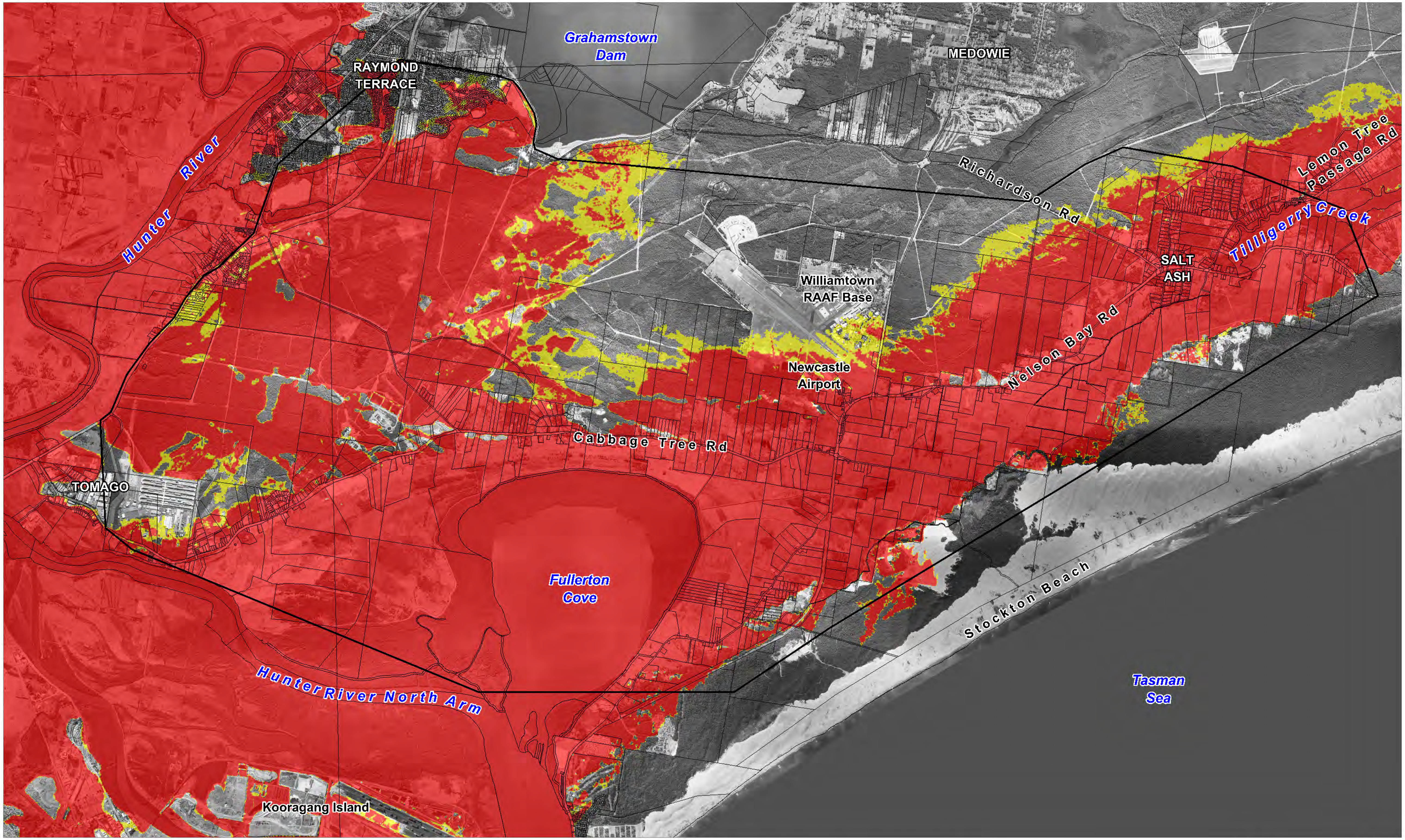
N

0 1.25 2.5km

Approx. Scale

BMT WBM
www.bmtwbm.com.au

Filepath : K:\N20209_Williamtown_Salt_Ash_FRMSP\MapInfo\Workspace\1%AEP_2100_haz.WOR



LEGEND

Hazard Category

- High Hazard
- Low Hazard
- Study Area

Title:

PMF Design Event - Hazard Categories

Figure: **A-10**

Rev: **A**

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 1.25 2.5km

Approx. Scale

BMT WBM

www.bmtwbm.com.au

Filepath : K:\N20209_Williamtown_Salt_Ash_FRMSP\MapInfo\Workspace\PMF_haz.WOR

Appendix B Flood Frequency Analysis

Review of Raymond Terrace Flood Frequency Analysis

The Lower Hunter River Flood Study (Green Rocks to Newcastle) (PWD, 1994) included a Flood Frequency Analysis (FFA) of water levels at Raymond Terrace. This FFA has been used as the basis for design flood estimation in the Hunter Estuary for all of the studies undertaken since 1994. There is an additional 23 years of complete annual maxima data available at the Raymond Terrace gauge since the original FFA, which is now out of date and in need of review.

As part of ongoing studies in the Lower Hunter, BMT WBM has undertaken an updated FFA at Raymond Terrace. This utilised the historic data detailed in the 1994 study and the continuous gauged data recorded at the site since 1984. The original FFA had been undertaken using recorded water levels, but it is a better approach to use flow data for the basis of an FFA. Rating curves (flow vs. level relationships) were extracted from the TUFLOW model results, in order to determine flow estimates for the recorded water level records. The historic record is reasonably complete back to 1893.

The rating curve at Raymond Terrace is significantly influenced by the floodplain constriction downstream at Hexham. The construction of the railway and New England Highway has reduced the floodplain flow through Hexham Swamp. The railway pre-dates the 1893 flood and it is assumed to have been at a similar level throughout the period of flood record. The current highway configuration was completed in 1964 and is now the control of floodwaters spilling into Hexham Swamp (being a little higher than the railway). Prior to 1964 it has been assumed that the railway would have been the highest control. To derive appropriate rating curves it was therefore necessary to model two separate conditions – one representing the current floodplain topography and another for the historic floods prior to 1964. The resultant curves are shown in Figure 1.

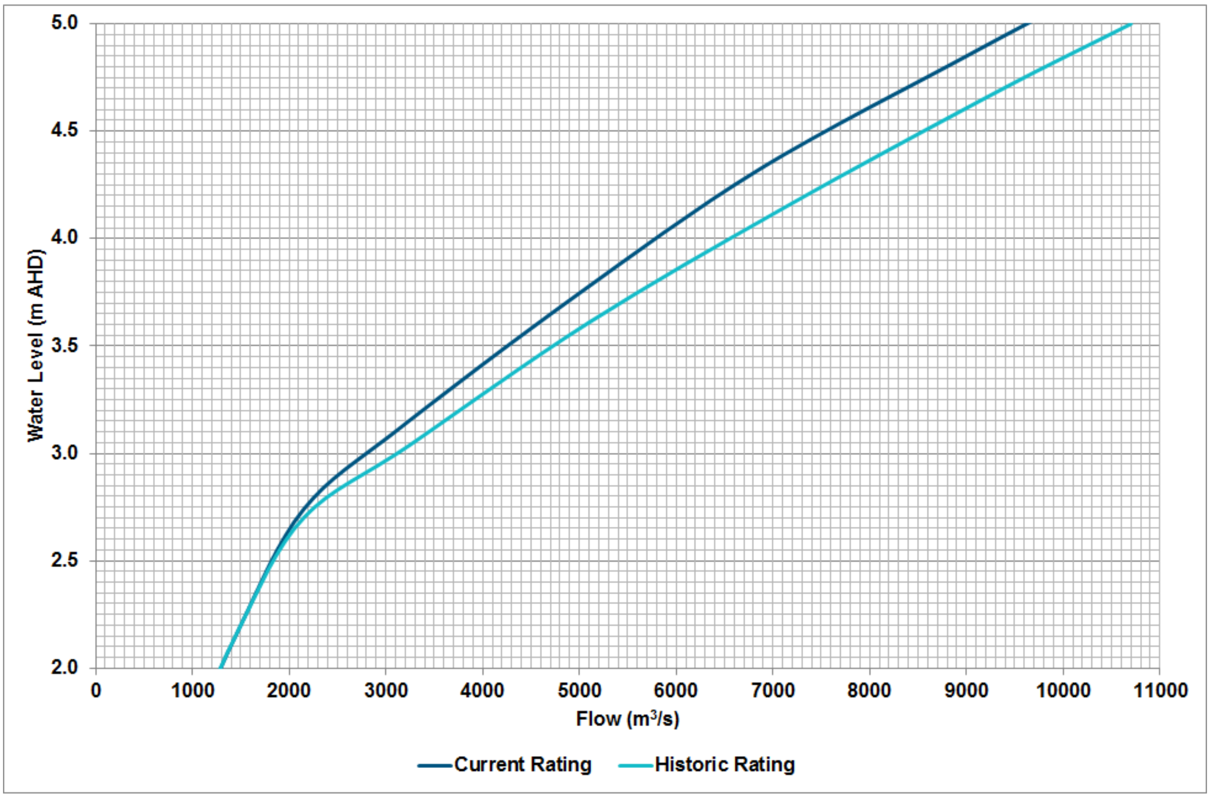


Figure 1 – Current and Historic Rating Curves at Raymond Terrace

The TUFLOW-FLIKE software was used to undertake a revised FFA at Raymond Terrace. This was based on a continuous annual maxima series of 30 years for the period 1984 to 2013. The historic data was incorporated as censored data, providing four floods above a 4,000m^3/s threshold in the 91 years prior to 1984. A flood frequency distribution was then derived using a Bayesian inference method and a Log Pearson III probability model. The resultant fitted distribution is presented in Figure 2 together with the plotting positions of the 20 largest floods since 1893, determined using the Cunnane formula.

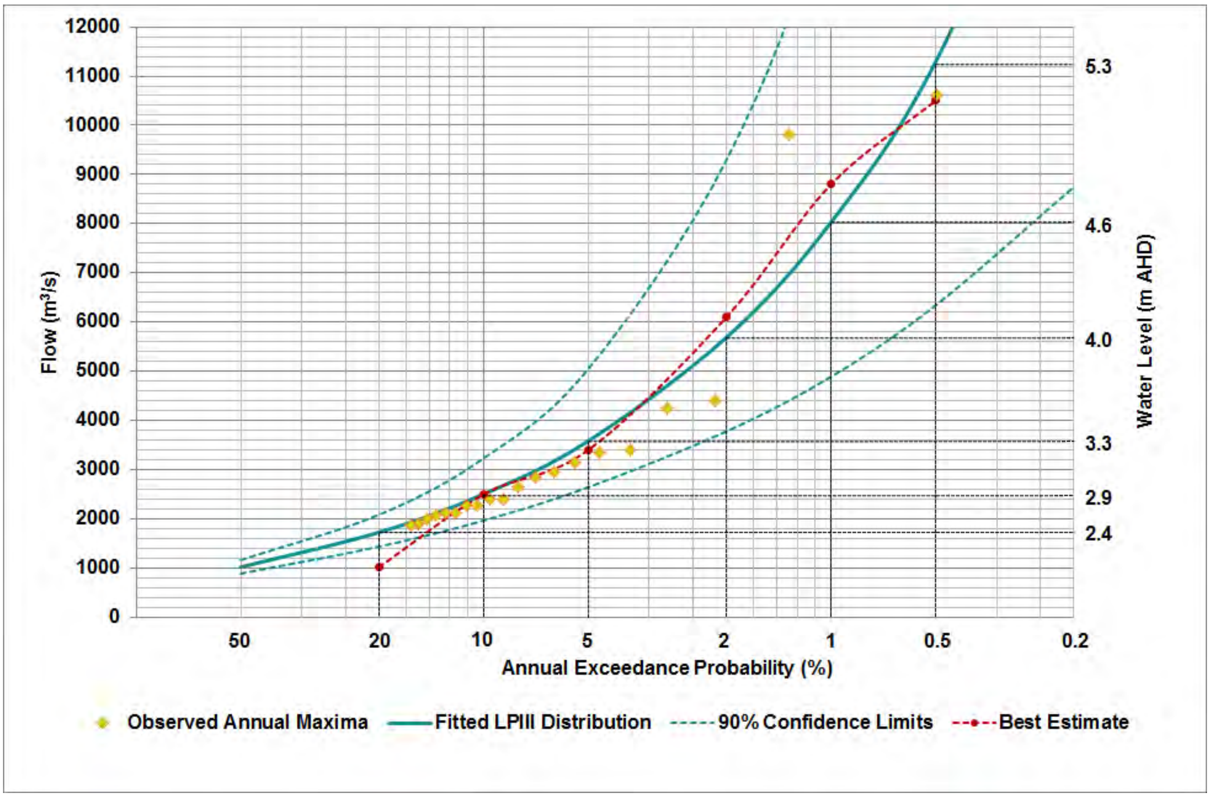


Figure 2 – Revised Flood Frequency Analysis at Raymond Terrace

It can be seen that there is a fairly even spread of flood events between a 2,000m^3/s and 4,000m^3/s magnitude. The two largest events in 1955 and 1893 are substantially larger than the other floods (at around 11,000m^3/s and 10,000m^3/s respectively). Inspection of the respective rainfall distributions for the historic floods shows that the two largest events have significant rainfall across the entire Hunter River catchment. The Hunter River catchment can be split into three broad sub-catchments: Goulburn River (7,800km^2), Upper Hunter (6,600km^2) and Lower Hunter (7,100km^2). The largest flows would be expected to be generated by heavy rainfall across all three. Other major events would likely have rainfall across two of the sub-catchments and events with significant rainfall in only one sub-catchment would be relatively minor.

Table 1 shows the 3-day rainfall distribution across the three Hunter River sub-catchments for five of the largest ten events. The two largest events (1893 and 1955) show significant rainfall across all three sub-catchments. The other three events show significant rainfall in two of the sub-catchments and only moderate rainfall across the Goulburn River catchment.

Table 1 – Historic Event Rainfall Distribution across the Hunter River Sub-catchments

	3-day Sub-catchment Rainfall Total (mm)		
Event	Goulburn River	Upper Hunter	Lower Hunter
1893	200	265	466
1913	123	254	210
1930	107	210	374
1955	310	321	266
1990	82	202	353

The flood flows from the FFA have been converted to water levels using the current rating presented in Figure 1 and were included within Figure 2. A comparison of the design flood levels at Raymond Terrace from the revised FFA with those from the 1994 study is presented in Table 2. The revised levels are typically 0.2m to 0.3m higher than the previous levels, although the revised 1% AEP level is 0.2m lower. There are a number of reasons for the differences between the two, including:

- There is an extra 20+ years of annual maxima data from which to derive the revised FFA;
- The previous FFA was fitted by eye whilst the revised FFA has used the Log Pearson III probability model; and
- The previous FFA was derived from plotting positions calculated using the Weibul formula rather than the Cunane. The latter is more appropriate when derived magnitudes for set return intervals.

The revised FFA is significantly influenced by the step change in historic flood event magnitudes between those events around or below 4,000m^3/s and the two largest events at around 10,000m^3/s. It is difficult to fit a distribution well to both, with the potential to overestimate some more frequent event magnitudes and underestimate some less frequent event magnitudes. A more realistic design flood estimation would incorporate a fitted distribution to the lower magnitude historic events, another fitted to the more extreme historic events and a transition between the two. Although there is a reasonable amount of certainty in fitting to the more frequent flood events, there are only a few historic events (and therefore more uncertainty) from which to derive a representative transition and large magnitude design flood estimate. A "best estimate" has been determined using the statistical FFA and engineering judgement, and has also been presented in Figure 2.

There are inherent uncertainties regarding the estimation of design flood flows, particularly for the large magnitude events. The revised FFA provides for some improvement over that undertaken in 1994 as it has been derived using a larger dataset and with the latest approach recommended by AR&R. To further improve the confidence of the Raymond Terrace FFA would involve significant investment in both catchment modelling and upstream gauge data analysis.

Table 2 – Comparison of Design Flood Levels from the 1994 and Revised FFAs

	Flood Level (m AHD)	
Design Event	1994 FFA	Revised FFA
20% AEP	2.1	2.4
10% AEP	2.7	2.9
5% AEP	3.1	3.2
2% AEP	3.7	4.1
1% AEP	4.8	4.8
0.5% AEP	-	5.2

Appendix C Public Exhibition Submissions

Williamtown/Medowie Flood Strategies Submission.

[redacted]

It is clear from the flood plain mapping provided in the Williamtown flood strategy that much of the coastal plain between the sand dunes up to and including properties on either side of Nelson bay Road stretching from Fullerton Cove through to the sand ridge to the north side of Marsh rd. was originally all part of an extensive coastal flood plain zone. The land was cleared and a series of drains constructed creating grazing pasture that supported numerous dairy farms. We have now reached tipping point with the volumes of water now entering an open drainage systems, apart from the main drainage channels they are not well maintained and in some cases cross tributaries are part filled in. Following repeated subdivisions and rezoning's the resulting hard surfaces, roads, driveways and roofs from multiple small development and larger rural residential estates such as Hideaway in Salt Ash have all helped tip the balance. Following a relatively low rainfall winter with exception of the major event in April the water table in the area has never been higher according to residents who have lived in the area for 50 years plus.

Studies carried out as part of the Williamtown aerospace development reported that drainage in the Williamtown Fullerton Cove area had reached capacity. GWH was required to construct extensive holding ponds as part of its development application approval for an aerospace industrial development at Williamtown airport. Other developments have followed some recommended by staff others not supported but approved by Council i.e. McDonalds fast food outlet. Add the twin garages, additional airport car park capacity, hotels and a potential hotel conference centre and they all seriously add to the local and downstream flooding right down to Fullerton Cove. This impact is now seen as a very high water table in locations such as the Bayway residential village where it is creating serious problems with the storm water drainage system, septic and water supply systems.

The gradual upgrade of the Nelson Bay Rd has contributed to localised flooding preventing water from freely moving across the land towards creeks and rivers, the installation of road underpass culverts and pipes has added to localised flooding problems as these points are easily blocked with vegetation siltation and storm flotsam creating a high demand maintenance problem for Council.

Specific drains.

The Moors drain is an example of a local drain which was built back in the 1940's to take storm water from the Williamtown RAAF base to the Tilligerry creek and ultimately into Port Stephens. This has long ago reached its use by date and a physical walk of the system reveals that around two kilometers from the Tilligerry creek, the storm water just breaks the very low bund created by dredged material and spreads out over the land. This is confirmed with recent water testing that finds the chemicals **PFOS/PFOA** originating from the RAAF base now turning up in water located in Salt Ash property dams.

Council needs to prepare a Drainage study and maintenance plan for the Williamtown drainage system.

- Identify the main drain and role in transfer of storm water to major water ways.

- Identify the side/cross tributaries. Those that contribute to drainage and those that have been dug illegally creating problems downstream or on neighboring properties.

- Determine what works are required to ensure the nominated major drains and tributaries retain their functionality.

- Identify all major culverts and pipeline systems particularly those taking storm water from open drainage systems under roads and manmade structures i.e. Infilling development such as the Cove and Palms resorts at Fullerton Cove.

- Prepare a schedule of maintenance works for open drains, budget and resource same.

- Prepare a maintenance servicing plan and budget for culverts drains and pipes.

- Commence the gradual process of planting out main drains with appropriate vegetation that will readily regenerate, tolerate changes in water levels and are known for their capacity to remove phosphates and nitrogen from contaminated water sources. It may be entirely appropriate to engage Land Care and re- vegetation groups to assist in undertaking these works.

Sustainable Management of Open Drainage Systems (Relevant to Medowie and Williamtown Flood strategies).

Council's current program for maintaining open drainage systems is not sustainable and exacerbates the problem of drains that increase turbidity and water contamination. The methodology of herbicide spraying of the sides and drain proper gives an appearance that the drain system is clear but this approach cultivates and promotes woody weed growth and provides little if any mechanism to adsorb nitrogen content and assist in the breaking down of pathogens before they make to drinking water storage or river systems. Mechanical digging of the drains exacerbates bank collapse and silting leading to creasing risk of culvert and pipe system blocking up and transfer of weed seed into difficult locations to clean out plus increasing water turbidity.

NB. As part of this drain assessment project Council should also be cognisant about determining what contributions should/could be made by the Dept. of Defense to maintain drainage system that takes water from RAAF Williamtown to Port Stephens. Pre-cleaning of the water and removal of potential chemical hazards. The timing will never be better to have Defence take some responsibility for their storm water liability.

30 September 2015

The General Manager
Port Stephens Council

Submission: Williamtown-Salt Ash Floodplain Risk Management Study and Draft Plan

Introduction

TRRA Inc. welcomes Port Stephens Council continuing work in undertaking the The Williamtown-Salt Ash Floodplain Risk Management Study and Draft Plan which is now at Stage 4 of a 5 stage process under the guidelines of the Floodplain Development Manual 2005 required by the NSW Office of Environment and Heritage.

Although TRRA Inc. is primarily concerned with the Tomaree Peninsula we have made a number of submissions to Council regarding Development Applications on Rural zoned land for commercial land uses in the vicinity of Nelson Bay Road, Lavis Lane and Cabbage Tree Road intersection as this is the main gateway for residents and tourist entering the Peninsula. In these submissions, apart from raising what we believe to be incorrect zoning issues and adverse economic and visual impacts, we have also raised the issue of the low lying land resulting in potential problems in the short and long term of the effects of flooding. We have also observed numerous examples of Councillors approving DAs for residential developments on ‘filled mounds’ in flood prone areas – often against professional planning advice. This is a matter of concern to all Port Stephens ratepayers, not only because it they appear to be poor decisions, but also because of potential financial liability in the event of flooding,

Although the technical nature of the study is beyond our organisation’s ability to analyse in any great depth, we support the general underlying theme of recognising the impact of Climate Change in terms of both increasing sea level and increased frequency/extent of river flooding. The Study and Plan emphasise the importance of acting now to manage this issue through Strategic Planning. This should help reduce the need for possibly very expensive mitigation works, and/or legal and financial liability, all at ratepayers expense, resulting from short sighted development approvals in areas likely to have medium to long term flooding problems.

Climate Change

The underlying theme of this draft document is that the risk of flooding will increase using the Government and Council endorsed estimates of sea level rise between now and 2050/2100.

The report states:

> 'Low-lying coastal areas, such as those surrounding Fullerton Cove and Tilligerry Creek are at particularly high risk to climate change. The potential for future sea level rise is now expected to be the biggest driver for floodplain management around coastal and estuarine systems such as the Hunter Estuary and Port Stephens. The issue of future sea level rise presents particular challenges to future development, as the risks associated with flooding will progressively increase during the lifetime of the development. It may be such that risks do not manifest until the development is nearing the end of its design life.'

This is an issue many Councils are having to face and TRRA Inc. strongly urges that any pressure from landowners or potential developers (or others arguing about economic consequences) to reduce forecast levels be resisted. We are not aware of any peer reviewed scientific evidence to suggest that the estimates used in this Study are anything other than conservative. The 'Precautionary Principle' supports the recommendations of the report incorporated in the Draft Plan. The issue needs to be addressed and planned for now and not left as an unfunded burden on future generations that will only become more expensive the longer it is ignored.

TRRA Inc, further endorses the report where it states

> 'The property inundation statistics confirms the relatively low flood risk exposure under existing floodplain conditions. However, the results also clearly demonstrate the increasing flood risk across the study area and relative vulnerability of the existing community to potential climate change influence. Accordingly, the floodplain risk management for the catchment is likely to have a focus on climate change adaptation rather than immediate flood protection works'.

Floodplain management measures:

The report lists 11 potential measures, **5 have been rated as a High priority**,

- Hunter River Levee Scheme Review
- **Planning and development controls**
- Improved flood awareness through issue of flood information and community flood emergency response planning
- Update of Local Flood Plans with current design flood information and intelligence.
- Improved flood warning system

TRRA Inc. agrees that these are all of a high priority. Specifically we would like to see the recommendations in the area the second set of measures - *Planning and development controls*, be implemented not only within the Williamtown/Salt Ash flood area but throughout the entire Council area. We note that a similar Medowie Study and Draft Plan has been developed and exhibited in parallel with this one – we have not been able to look at that report, but assume that it makes similar sensible recommendations. We also note that similar issues arise in the Corlette foreshore erosion study that is currently on exhibition.

In the report, *Planning and development controls* are described in the Executive Summary as follows:

> 'Land use planning and development controls are key mechanisms by which Council can manage flood-affected areas within Williamtown-Salt Ash. This will ensure that new development is compatible with the flood risk, and allows for existing problems to be gradually reduced over time through sensible redevelopment. The Plan has recommended the adoption of the established 1% AEP flood level plus 0.5m freeboard as the flood planning level (maintains the existing design flood standard) and a review of current landuse zoning with respect to Floodway areas. It is noted the adopted FPL includes climate change allowance as per current Council policy. The recommendation also provides for adoption of the updated flood risk mapping including flood planning areas and hydraulic and hazard classifications.'

We endorse the recommended measures in this area as high priority.

The report also lists 3 measures rated as a **medium priority**

- Flood proofing of individual buildings (installation of flood gates at commercial centre)
- Investigate voluntary house raising program
- Regional Floodplain Development Strategy incorporating cumulative development flood impact assessment (including long-term strategic planning and climate change adaption specific to the Williamtown-Salt Ash area)

In relation to Strategic Planning, the report says:

> 'Strategic planning – the study investigated a number of potential large scale redevelopment areas within the Port Stephens LGA. **Investigated in isolation, a number of these areas show potential for future redevelopment (including large scale filling/earthworks) with limited impact on existing flood conditions.** However, **a more coordinated flood impact assessment is recommended comprising a full cumulative development assessment with consideration of regional development** opportunities across the Lower Hunter River floodplain incorporating the Port Stephens and Newcastle LGAs. Such an investigation is likely to consider broader regional land use planning and identify future development areas within the floodplain that duly consider overall flood risk and potential impacts under an ultimate development scenario. The outcomes of this cumulative impact assessment would further inform future LEP and DCP amendments (e.g. rezoning, development controls such as fill limitations).' (**our emphasis**)

We submit that the Strategic Planning measure, currently listed as 'medium priority' should be elevated to **high priority**. TRRA Inc. has long been concerned about piece-meal or isolated development approvals, including specifically in the Williamtown and Salt Ash areas, and we strongly urge Council to consider a "full cumulative development assessment" which will have a far greater long term benefit to the community than the relative minor estimated costs of $50K plus staff costs.

[redacted]
Convenor, Planning Committee
Tomaree Ratepayers & Residents Association Inc.

[redacted]

[redacted]

I wish to make a submission to the Williamtown – Salt Ash flood plan.

Our property: [redacted] Nelson Bay Road Salt Ash. We are frequently flooded by water overflowing low section of the levee bank on the Moors Drain. The low section of the levee is behind Sansom Road Williamtown. The Moors Drain flood water floods properties on Sansom Road and Nelson Bay Road Williamtown, then flows towards Salt Ash flooding properties along Nelson Bay Road, Salt Ash. When the flood water enters our property it flows out to Richardson Road. The flood water is then trapped between Moors Drain levee, Richardson Road and Nelson Bay Road.

We were last flooded in April 2015, the flood water laid in our paddocks until the end of August 2015, flooding 100+ acres of our property at a depth of 1.2 metres to 0.3 metre.

Can this low section of the Moors Drain levee be raised to stop the water over flowing?

Attached a goggle map:

- Red Line Our property boundary 2481 and 2501 Nelson Bay Road, Salt Ash.
- Yellow Line Moors Drain and Tilligerry Creek
- Orange Line Direction of flood water from Moors drain flowing into property along Samson Road and Nelson Bay Road Williamtown and property on Nelson Bay Road Salt Ash and out to Richardson Road.
- Blue Line Farm drains on our property.

Appendix D Stage-Damage Curves for Flood Damages

SITE SPECIFIC INFORMATION FOR RESIDENTIAL DAMAGE CURVE DEVELOPMENT

Version 1.00 — Queries to duncan.mcluckie@dipnr.nsw.gov.au

PROJECT	DETAILS	DATE	JOB No.

BUILDINGS

Regional Cost Variation Factor	1.00	*From Rawlinsons*
Post late 2001 adjustments	1.70	*Changes in Avge Weekly Earnings - www.abs.gov.au*
Post Flood Inflation Factor	1.30	*1.0 to 1.5*
Multiply overall structural costs by this factor		*Judgement to be used. Some suggestions below*

	Regional City			Regional Town		
		Houses Affected	Factor		Houses Affected	Factor
Small scale impact	<	50	1.00	<	10	1.00
Medium scale impacts in Regional City		100	1.20		30	1.30
Large scale impacts in Regional City	>	150	1.40	>	50	1.50

Typical Duration of Immersion	24	hours
Building Damage Repair Limitation Factor	0.75	*due to no insurance — short duration flood — long duration flood*
		Suggested range 0.75 to 0.85
Average House Size	240	m^2 — *240 m^2 is Base*
Building Size Adjustment	1.0	
Total Building Adjustment Factor	**1.66**	

CONTENTS

Average Contents Relevant to Site	$ 60,000	*Base for 240 m^2 house $ 60,000*
Post late 2001 adjustments	1.70	*From above*
Contents Damage Repair Limitation Factor	0.85	*due to no insurance — short duration flood — long duration flood*
Sub-Total Adjustment Factor	0.85	*Suggested range 0.75 to 0.85*
Level of Flood Awareness	low	*low or high only. Low default unless otherwise justifiable.*
Effective Warning Time	12	hour
Interpolated DRF adjustment (Awareness/Time)	0.89	
Typical Table/Bench Height (TTBH)	0.90	*0.9m is typical height. If typical is 2 storey house use 2.6m.*
Total Contents Adjustment Factor AFD <= TTBH	**0.76**	
Total Contents Adjustment Factor AFD > TTBH	**0.85**	

Most recent advice from Victorian Rapid Assessment Method

Low level of awareness is expected norm (long term average) any deviation needs to be justified.

Basic contents damages are based upon a DRF of	*0.9*				
Effective Warning time (hours)	*0*	*3*	*6*	*12*	*24*
RAM AIDF Inexperienced (Low awareness)	*0.90*	*0.80*	*0.80*	*0.80*	*0.70*
DRF (ARF/0.9)	*1.00*	*0.89*	*0.89*	*0.89*	*0.78*
RAM AIDF Experienced (High awareness)	*0.80*	*0.80*	*0.60*	*0.40*	*0.40*
DRF (ARF/0.9)	*0.89*	*0.89*	*0.67*	*0.44*	*0.44*
Site Specific DRF (SRF/0.9) for Awareness level for iteration	*1.00*	*0.89*	*0.89*	*0.89*	*0.78*

Effective Warning time (hours)	*12*	*24*	*12*
Site Specific iterations	*0.89*	*0.78*	*0.89*

ADDITIONAL FACTORS

Post late 2001 adjustments	1.70	*From above*
External Damage	$ 6,700	*$6,700 recommended without justification*
Clean Up Costs	$ 4,000	*$4,000 recommended without justification*
Likely Time in Alternate Accommodation	2	weeks
Additional accommodation costs /Loss of Rent	$ 220	*$220 per week recommended without justification*

TWO STOREY HOUSE BUILDING & CONTENTS FACTORS

Up to Second Floor Level, less than	2.6 m	70%	Single Storey Slab on Ground
From Second Storey up, greater than	2.6 m	110%	Single Storey Slab on Ground

Base Curves

AFD = Above Floor Depths

Single Storey Slab on Ground/Low Set	13164	+	4871		x	AFD in metres
Structure with GST	AFD	greater than	0.0	m		
Validity Limits	AFD	less than or equal to			6	m
Single Storey High Set	16586	+	7454		x	AFD
Structure with GST	AFD	greater than	-1.50	m		
Validity Limits	AFD	less than or equal to			6	m
Contents	20000	+	20000		x	AFD
Contents with GST	AFD	greater than			0	
Validity Limits	AFD	less than or equal to			2	

Floodplain Specific Damage/Aftermath Curves

Allowance for Waves 0 m

Steps in Curve 0.1 m

Single Storey Slab on Ground/Low Set

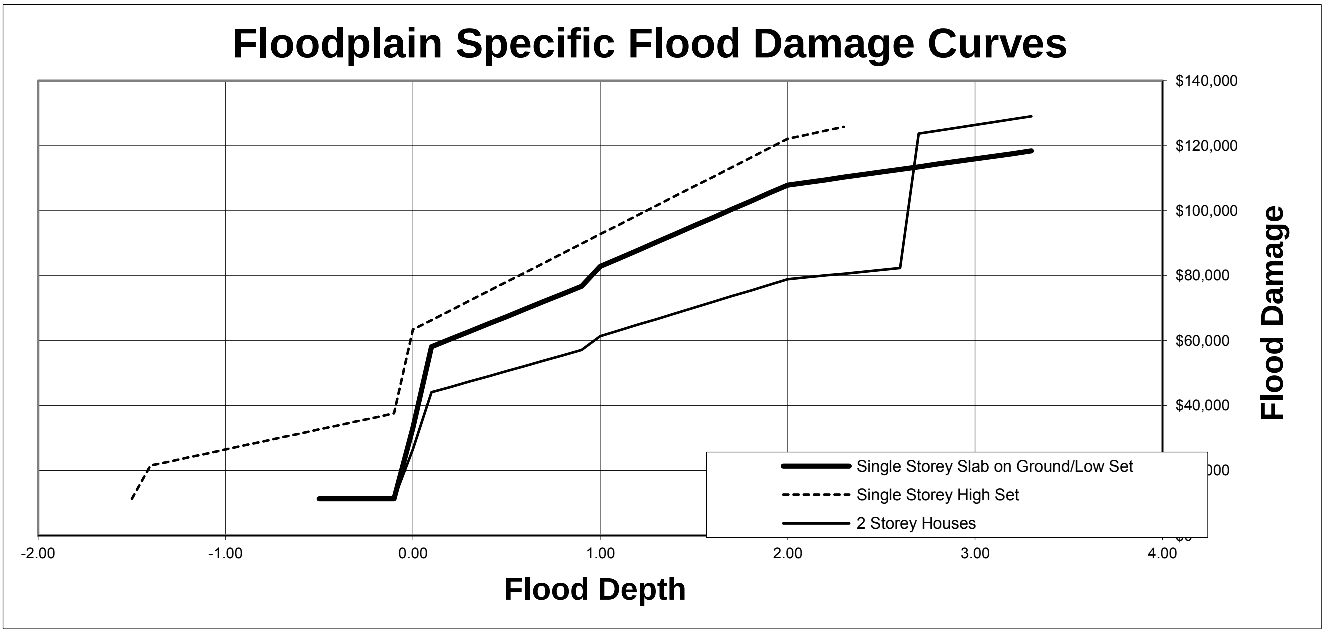
Static AFD	AFD + Wave Action	Damage
-0.50	-0.50	$ 11,390
-0.40	-0.40	$ 11,390
-0.30	-0.30	$ 11,390
-0.20	-0.20	$ 11,390
-0.10	-0.10	$ 11,390
0.00	0.00	$ 33,209
0.10	0.10	$ 58,186
0.20	0.20	$ 60,505
0.30	0.30	$ 62,823
0.40	0.40	$ 65,142
0.50	0.50	$ 67,460
0.60	0.60	$ 69,779
0.70	0.70	$ 72,097
0.80	0.80	$ 74,416
0.90	0.90	$ 76,734
1.00	1.00	$ 82,830
1.10	1.10	$ 85,338
1.20	1.20	$ 87,845
1.30	1.30	$ 90,352
1.40	1.40	$ 92,860
1.50	1.50	$ 95,367
1.60	1.60	$ 97,874
1.70	1.70	$ 100,382
1.80	1.80	$ 102,889
1.90	1.90	$ 105,396
2.00	2.00	$ 107,904
2.10	2.10	$ 108,711
2.20	2.20	$ 109,518
2.30	2.30	$ 110,326
2.40	2.40	$ 111,133
2.50	2.50	$ 111,940
2.60	2.60	$ 112,748
2.70	2.70	$ 113,555
2.80	2.80	$ 114,362
2.90	2.90	$ 115,170
3.00	3.00	$ 115,977
3.10	3.10	$ 116,784
3.20	3.20	$ 117,592
3.30	3.30	$ 118,399

Single Storey High Set

Static AFD	AFD + Wave Action	Damage
-1.50	-1.50	$ 11,390
-1.40	-1.40	$ 21,585
-1.30	-1.30	$ 22,820
-1.20	-1.20	$ 24,056
-1.10	-1.10	$ 25,291
-1.00	-1.00	$ 26,527
-0.90	-0.90	$ 27,762
-0.80	-0.80	$ 28,997
-0.70	-0.70	$ 30,233
-0.60	-0.60	$ 31,468
-0.50	-0.50	$ 32,704
-0.40	-0.40	$ 33,939
-0.30	-0.30	$ 35,175
-0.20	-0.20	$ 36,410
-0.10	-0.10	$ 37,646
0.00	0.00	$ 63,429
0.10	0.10	$ 66,364
0.20	0.20	$ 69,300
0.30	0.30	$ 72,235
0.40	0.40	$ 75,171
0.50	0.50	$ 78,106
0.60	0.60	$ 81,042
0.70	0.70	$ 83,977
0.80	0.80	$ 86,912
0.90	0.90	$ 89,848
1.00	1.00	$ 92,783
1.10	1.10	$ 95,719
1.20	1.20	$ 98,654
1.30	1.30	$ 101,590
1.40	1.40	$ 104,525
1.50	1.50	$ 107,460
1.60	1.60	$ 110,396
1.70	1.70	$ 113,331
1.80	1.80	$ 116,267
1.90	1.90	$ 119,202
2.00	2.00	$ 122,138
2.10	2.10	$ 123,373
2.20	2.20	$ 124,609
2.30	2.30	$ 125,844

2 Storey Houses

Static AFD	AFD + Wave Action	Damage
-0.50	-0.50	$ 11,390
-0.40	-0.40	$ 11,390
-0.30	-0.30	$ 11,390
-0.20	-0.20	$ 11,390
-0.10	-0.10	$ 11,390
0.00	0.00	$ 26,663
0.10	0.10	$ 44,147
0.20	0.20	$ 45,770
0.30	0.30	$ 47,393
0.40	0.40	$ 49,016
0.50	0.50	$ 50,639
0.60	0.60	$ 52,262
0.70	0.70	$ 53,885
0.80	0.80	$ 55,508
0.90	0.90	$ 57,131
1.00	1.00	$ 61,398
1.10	1.10	$ 63,153
1.20	1.20	$ 64,908
1.30	1.30	$ 66,664
1.40	1.40	$ 68,419
1.50	1.50	$ 70,174
1.60	1.60	$ 71,929
1.70	1.70	$ 73,684
1.80	1.80	$ 75,439
1.90	1.90	$ 77,194
2.00	2.00	$ 78,949
2.10	2.10	$ 79,515
2.20	2.20	$ 80,080
2.30	2.30	$ 80,645
2.40	2.40	$ 81,210
2.50	2.50	$ 81,775
2.60	2.60	$ 82,340
2.70	2.70	$ 123,771
2.80	2.80	$ 124,659
2.90	2.90	$ 125,548
3.00	3.00	$ 126,436
3.10	3.10	$ 127,324
3.20	3.20	$ 128,212
3.30	3.30	$ 129,100



Appendix E Cumulative Development Assessment

E.1 Introduction

Section 7.1.8 identified the importance of a strategy to coordinate future development in the Lower Hunter River floodplain in order to manage the potential impacts of cumulative development on flood risk. A number of potential development areas have been identified in consultation with Council. These areas include:

- Cabbage Tree Road – area north of Cabbage Tree Road including local drainage catchment areas (e.g. Dawsons Drain);
- Tomago Road – area adjacent to Tomago Road around Fullerton Cove. There are existing development approvals in this location including the WesTrac Facility and Northbank Enterprise Hub;
- Tomago North – floodplain area to the north of existing industrial development (e.g Tomago Aluminium) at Tomago between Tomago Road and the Pacific Highway; and
- Windeyers Creek - a large proportion of this area lies within the direct backwater influence of the Hunter River.

Large scale filling of the floodplain within these nominal areas has the potential to modify flood behaviour through redistribution of flow and loss in temporary flood storage. The existing models have been applied to assess the relative impact of potential fill scenarios in each of these areas individually (refer Section E2) and the cumulative impact (refer Section E3). Given the focus of the assessment on future planning and development, the relative impacts are considered for the nominal 2100 planning condition incorporating 0.9m sea level rise and flow increase of 20%.

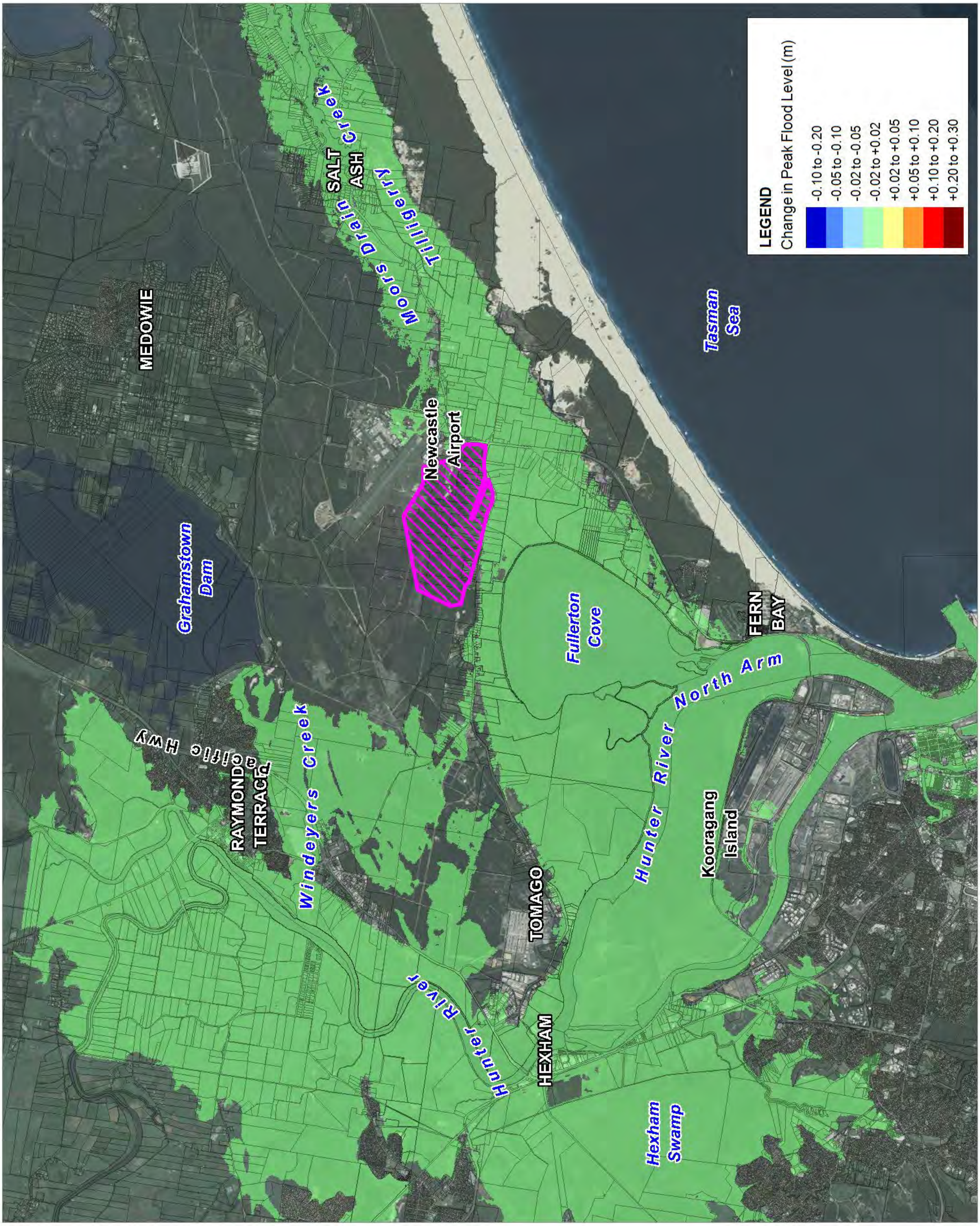
E.2 Individual Development Assessment

Cabbage Tree Road

The area north of Cabbage Tree Road is identified as a potential development area. Located on the northern edge of the Hunter River floodplain at Fullerton Cove, the area is classified as flood storage and is outside the main flow path. No specific development proposal has been incorporated in the assessment. The potential development area considered encompasses the full floodplain extent on the northern side of Cabbage Tree Road.

The assumed development area extent and the resulting change in peak 1% AEP flood level (2100 planning condition) is shown in Figure E-1. Potential filling of the area identified has a limited impact on the simulated peak flood inundation. This limited impact is largely due to the total flood storage volume lost being only a relatively small percentage of the total flood volume conveyed throughout the total floodplain for the event.

The assessment has not considered potential increase in local runoff for new development. However, it is expected that existing development controls would be applied accordingly to manage local stormwater runoff and thereby limit any potential adverse changes to existing flood conditions.



Title:

Peak Flood Level Impact - Cabbage Tree Road Development 1% AEP +0.9m SLR + 20% flow scenario

Figure: **E-1**

Rev: **A**

N

0 2.5 5km

Approx. Scale

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WesTrac Facility and Tomago Industrial Park

Details of the approval for the WesTrac facility and Tomago Industrial Park were presented in Section 0. The approval provides for a multi-staged development. Presently only the Stage 1 works incorporating the WesTrac facility have been constructed to date. For the purpose of the cumulative development assessment the full future development footprint as per the approvals is considered.

The proposed development area extent and the resulting change in peak 1% AEP flood level (2100 planning condition) is shown in Figure E-2. The proposed development provides for local increases in peak flood level of 0.15m. Increases in peak flood level of over 0.02m extend for a distance of some 3 to 4 km upstream of the development. The area impacted is largely floodplain and mangrove area between Tomago and Kooragang Island. Some existing industrial property along Tomago Road may also be impacted.

There is no impact across the broader Hunter River floodplain with effectively no major changes to overall flow distribution apart from the local conditions in the vicinity of the development.

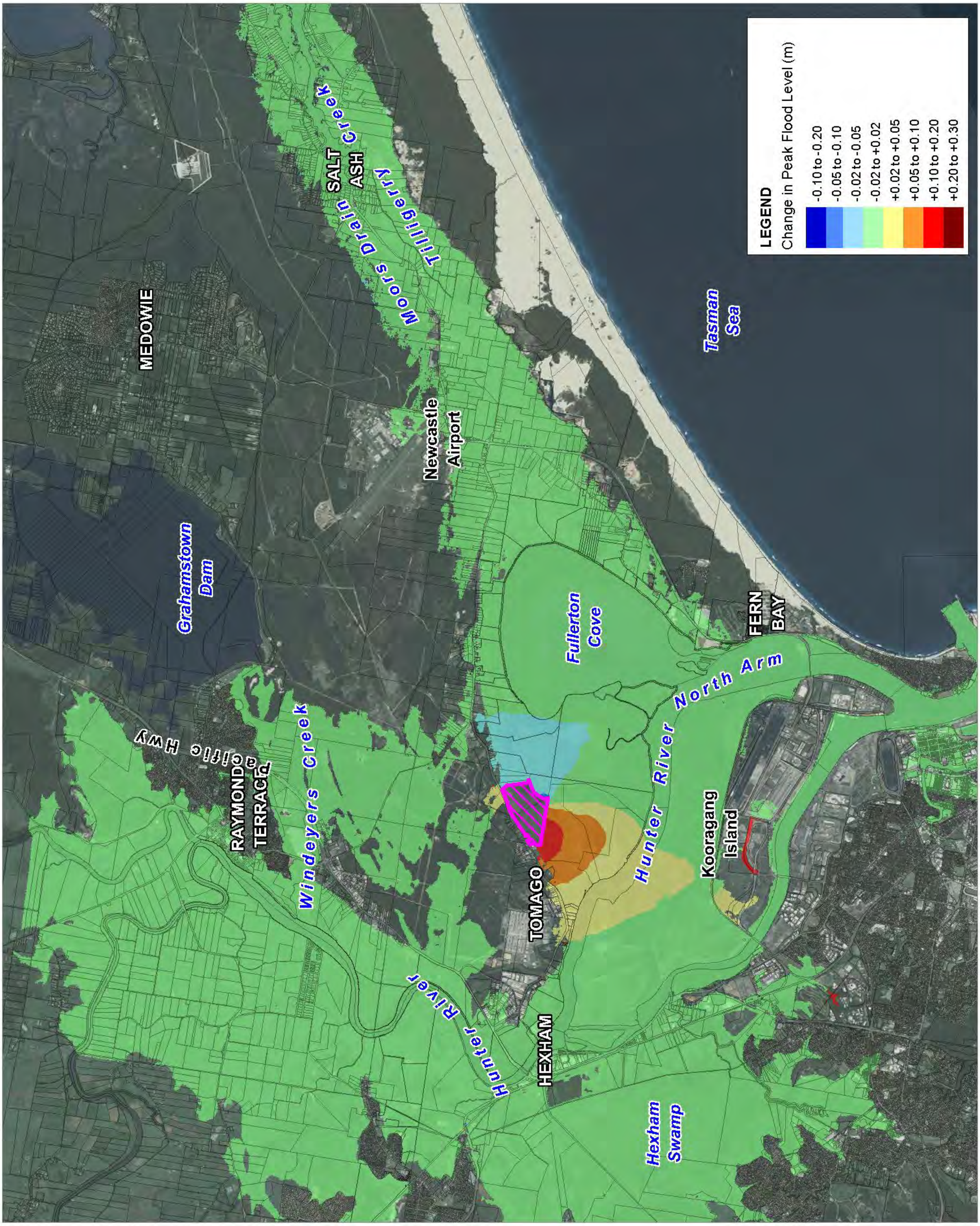
Northbank Entrprise Hub

Details of the approval for the Northbank Enterprise Hub were presented in Section 0. The development application includes a multi-staged development with the existing approval in place for Stage 1. Future stages of the development are subject to further assessment as part of the conditional approval, particularly in regards to flood risk. For the purpose of the cumulative development assessment, the full development footprint as per the development application has been considered. The Northbank assessment also includes the full WestTrac development footprint on the neighbouring lot.

The proposed development area extent and the resulting change in peak 1% AEP flood level (2100 planning condition) is shown in Figure E-3. The proposed development provides for local increases in peak flood level of 0.35m immediately upstream of the development. The full extent of flood level increases for this scenario is significant, with the broader Hexham Swamp storage area subject to an increase of the order of 0.1m, and up to 0.02m increase extending upstream of Raymond Terrace across the full Hunter River floodplain.

The principle reason for the significant area of increase flood affectation is due to the redistribution of flow resulting from the development fill area. The fill footprint is located at a reach of the Hunter River where overbank flows are initiated on the left (northern) floodplain of the North Arm adjacent to Tomago Road. These floodplain flows continue through to Fullerton Cove. The proposed development footprint restricts to some degree the magnitude of flow being able to spill onto the floodplain. The redistribution of flow provides for greater volume of floodwater to be conveyed through the broader Hexham Swamp, providing for the increase in peak flood levels. The restriction of the overbank flow at Tomago effectively provides another “pinch point” on the floodplain, resulting in a backwater influence extending to Raymond Terrace.

The flood level impacts shown in Figure E-3 is greater than assessed during the development approval process. This is due to an increased design flow condition adopted in the current study, being the 20% increase in flow from existing conditions. The higher adopted design flows provides



Title:

Peak Flood Level Impact - WestTrac Development
1% AEP +0.9m SLR + 20% flow scenario

Figure: **E-2**

Rev: **A**

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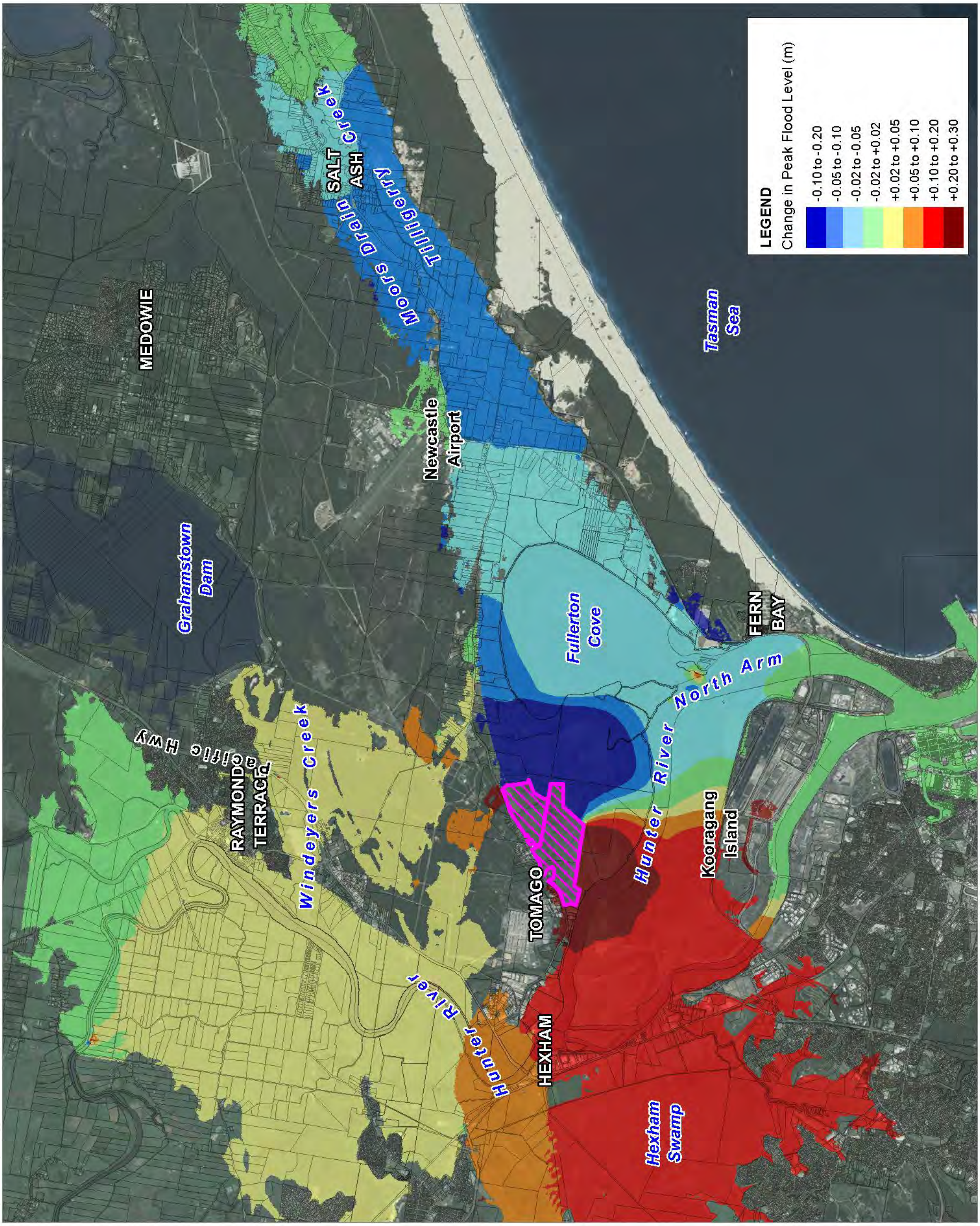

Title:

Peak Flood Level Impact - WestTrac and Northbank Development 1% AEP +0.9m SLR + 20% flow scenario

Figure: **E-3**

Rev: **A**

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 2.5 5km

Approx. Scale

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Filepath : K:\N20209_Williamtown_Salt_Ash_FRMSP\MapInfo\Workspace\Flood_Impact_Future_Development_2100_WesTrac.WOR for a similarly higher magnitude of flow redistributions compared to existing conditions, thereby increasing relative impacts. It is noted that development beyond Stage 1 of the approved Northbank development is subject to future approval with consideration of additional flood impact analysis.

Tomago North

There is low-lying floodplain area to the north of existing industrial development at Tomago. The area largely comprises floodplain inundated by backwater from the Hunter River between the Pacific Highway and Tomago Road. The proposed Hunter Corporate Park development encompasses a proportion of the future development area assessed.

The potential development area extent and the resulting change in peak 1% AEP flood level (2100 planning condition) is shown in Figure E-4. The simulated results show no extensive flood impact from a potential filling of the indicated floodplain area. The impact is limited given the relative magnitude of the flood storage volume lost in comparison to the total volume of floodwater conveyed through the floodplain for the event.

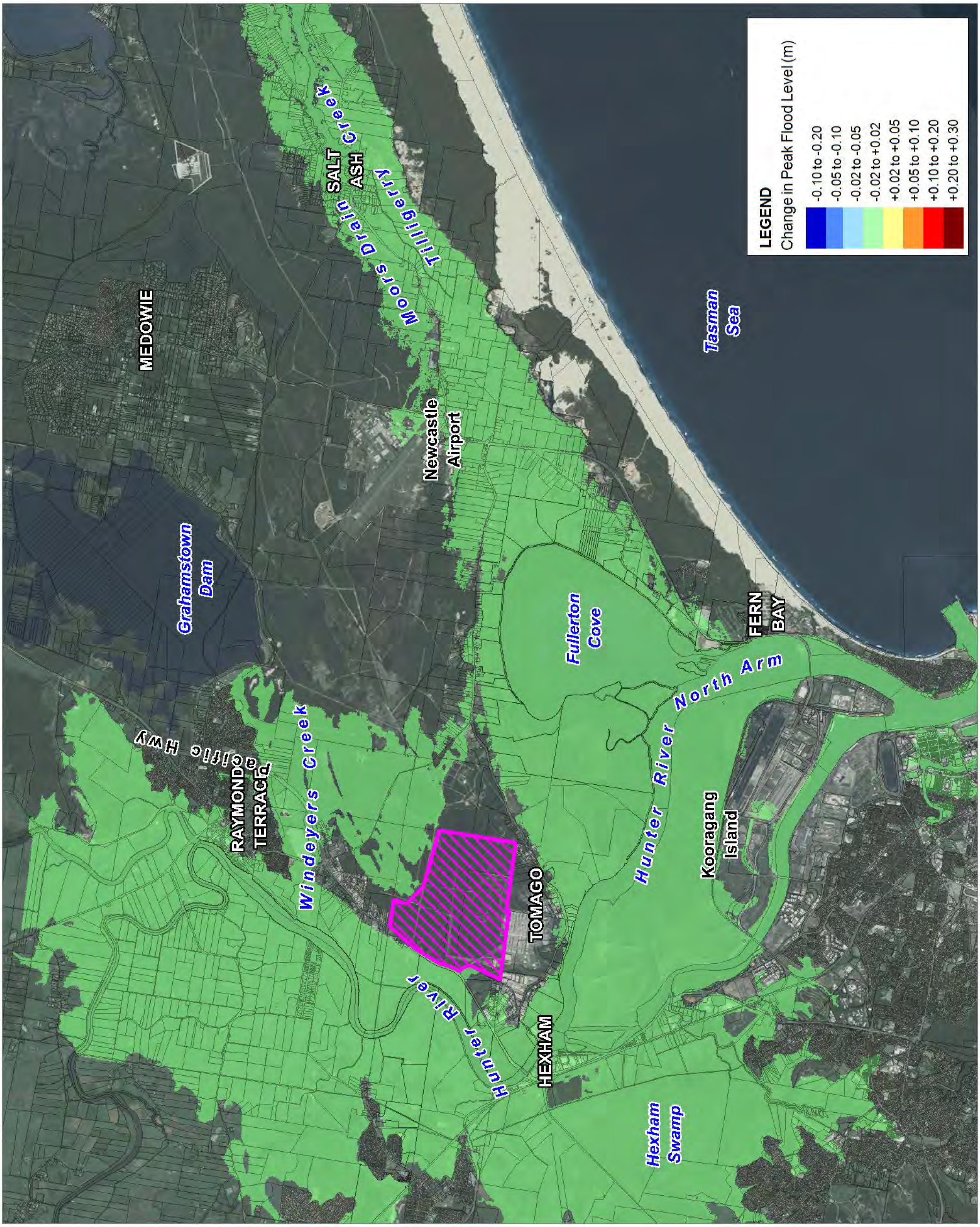
It is noted however, that there are peak flood level increases of the order of 1 to 1.5cm across the broader Hunter River floodplain adjacent to the nominal development area as a result of the loss in storage. Whilst the absolute magnitude of the increase is relatively small, development of this nature is a good example of the significance of incremental development impacts and contribution to cumulative impact of multiple floodplain developments.

Windeyers Creek

Similar to the Tomago North area discussed above, the floodplain area of the Windeyers Creek catchment provides for significant flood storage for Hunter River flooding. Peak flood levels in the Windeyers Creek floodplain are driven by the peak flood levels in the Hunter River. It is understood there are existing development proposals (e.g. Kinross Estate) within this area of the floodplain. The future development assessment has considered potential development across a broad floodplain area classified as a flood storage south of the Pacific Highway. The current development assessment however considers a larger potential development area.

The potential development area extent and the resulting change in peak 1% AEP flood level (2100 planning condition) is shown in Figure E-5. The simulated results provide an increase in peak flood level of 0.08m locally within the Windeyers Creek floodplain. The flood level impact reduces to some 0.06m in the broader Hunter River floodplain adjacent to the Windeyers Creek confluence, but still covers a large area extending between Hexham and Raymond Terrace. A similar broad impact is noted across Hexham Swamp, with peak flood level increase between 0.04-0.05m.

Both the magnitude and extent of the simulated impact indicates significant loss in floodplain storage within the assumed development footprint. Accordingly, the attenuative effect of this storage is lost, thereby providing for increased flows through the adjacent floodplain and a larger flow volumes redistributed to areas such as Hexham Swamp.



Title:

Peak Flood Level Impact - Tomago North Development
1% AEP +0.9m SLR + 20% flow scenario

Figure: **E-4**

Rev: **A**

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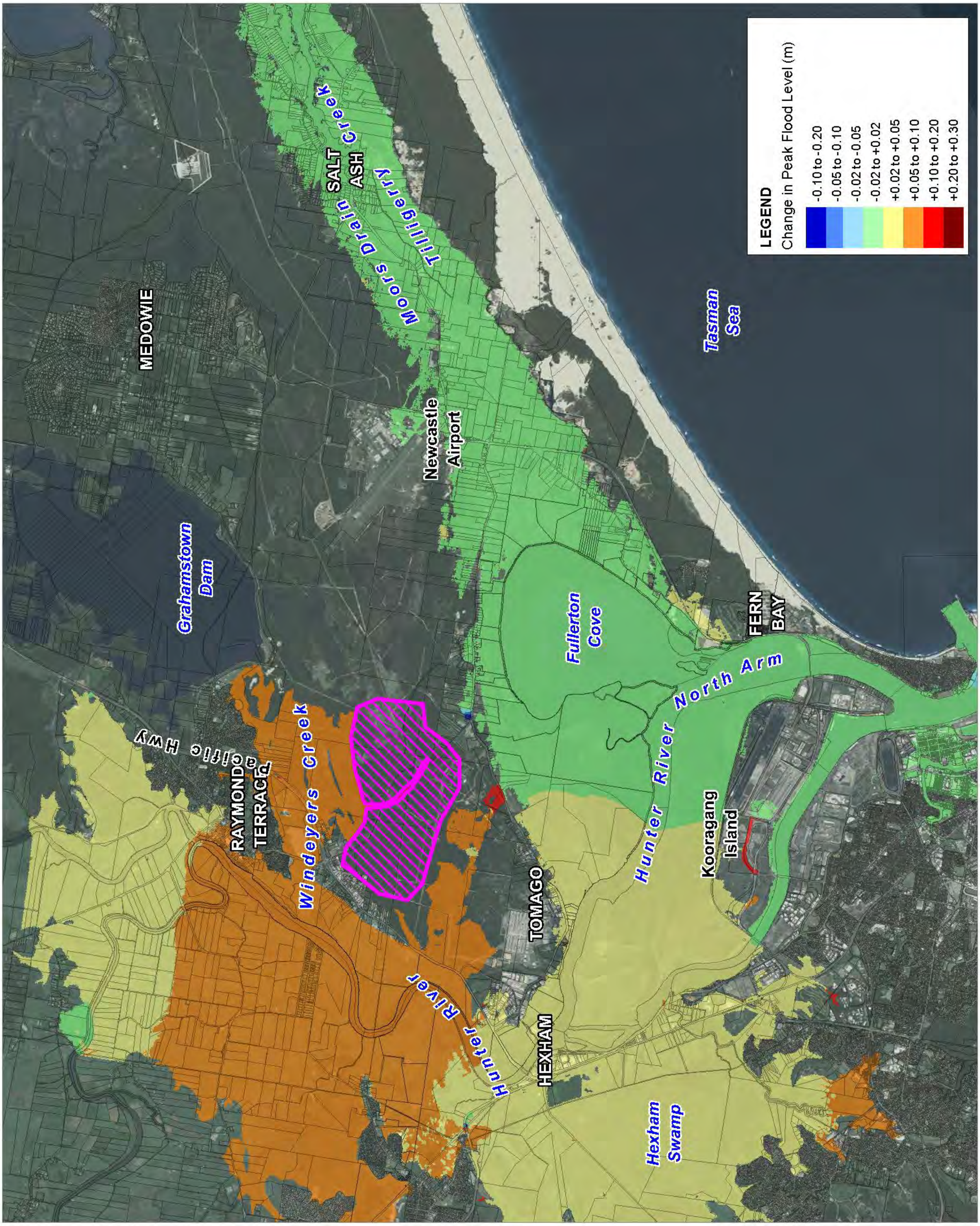

Title:

Peak Flood Level Impact - Windeyers Creek Development 1% AEP +0.9m SLR + 20% flow scenario

Figure: E-5

Rev: A

N

0 2.5 5km

Approx. Scale

BMT WBM

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Filepath : K:\N20209_Williamtown_Salt_Ash_FRMSP\MapInfo\Workspace\Flood_Impact_Future_Development_2100_Windeyers.WOR

E.3 Cumulative Development Assessment

The previous analysis provided an overview of the relative impact of individual developments. The location and scale of the development footprint in relation to the existing flood inundation extents has a significant influence on overall flood impact. A cumulative impact assessment has been undertaken to demonstrate the combined flood impact of potential development.

Figure E-6 shows the cumulative development flood impact as change in peak 1% AEP flood level (2100 planning condition). Each of the development footprints assessed individually in the previous section has been incorporated in the simulation. The peak flood level impact exceeds 0.1m across a large area of the floodplain. This impact effectively extends across the entire floodplain between Raymond Terrace and Kooragang Island, including Hexham Swamp.

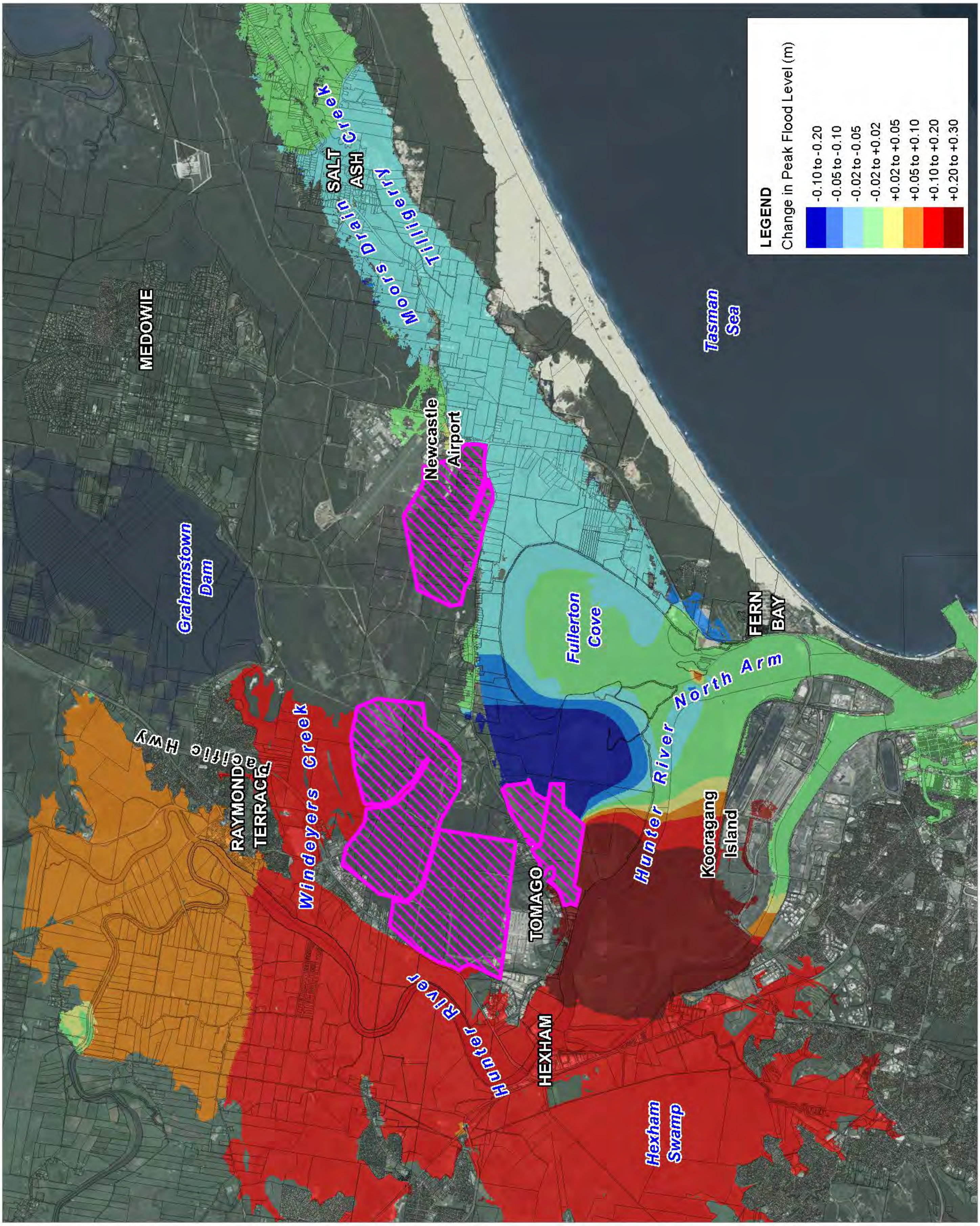
The extensive flood impact is realised through a combination of loss in flood storage and redistribution of flow associated with encroachment of the development footprints into convective flow areas.

The cumulative development scenario shown in Figure E-6 considers only development within the Port Stephens LGA. However, there is potential for development of similar sites within the floodplain within other local government areas. A significant proportion of the Lower Hunter floodplain lies within the Newcastle LGA, however, it is understood there is no existing overarching strategy for future development within this area. A large proportion of the floodplain area encompasses the broader Hexham Swamp. There may be opportunities for some filling around the fringes of the Swamp, however, for the current assessment no major development areas have been considered. There is existing industrial development along the Pacific Highway at Hexham. The cumulative development assessment has considered potential further industrial development on similarly zoned lots along the highway.

Figure E-7 shows a second cumulative development scenario incorporating additional industrial development along the Pacific Highway at Hexham. Some additional industrial development is also included along Tomago Road. As per the other development areas considered, the ground elevations within the fill footprints have been raised above the 2100 planning condition flood levels.

Figure E-7 shows the cumulative development flood impact as change in peak 1% AEP flood level (2100 planning condition). The general pattern of change in the peak flood level distribution is similar to the scenario shown in Figure E-6, albeit with a greater magnitude and extent of impact. Peak flood levels across to Kooragang Island and within Hexham Swamp increased in the order of 0.2-0.3m. The extent of peak flood increase in excess of 0.1m has also extended upstream of Raymond Terrace.

The cumulative development impacts represent significantly greater impacts compared to those provided by the individual developments. The principal area affected by increases in peak flood levels are upstream of the developments at Tomago and Hexham. In the Williamtown-Salt Ash locality, the simulated results show some minor reductions in peak flood levels. This can be attributed to the lower flood volumes spilling over Nelson Bay Road. This is a result of the broader redistribution of flow towards Hexham Swamp as a result of the development footprints, and the corresponding attenuation of flow to the downstream are of Williamtown-Salt Ash.



Title:
Peak Flood Level Impact - Combined Development 1% AEP +0.9m SLR + 20% flow scenario

Figure: E-6

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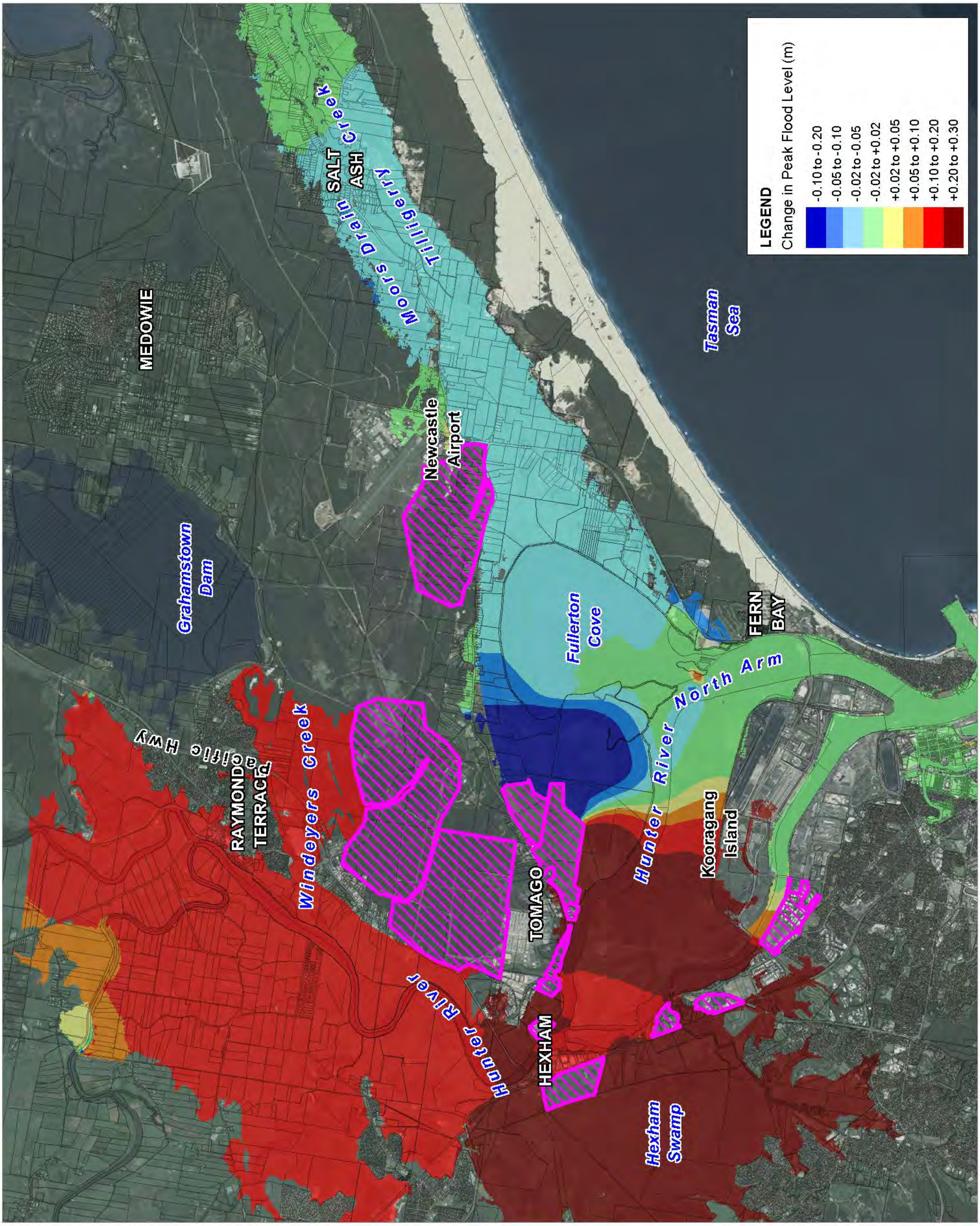

Title:

Peak Flood Level Impact - Combined Development 1% AEP +0.9m SLR + 20% flow scenario

Figure: E-7

Rev: A

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0 2.5 5km

Approx. Scale

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E.4 Summary

As previously noted, it is not the intention of the cumulative impact analysis to demonstrate the appropriateness or otherwise of individual land development areas. The analysis has identified broad areas of potential development (some areas with existing approvals) and determined the relative impact of these developments on peak flood conditions for the 2100 planning scenario. In the least, the analysis has identified the potential development areas that provide the most sensitivity in terms of increases in peak flood levels.

Notwithstanding the above, some lesser development potential may be realised in all of the locations in order to limit flood impacts. However, from a cumulative impact perspective, it is expected an appropriate regional development strategy should be established to guide the cumulative floodplain development.

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