Murrumbidgee COUNCIL

Darlington Point

Draft Floodplain Risk Management Study & Plan

Volume 1 of 2: Report Text & Appendices

February 2021

Catchment Simulation Solutions

Darlington Point
Floodplain Risk Management Study & Plan
Draft

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1 INTRODUCTION

1.1 Background

The township of Darlington Point is located on the floodplain of the Murrumbidgee River in western NSW. The township is divided by the Murrumbidgee River into north Darlington Point and Darlington Point. At the 2016 census, there were 1,162 people residing in Darlington Point.

Darlington Point is located within the Murrumbidgee Local Government Area. Murrumbidgee Council was established in 2016 when the previous local government areas of Murrumbidgee Shire Council and Jerilderie Shire Council were amalgamated. Approximately 4,065 people live within the local government area of 3,508 square kilometres.

The Murrumbidgee River catchment upstream of Darlington Point covers an area of approximately 32,000 square kilometres. The Darlington Point and Environs Flood Study was completed in 2018 and covered an area of 204 square kilometres. This floodplain risk management study and plan will cover a study area of approximately 204 square kilometres, extending along an approximate length of 45 kilometre of the Murrumbidgee River adjacent to Darlington Point.

The extent of the study area considered in this floodplain risk management study and plan is indicated on **Figure 1**.

Darlington Point is subject to both riverine and major overland flow flooding. Flooding of the Murrumbidgee River at Darlington Point has occurred on a number of occasions in the past, most notably in 1891, 1956, 1974 2010, 2012 and 2016.

The part of the township on the southern floodplain is protected from riverine flooding by an existing levee that has been recently upgraded. These upgrade works were expected to provide a levee that would cater for a 1 in 100 year flood plus 1 metre freeboard (Worley Parsons, 2009). However, there is no levee protecting north Darlington Point from riverine flooding.

The southern township within the levee is prone to overland flow flooding when elevated Murrumbidgee River water levels can prevent local runoff from draining through the levee system and into the river.

In recognition of the flood risks to Darlington Point, Murrumbidgee Council completed the *'Darlington Point and Environs Flood Study'* (BMT) in 2018. The flood study defines the nature and extent of flooding due to the Murrumbidgee River, as well as overland flooding behind the levee due to local rainfall. It provides information on design flood discharges, levels, depths and velocities, as well as hydraulic and flood hazard categories for a range of design flood events.

The flood study also defined a preliminary flood planning level and flood damages for the study area. The study estimated that with the upgraded levee works complete, 26 properties would be inundated above floor level in a 1% AEP design flood event, with 328 properties estimated to be impacted in an extreme flood event.

Murrumbidgee Council subsequently engaged Catchment Simulation Solutions to prepare a Floodplain Risk Management Study and Plan for the Murrumbidgee River at Darlington Point. The overall goal of the Floodplain Risk Management Study and Plan is to evaluate a range of potential flood risk reduction options culminating in a preferred set of options that can be implemented to best manage the flood risk across the Darlington Point area.

1.2 The Floodplain Risk Management Process

The '*Darlington Point Floodplain Risk Management Study and Plan'* has been prepared in accordance with the requirements of the NSW Government's '*Floodplain Development Manual' (NSW Government, 2005).* The '*Floodplain Development Manual'* guides the implementation of the State Government's *Flood Policy*. The *Flood Policy* is directed towards providing solutions to 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. The Policy is defined in the NSW Government's '*Floodplain Development Manual' (NSW Government, 2005)*.

Under the Policy, the management of flood liable land remains the responsibility of Local Government. However, the State Government subsidiNSW SES flood mitigation works to alleviate existing problems and provides specialist technical advice to assist Local Government in its floodplain management responsibilities.

The Policy provides for technical and financial support by the State Government through the floodplain risk management process which is outlined on the following page.

Stages 1 and 2 of this process were completed as part of the *'Murrumbidgee River at Darlington Point and Environs Flood Study'* (BMT, 2018). The current study represents stages 3 and 4 of the floodplain risk management process and will build upon the work that was previously completed as part of the 2018 Flood Study. This will include reviewing the previous study to ensure it provides the best possible representation of the existing flooding problem in the catchment. It will also identify, assess and compare various options for managing the flood risk across the catchment, culminating in the preparation of the Darlington Point Floodplain Risk Management Plan. The Floodplain Risk Management Plan draws on the outcomes of the Study and provides a preferred set of options that will outline how to best manage the existing, future and continuing flood risk from the Murrumbidgee River and local flooding at Darlington Point, North Darlington Point and surrounding areas.

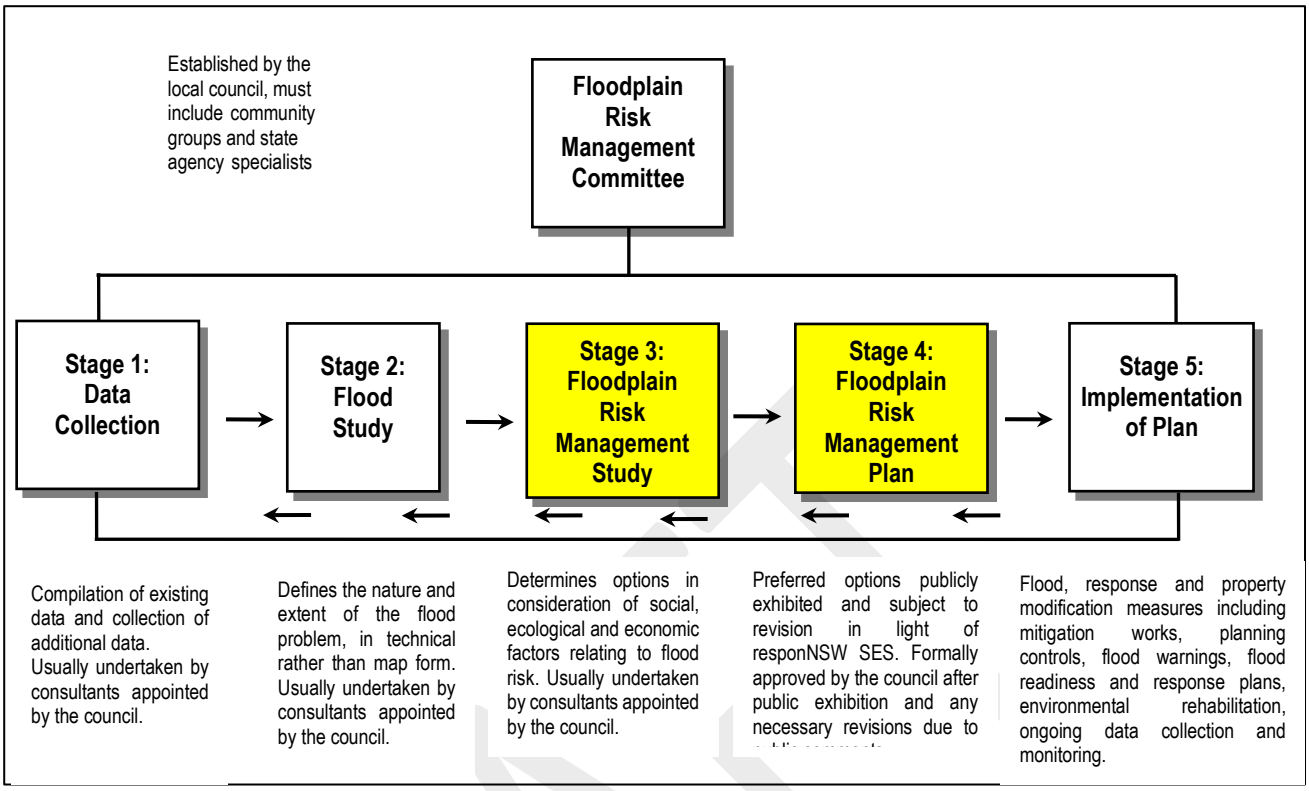


Plate 1 - NSW Floodplain Risk Management Process (NSW Government, 2005)

1.3 Report Structure

The following report forms the Darlington Point Floodplain Risk Management Study and Plan. It has been divided into the following sections:

- Section 2 - Catchment Information: Provides general information on the catchment including available flooding information, potential constraints, key facilities and the makeup of the local community.
- Section 3 – Consultation: Sumarises the consultation that was completed with key stakeholders and the community and the outcomes of this consultation.
- Section 4 – The Existing Flood Risk: Describes the current flood behaviour in the catchment, from both mainstream flooding associated with the Murrumbidgee River, and local flooding behind the levee. This section provides information on the updates undertaken to the flood study model, and the resultant floodwater levels and depths, hydraulic categorisation and hazard categories defined in the study area. A freeboard analysis of the upgraded levee has been undertaken. This section also includes discussion on a spillway analysis, future development and the flood planning area for the study area.
- Section 5 – Impacts of Flooding in the Community: Describes the current impact of flooding on the community for a range of different floods. This includes an assessment of the potential cost of flooding as well as the potential for floodwater to damage buildings and/or pose a danger to personal safety, the impact of flooding on transportation links and vulnerable and critical infrastructure.

- Section 6 – Existing Planning Information: Describes existing national, state and local planning regulations associated with flood related development controls in the study area.
- Section 7 – Existing Emergency Management Protocols: Provides an overview of emergency management measures that are currently implemented across the study area.
- Section 8 – Options for Managing the Flood Risk: Provides an overview of potential options to manage the flood risk, and the options assessment approach undertaken in this study.
- Sections 9 to 11: Discusses the merits of a range of flood, property and response modification measures that could be potentially implemented to manage the existing, future and continuing flood risk across the catchment
- Sections 12: Provides a summary of the options recommended in Section 9 to 11 and discussion and proposes a draft floodplain risk management plan.

The report comprises two volumes:

- Volume 1 (this document): contains the report text and appendices
- Volume 2: contains all figures and maps that supplement the Volume 1 report

2 CATCHMENT INFORMATION

2.1 Overview

The following chapter provides a summary of relevant information for the Murrumbidgee catchment at Darlington Point. This includes a description of the catchment, the makeup of the local community, critical and vulnerable facilities as well as an overview of previous flooding investigations.

2.2 Flooding History

Darlington Point is subject to both riverine and major overland flow flooding. Flooding of the Murrumbidgee River at Darlington Point has occurred on a number of occasions in the past, most notably in 1891, 1956, 1974, 2010, 2012 and 2016.

Darlington Point is protected from riverine flooding by an existing levee. North Darlington Point, the area on the northern banks of the Murrumbidgee, is not protected by a levee. The areas of Darlington Point within the levee are prone to overland flow flooding when elevated Murrumbidgee River water levels can prevent local runoff from draining through the levee system and into the river.

2.3 Catchment Description

Darlington Point is located on the Murrumbidgee River in the Riverina district, and falls within the Murrumbidgee Council local government area. The township is divided into North Darlington Point, which is located on the northern banks of the Murrumbidgee River, and Darlington Point, which is located on the southern side of the Murrumbidgee River. The catchment of the Murrumbidgee River to Darlington Point is approximately 32,000 square kilometres.

The Murrumbidgee River has its headwaters in the Snowy Mountains at an elevation of 1,560 metres. It travels westwards through Wagga Wagga and Narrandera before travelling through Darlington Point where the elevations range from 140 to 100 mAHD. It continues to travel in a westerly direction for 250 kilometres, before it merges with the Murray River at the NSW Victorian border. The floodplain from the upper catchment to Narrandera is generally confined and well defined, downstream of Narrandera the floodplain is broad and flat, with numerous flood runners becoming active at different water level elevations across the floodplain. The change in grades throughout the study area are evident in **Figure 2,** which includes the digital elevation model (DEM) to be used in this study.

Darlington Point is protected by a levee that extends around the whole town. Levee upgrade works were in the final stages of being upgraded at the commencement of this study, with the levee upgrade completed as the draft floodplain risk management study and plan were prepared during 2020. Most of the length of the levee is an earthen levee with a clay core with

gently sloping embankments. There is a small section immediately adjacent to the Murrumbidgee River constructed from rock, with near vertical sides.

A range of datasets have been used to define the topography for this study, as indicated on **Figure 3**. The study area focuses on the areas of the more populated areas of Darlington Point, north Darlington Point, and the areas immediately around these two settlements. Flood emergency management considered in this study will consider all of the access roads into these settlements.

The catchment has generally been cleared for agricultural activities, with areas of vegetation primarily along the waterways. There are small patches of remnant native vegetation scattered throughout the catchment. The township of Darlington Point and north Darlington Point generally contain low density residential development, with some commercial development scattered throughout these areas.

The Murrumbidgee River is a regulated river, which means its flows are regulated by a series of dams and weirs along its length for irrigation and water supply purposes . Several dams have been constructed along the upper sections of the Murrumbidgee catchment, including Burrinjuck Dam near Yass and Blowering Dam upstream of Gundagai on the Tumut River tributary. Both dams were constructed for water supply, flood mitigation and agricultural supply purposes , and can influence flood behaviour at Darlington Point.

Burrinjuck Dam was constructed between 1907 and 1928 and been upgraded twice since then, in 1957 and 1994. It currently has an estimated capacity of 1,026,000ML. Blowering Dam was constructed between 1964 and 1968 and was upgraded in 2010. It has an estimated capacity of 1,628,000ML. Water NSW controls releaNSW SES from both of these dams into the Murrumbidgee River for water supply purposes .

Two irrigation areas operate within the catchment around Darlington Point. The Murrumbidgee Irrigation Area (MIA) extends from Narrandera to the east of Darlington Point, to approximately 110 kilometres west of Darlington Point, to the confluence of Mirrool Creek and the Lachlan River north of the township of Hay. The Coleambally Irrigation District/Area (CID or CIA) operates between Darlington Point and Jerilderie to the south. The main supply offtake for the MIA is at Gogeldrie Weir, approximately 50 kilometres upstream of Darlington Point. At the time of writing, there were preliminary plans for changes to the CID offtake attributes for the Coleambally CIA. Although these irrigation schemes influence the supply of water in the Murrumbidgee River during normal environmental conditions, they will not influence floodwaters of the Murrumbidgee during higher flow conditions.

There are a number of water level and rainfall gauges throughout the catchment, and in close proximity to the study area, as indicated on **Figure 4.** The owners of these gauges vary between the NSW Department of Planning, Industry and Environment and the Bureau of Meteorology.

2.4 Land USES

2.4.1 Existing Land Use

Figure 5 shows the existing land zoning information for the study area based upon information contained in the Murrumbidgee Local Environmental Plan (LEP) 2013.

The majority of the land within Darlington Point and North Darlington Point is zoned RU5 – Village, with scattered areas of RE1 – Public Recreation. There are areas of E3 – Environmental Management in Darlington Point immediately adjacent to the levee.

North Darlington Point is surrounded by land zoned RU1 – Primary Production, with the heavily vegetated areas between North Darlington Point and Murrumbidgee River zoned E1- National Parks and Nature Reserves. Darlington Point is surrounded by land zoned RU1 – Primary Production with a small section zoned E1- National Parks and Nature Reserves. The areas adjacent to the junction of Kidman Way and the Sturt Highway are zoned RU5 – Village and R5 – Large Lot Residential.

The Murrumbidgee Waterway area is zoned as W2 – Recreational Waterways, and the Kidman Way zoned as SP2- Infrastructure. The wastewater treatment plant, located within the boundary of the upgraded levee, falls within the RU1 Primary Production zoning.

The primary focus of this floodplain risk management study and plan is to assess floodplain risk management options to help manage the flood risk to the residents within the more urban areas of Darlington Point and North Darlington Point where the land is primarily zoned as RU5- Village and E3 – Environmental Management.

The remainder of the land around the study area is primarily composed of land zoned RU1 – Primary Production and areas zoned E1- National Parks and Nature Reserves, except for the developed towns and villages that are zoned more appropriately as urban areas.

2.4.2 Potential Future Development

Murrumbidgee Local Government Area (LGA) is located in one of the prime agricultural regions of NSW. Darlington Point is one of the more urban areas servicing these agricultural activities. There is a small area with some commercial developments in Darlington Point itself, however there is no major commercial or business area within the study area. As such, there is not anticipated to be a substantial increase in development in the Darlington Point area at any time in the future.

Notwithstanding this, Council is intending to rezone land within the upgraded levee area in the western section of Darlington Point to facilitate additional residential development. The details of this planning proposal are not known at this time, however it is assumed that the area will be rezoned from RU1 Primary Production to R5 – Village, as per the other existing residential areas in Darlington Point. Further comments are provided on this potential future development in **Section 6.3.4.**

2.4.3 Critical and Vulnerable Facilities

The catchment includes some current land uses that may be particularly vulnerable to the impacts of flooding (i.e., vulnerable facilities) as well as facilities that may play an important emergency response role during floods (i.e., critical facilities). The location of vulnerable and critical facilities/land uses are shown in **Figure 8**. These facilities are also summarised in **Table 1** below.

Table 1 Summary of critical and vulnerable developments in study area

ID on Figure 10	Description	Address
1	Darlington Point Public School	Hay Rd, Darlington Point
2	Saint Pauls Anglican Church	38 Carrington Street, Darlington Point
3	Darlington Point Church	2 Hay Road, Darlington Point
4	Darlington Point Riverside Caravan Park	Kidman Way, Darlington Point
5	Wastewater Treatment Plant	Boyd Street, Darlington Point
6	Murrumbidgee Council	21 Carrington St, Darlington Point
7	Petrol station	22 Carrington St, Darlington Point

The Altina wildlife Park is at the outer extent of the study area, however, has been included in this study, primarily for emergency management considerations. It is located approximately 10 kilometres west of Darlington Point, and approximately 8 kilometres east of the junction of the Sturt Highway and The Kidman Way.

Altina Wildlife Park borders the Murrumbidgee River. It is a wildlife zoo that houses a range of exotic species, including lions, antelopes, American Alligators, American Bison, giraffe, zebras and rhinoceros.

2.5 Local Environment

The study area contains a number of Aboriginal cultural and heritage items and are included on **Figure 6.**

2.5.1 Local Heritage Sites

There are a number of heritage items listed in the Environmental Planning Instrument (EPI) of the Murrumbidgee LEP 2010 as shown in **Figure 6** and listed in **Table 2**.

Table 2 Summary of heritage and archaeological items Listed by Murrumbidgee LEP 2013

ID on Figure 8	LEP Heritage Item Number	Address	Description
1 and 3	*I1*	23 Carrington Street and 6 Punt Road, Darlington Point	Court House (former)
2	-	Darlington Street, Darlington Point	Darlington Point Museum

The potential for implementation of structural mitigation options in areas with heritage items listing will need to consider the effect of the proposed measure on the heritage significance

of the item or area and comply with the Council's development consent conditions for heritage items.

2.5.2 Aboriginal Heritage

There are number of Aboriginal Cultural heritage sites within the study area, as indicated on **Figure 6** as well as listed in

Table 3**.** As shown in **Figure 6**, a lot of these sites are located within or adjacent to waterway or vegetated areas.

A number of Aboriginal Cultural heritage sites and items were identified during the preparation of the REF for the Darlington Point Pont Levee Realignment Report (2015). This included site specific review for the areas of that development, which have also been included on **Figure 6,** which are in addition to those listed in Councils' LEP**.**

Aboriginal Cultural heritage sites shown on **Figure 6** include both Carved or Scarred Tree and /or Artefacts. Schedule 5 of Murrumbidgee LEP also lists Heritage Items and Archaeological sites, which include items of Aboriginal significance and discussed in **Section 2.5.4.**

The declaration of an Aboriginal Place does not change the status of or affect ownership rights for the land. However, a declared Aboriginal Place must not be modified, harmed or desecrated without an Aboriginal Heritage Impact Permit issued under the *NSW National Parks and Wildlife Act 1974*. Accordingly, any potential mitigation options in the vicinity of an Aboriginal Heritage location would be subject to these same restrictions.

2.5.3 NSW State Heritage Sites

There is one site within the general vicinity of Darlington Point that is listed under the NSW Heritage Act 1977 however it is at the outer bounds of the study area under consideration for floodplain risk management options as part of this study. This State Heritage Item is the Warrangesda Aboriginal Mission and Station (SHR Item No 01810) on the Kidman Way, which is also located with the bounds of the Environment Heritage - Archaeological site discussed below.

Table 3 Summary of Aboriginal Cultural Heritage items in study area

Site ID	Site name	Item name or number on Figure 8	Address	Site Features
49-4-0017	Possum Tree;Warangesda;	Possum Tree;Warangesda;	Hay Road, Darlington Point	Modified tree (Carved or scarred)
49-5-0065	Kooba;MSC;	Kooba;MSC;	8607 Kidman Way, North Darlington Point	Modified tree (Carved or scarred)
49-5-0076	Kooba 111;	Kooba 111;	Kidman Way, North Darlington Point	Modified tree (Carved or scarred)
49-4-0005	Darlington Pt;Swimming Pool Site;	Darlington Pt;Swimming Pool Site;	Carrington Street, Darlington Point	Modified tree (Carved or scarred)
49-4-0006	Benerembah Canoes;T.S.R.;	Benerembah Canoes;T.S.R.;	Britts Road, Darlington Point	Modified tree (Carved or scarred)
49-4-0009	Waddi;Darlington Point;	Waddi;Darlington Point;	Hay Road, Darlington Point	Modified tree (Carved or scarred)
49-4-0010	Kooba;M.S.C.;Darlington Point;	Kooba;M.S.C.;Darlington Point;	8607 Kidman Way, North Darlington Point	Modified tree (Carved or scarred)
49-4-0011	Kooba;Kooba Station;	Kooba;Kooba Station;	8607 Kidman Way, North Darlington Point	Modified tree (Carved or scarred)
49-4-0064	Darlington Point Public School	Darlington Point Public School	Hay Road, Darlington Point	Modified tree (Carved or scarred)
49-4-0068	Darlington Point STP-2	Darlington Point STP-2	Hay Road, Darlington Point	Modified tree (Carved or scarred)
49-5-0104	Darlington Point STP-3	Darlington Point STP-3	Punt Road, Darlington Point	Modified tree (Carved or scarred)
49-5-0019	Darlington Point, Waddi	Darlington Point, Waddi	Punt Road, Darlington Point	Ceremonial Ring (stone or Earth)
49-4-0067	Darlington Point STP-1	Darlington Point STP-1	Hay Road, Darlington Point	Modified tree (Carved or scarred)
49-4-0066	DARLING POINT STP - 1 similar to 49-4-0067	DARLING POINT STP - 1 similar to 49-4-0067	Hay Road, Darlington Point	Modified tree (Carved or scarred)
49-4-0070	DPCOS-ST1	DPCOS-ST1	north-west of updated levee alignment	Modified tree (Carved or scarred)

Site ID	Site name	Item name or number on Figure 8	Address	Site Features
49-4-0069	DPCOS IF01	DPCOS IF01	north-west of updated levee alignment - may not be present any longer	Lithic flake with retouch
49-4-0072	DPCOS-OS1 with PAD	DPCOS-OS1 with PAD	north-west of updated levee alignment - may not be present any longer	Artefact Scatter with Ground Cover
49-4-0075	Darlington Point Common 1	Darlington Point Common 1	Murrumbidgee Regional Park	Modified tree (Carved or scarred)
49-4-0076	Darlington Point Common	Darlington Point Common	Murrumbidgee Regional Park	Modified tree (Carved or scarred)
49-4-0080	Crown Land Darlington Point 1	Crown Land Darlington Point 1	Hay Road, Darlington Point	Modified tree (Carved or scarred)
49-4-0081	UriCrown Land Darlington Point 2	UriCrown Land Darlington Point 2	Hay Road, Darlington Point	Modified tree (Carved or scarred)
49-4-0113	DPCOS ST13	Crown Land Darlington Point 1	Hay Road, Darlington Point	Scarred Tree
49-4-0114	DPCOS ST12			
49-4-0131	DPCOS ST6	DPCOS ST6	Hay Road, Darlington Point	Scarred Tree

Site ID	Site name	Site ID	Site name			
49-4-0112	DPSub ST11	49-4-0100	DPSub ST23	1	Britts Road and Hay Road, Darlington Point	Scarred Tree
49-4-0120	DPSub ST10	49-4-0101	DPSub ST22			
49-4-0121	DPSub ST1	49-4-0102	DPSub ST21			
49-4-0122	DPSub ST8	49-4-0103	DPSub ST20			
49-4-0123	DPSub ST7	49-4-0104	DPSub ST19			
49-4-0124	DPSub ST6	49-4-0105	DPSub ST18			
49-4-0125	DPSub ST5	49-4-0106	DPSub ST17			
49-4-0126	DPSub ST4	49-4-0107	DPSub ST16			
49-4-0127	DPSub ST3	49-4-0108	DPSub ST15			

Site ID	Site name			Item name or number on Figure 8	Address	Site Features
49-4-0128	DPSub ST2	49-4-0109	DPSub ST14			
49-4-0129	DPSub ST26	49-4-0110	DPSub ST13			
49-4-0098	DPSub ST25	49-4-0111	DPSub ST12			
49-4-0099	SPSub ST24	49-4-0116	DPCOS ST10			
49-4-0071	DPCOS ST4	49-4-0117	DPCOS ST9	2	north-west section of updated levee alignment, to the rear of Krook Street	Scarred Tree
49-4-0073	DPCOS ST2	49-4-0118	DPCOS ST8			
49-4-0074	DPCOS ST5	49-4-0119	DPCOS ST7			
49-4-0115	DPCOS ST11					
49-4-0082	Darlington Point Golf Course 1			3	6 Demamiel Street, Darlington Point	Scarred Tree
49-4-0083	Darlington Point Golf Course 2					
49-4-0084	Darlington Point Golf Course 3					
49-4-0085	Darlington Point Golf Course 4					

2.5.4 Environmental Heritage – Archaeological sites

There are two archaeological sites listed in Part 2 of Schedule 5 the Murrumbidgee LEP 2010, however only one of these falls within the study area. These are shown on **Figure 6** and are also listed in **Table 4**.

Table 4 Summary of archaeological items Listed by Murrumbidgee LEP 2013

ID on Figure 6	LEP Heritage Item Number	Address	Description
1	*A4*	Lots 5, 137, 147, 275 and 280, DP 750908, Kidman Way, Darlington Point	Warangesda Aboriginal Mission and Station
2	*A5*	Stock Street, Darlington Point	Waddi Creek Scar Trees

The potential for implementation of structural mitigation options in areas with archaeological sites will need to consider the effect of the proposed measure on the heritage significance of the item or area and comply with the Council's development consent conditions for heritage items.

2.5.5 Landscape

The Murrumbidgee River is a key landscape of the local area, and there are a number of natural and environmental features at and around Darlington Point. The study area includes a number of environmental and landscape values, as identified on Murrumbidgee Council's LEP 2013. These includes areas identified as:

- Riparian lands and watercourses
- Terrain biodiversity
- Wetlands
- National Parks and Nature Reserves

The extent of these areas are shown in **Figure 7**. As can be seen on **Figure 7,** a large portion of the study area is impacted by one or more of the environmental constraints.

The potential for implementation of structural mitigation options in areas with environmental constraints will need to consider the effect of the proposed measure on the constraint and comply with Council and/or state government development consent conditions for each individual constraint. Planning options related to floodprone land will also need to consider the planning and development requirements of these environmental constraints, with both the state and local legislative requirements.

2.6 Demographics

Understanding the characteristics of the population living and working within the catchment is an important component of developing and assessing potential flood risk management options. For example, the availability of internet, the primary language spoken at home and the availability of a motor vehicle can have a strong bearing on the feasibility of different education, flood warning and evacuation strategies.

In this regard, the Australian Bureau of Statistics (ABS) provides a range of information for the areas of Darlington Point and surrounding areas that was collected as part the 2016 census. A summary of pertinent information extracted from the ABS website (http://www.abs.gov.au/) is provided in **Table 5**. **Table 5** also includes averages for each statistic for the state of NSW.

The information presented in **Table 5** shows that:

- Approximately 1,162 live in the study area.
- Almost 40% of the population within the study area would be considered more vulnerable to the impacts of flooding (i.e., people under the age of 15 or over the age of 65). The median age of residents within the area is 41.
- English is spoken in all households. However, there a small number of residents have said they speak a language other than English at home. This includes Tagalog, Cantonese and other (not stated).

Table 5 Summary of Catchment Demographics

Statistic			Darlington Point	NSW
Population Statistics	Total population		1,162	7,480,228
	Age	Median Age	41	38
		<15 years of age	20%	19%
		>65 years of age	17%	16%
		Proportion of population that volunteers	79%	18%
	Education	Year 12 or equivalent	25%	54%
		Year 10 or equivalent	30%	26%
		Did not Complete Year 10	24%	11%
Dwelling Statistics	Motor Vehicles	Dwellings with no vehicles	4%	9.20%
		Dwellings with ≥ 1 vehicle	92%	87.10%
		Average persons per dwelling	2.5	2.6
	The language spoken at home	Speaks English only	100%	69%
		Other	Tagalog <1%	
			Cantonese < 1%	
			Other (not stated) <2%	
		Proportion of renters	13%	32%
	Dwelling Type	Separate house	97%	66%
		Semi-detached, row or terrace house, townhouse	1%	12%
		Flat, unit or apartment:	2%	20%
		Other dwelling (cabin, caravan):	1%	1%

Income	Median total household income ($/weekly)	$1,370	$1,486
	Median Rent ($/weekly)	$170	$380
Internet Statistics	No Internet connection	30%	15%
	Access to Internet connection	68%	83%
	Not Stated	1%	3%

- Approximately 13% of the dwellings are rented in the study area. The proportion of renters across the catchment is, therefore, much lower than the state average (32%) indicating there is much less potential for greater "turn over" of residents in the catchment and therefore greater flood exposure and awareness.
- Only 68% of households have an internet connection in the study area. This is much lower than the state average of 83% and must be kept in mind when proposing new management options.
- The average household within the catchment has 2.5 or more people, and at least one motor vehicle. However, there are around 8% of properties with no access to a motor vehicle.
- The median household income for the study area is slightly lower than the state average. Therefore, if a large flood occurred that resulted in significant financial losses, there would be less potential for the local community to financially recover.

2.7 Past Studies

A summary of previous flood investigations relevant to the Murrumbidgee River flooding at Darlington Point is provided below. They are listed in reverse chronological order to demonstrate how the understanding of flooding and the management of flood risk across the catchment has evolved.

2.7.1 Murrumbidgee River at Darlington Point and Environs Flood Study, 2018.

The '*Murrumbidgee River at Darlington Point*' was prepared by BMT for Murrumbidgee Council in 2018. The study was commissioned to define flood behaviour across the Murrumbidgee River at Darlington Point for topographic and development conditions at that time. Council had commissioned this flood study with the intention of using it as a base to complete a floodplain risk management study and plan for the same area.

The flood study was the first-time that flood behaviour had been formally defined across the whole of the Murrumbidgee River at Darlington Point using a 2-dimensional flood model. It was also the first flood study to formally assess flooding behind the levee at Darlington Point as a result of local rainfall.

The study included used a three-stage process to simulate flood behaviour across the catchment:

- An XP-RAFTS model to simulate the rate of local storm runoff behind the levee. The output from the hydrologic model was used to define local inflows behind the levee within the TUFLOW model of Darlington Point township.

- A broad-scale TUFLOW HPC model to provide a two-dimensional (2D) representation of the Murrumbidgee River channel and floodplain that extends approximately 600 metres upstream and almost 5 km downstream of the study area, covering a total area of around 200 km^2. This model is referred to hereafter as the "Murrumbidgee River TUFLOW Model".
- A more detailed TUFLOW HPC model of the Darlington Point township to simulate local catchment runoff behind the levee. This model is a linked 1D/2D model and covers an area of around 2.1 km^2. This model is referred to hereafter as the "Darlington Point Local TUFLOW Model".

The Murrumbidgee River catchment area upstream of Darlington Point is over 32,000 km^2. Due to the long history of stream gauge records along the Murrumbidgee River upstream of Darlington Point, mainstream inflows into the broad-scale TUFLOW model were not defined based on hydrologic modelling, but rather using historic streamflow data recorded at the Darlington Point gauge for calibration events, and based on flow rates determined through Flood Frequency analysis for design events.

Local Darlington Point model

The local catchment rainfall-runoff within the levee extent has also been considered for the determination of design flood conditions at Darlington Point. A XP-RAFTS hydrological model was developed to provide local inflows into the detailed TUFLOW model of the township behind the levee. Given the lack of historic flood level data behind the levee, local runoff was not simulated for historic events. Local model inflows were only generated for simulation of design flood events only.

The XP-RAFTS model for the local Darlington Point catchment also includes four (4) detention basins in sub-catchments behind the levee (refer to **Appendix A** for further details for the location of these basins). These basins represent "informal" storages behind the levee embankment that would serve to reduce flows during large events.

Eight (8) design rainfall events were modelled as part of the study – 20% AEP, 10% AEP, 5% AEP, 2% AEP, 1% AEP, 0.5% AEP, 0.2% AEP and the Probable Maximum Flood (PMF). The design storms were applied based upon procedures documented in the 2016 version of Australian Rainfall & Runoff (ARR) (Engineers Australia).

Mainstream Murrumbidgee River TUFLOW model

A TUFLOW HPC model was developed to provide a fully two-dimensional (2D) representation of the channel and floodplain of the Murrumbidgee River floodplain at Darlington Point. The hydraulic model uses a 10 metre grid size, covers an area of 204 km^2 and extends approximately 46 km along the Murrumbidgee River

The floodplain topography is defined using a 5m x 5m gridded digital elevation model (DEM) derived from aerial survey data. Available channel cross section survey was used to inform and reinforce channel capacity and channel bed elevations along the Murrumbidgee River. The location of these cross sections are indicated on **Figure 3**.

The calibration data available for the study area comprises the record from the Darlington Point streamflow gauge that has been in operation since 1939, with continuous time series records available from 1970. The 1956, 1974, 2010, 2012 and 2016 events were utilised for model calibration. Due to the long period of record and high flow spot gaugings available at the gauge site, the TUFLOW HPC model parameters were adjusted so the modelled rating curve matched the spot gaugings at the gauge site. The calibration process firstly involved calibrating the modelled channel bed elevation and roughness to low, in-channel flows, before calibrating the floodplain roughness to higher, out-of bank flows.

The TUFLOW derived rating curve was used to adjust historical peak flows estimated from the gauge site rating curve. These updated historical flows were used to complete a Flood Frequency Analysis at the Darlington Point Bridge gauge location, and mainstream inflows into the model domain were determined from the result of this Flood Frequency Analysis. The model was used to simulate a range of design event including the 20% AEP, 10% AEP, 5% AEP, 2% AEP, 1% AEP, 0.5% AEP, 0.2% AEP and extreme flood event.

The outputs from the design flood simulation were used to prepare design flood extent, depth and velocity mapping, provisional hydraulic hazard mapping for both the mainstream inundation and local catchment flooding. Provisional flood function was mapped for the mainstream flooding only.

2.7.2 Darlington Point Levee Realignment – review of Environmental Factors completed by NSW Public Works of the NSW Department of Finance and Services on behalf of Murrumbidgee Shire Council in May 2015.

The *'Darlington Point Levee Realignment – Review of Environmental Factors',* was prepared by NSW Public Works of the NSW Department of Finance and Services on behalf of Murrumbidgee Shire Council in 2015. Murrumbidgee Shire Council proposed to realign the levee around Darlington Point in three different areas, due to the outcomes and recommendations presented in the 2009 report *Darlington Point Levee Rehabilitation Project: Phase A – Geotechnical Investigations and Options Assessment*, by Worley Parsons.

The realignment works were intended to be undertaken in association with the previously approved levee upgrade works. The intention of the realignment works was to protect previously unprotected land in three different areas around Darlington Point. Proposed borrow pits were also identified.

The objectives of the Review of Environmental Factors were to:

- Identify the key environmental interactions to be taken into account during construction
- Assess the existing conditions on the sites proposed for the levee realignment and any potential environmental impacts
- Identify environmental mitigation measures and safeguards.

The study concluded that the works proposed as part of the levee realignment may have the potential to cause minor adverse environmental impacts to water quality, soils and landowner amenity during construction. These impacts were considered to be temporary and of minor significance. Levee works were not considered to have a significant impact on terrestrial or

aquatic species, populations or communities that are of state or federal conservation significance. The Aboriginal heritage assessment concluded that a section 90 Aboriginal Heritage Impact Permit (AHIP) under the NSW National Park and Wildlife Act would be required. No items of European historic heritage were identified for the levee realignment.

As such, on the basis of the information presented in the REF, there would be no significant adverse environmental impacts associated with the proposed works, so long as the safeguards identified and detailed in the study were adopted.

2.7.3 MR 321 Darlington Bridge and Road upgrades – Flood Impact Assessment, Worley Parsons, 2014.

The *'MR* 321 *Darlington Bridge and Road upgrades – Flood Impact Assessment ,* was prepared by Worley Parsons on behalf of Roads and Maritime Services. The study built upon the 2009 study undertaken by Worley Parsons '*Darlington Point Levee Rehabilitation Project: Phase A – Geotechnical Investigations and Options Assessment* to assess the post construction impacts associated with previous road and bridge works in the area.

The study assessed two sites – the upgrade of Carrington Street / Kidman Way around 1983 and the upgrade of the bridge across the Murrumbidgee River in 1978. Carrington Street / Kidman Way was raised by approximately 800mm for an approximate length of 1.5 kilometres. The original bridge over the Murrumbidgee was installed circa. 1905 and was replaced with a concrete span bridge in 1978 so that there was a consistent 19m span between each pier across the 11 spans of the river. The road embankment between the main river bridge and the flood channel bridge was also increased.

The study modified and refined the original RMA-2 model that was developed for the 2009 study to provide a model that could assess flood impacts at a local scale. Impacts were assessed individually in isolation and on a cumulative basis.

- Flow distribution across the main river channel, and the adjacent flood runners and flow paths was also assessed. The impact to the east of the levee and south along Kidman Way was shown to be approximately 20mm at the closest property to the raised Kidman Way embankment in this area. The raising of the road was shown to prevent over topping of the Kidman Way, at the low point in the road at the peak of the 100 year ARI design flood event. This redistribution of flows was considered to be relatively minor in the overall volume of total peak flow due to floodwaters from the Murrumbidgee River.
- The upgraded bridge constructed in 1978 across the Murrumbidgee River was shown to have a similar or better flow conveyance than the previous bridge. This was primarily due to the reduction of number of piers across the Murrumbidgee River, compared to the previous bridge. Raising of the road surfaces between the main river bridge and the flood channel bridge did not show any adverse impact on flood conveyance in this area. The results also indicated a greater afflux across the flood channel to the east as a result of these works, albeit a minor impact at a very localised scale.

The report concluded that neither of these road works had an impact on the 100 year ARI flow capacity of the Murrumbidgee River floodplain at this location.

2.7.4 Darlington Point Levee Preliminary Design report, completed by SMEC in December 2010 for Murrumbidgee Shire Council

The preliminary design report covers the assessment of existing riverbank stability together with suggestion of remediation where stability is a concern, consideration of an alternative levee alignment, preliminary design of the levee and borrow areas, augmentation of drainage structures and treatment of existing services. Preliminary design details, sketches and drawings were also prepared as part of this work as well as preliminary cost estimates.

The study utilised the variety of geotechnical investigation data that had been undertaken between 2003 and 2010 (by others) on behalf of council in relation to the Darlington Point levee. The study used information from Tender documents for the hydraulic information, which were based on the outcomes of the 2009 report for Worley Parsons, discussed in **Section 2.7.6**.

2.7.5 Darlington Point Levee Gradient Sensitivity Analysis (WorleyParsons, 2009a)

The *'Darlington Point Levee Gradient Sensitivity Analysis'* was prepared for Murrumbidgee Shire Council (now Murrumbidgee Council) by WorleyParsons (formerly Patterson Britton and Partners) in conjunction with the project listed in section 2.7.6. The aim of the investigation was to determine the effect of hydrograph shape (rate of rise and total volume) on peak flood level gradients at Darlington Point.

A flood frequency analysis was completed using information from a variety of gauges in the catchment, both upstream and downstream of Darlington Point. A hydraulic model was developed using RMA-2 and calibrated to the 1956 and 1974 events. The study concluded that there is minimal variation in the flood gradient around the levee regardless of the hydrograph shape or relative magnitude of peak discharge adopted. The study determined that the existing levee would overtop with Murrumbidgee River flows that are approximately equal to a 0.5% AEP design flood event.

2.7.6 Darlington Point Levee Rehabilitation Project: Phase A – Geotechnical Investigations and Options Assessment, Worley Parsons, 2009

'Darlington Point Levee Rehabilitation Project: Phase A – Geotechnical Investigations and Options Assessment was undertaken by Worley Parsons (formally Patterson Britton and Partners) on behalf of Murrumbidgee Shire Council in 2009. The study aimed to investigate options for the upgrade and/or rehabilitation of the existing levee around Darlington Point by undertaking geotechnical investigations of the existing levee and flood investigations to determine the susceptibility of the levee to over topping in design flood events. The study also assessed the feasibility of constructing a levee at North Darlington Point.

The study undertook an assessment of the condition of the existing levee and the area of the proposed new levee alignment. This assessment included field observations, insitu testing and samples from 13 boreholes and 11 test pits. The existing levee at the time of the study had an approximate length of 5.8 kilometres.

These geotechnical investigations revealed that the existing levee was generally in poor condition with slope instability, low permeability, poor compaction and potential for piping

failure (such as power poles and shrubs embedded into the levee) that must be addressed as part of the rehabilitation measures. The investigations also revealed that the subsurface conditions in the north Darlington Point area are considered suitable to provide an adequate foundation for a potential new levee.

A bank stability assessment of the eastern bank of the Murrumbidgee River in the vicinity of Punt Road was also undertaken as part of the study. The assessment defined the principle features of the river bank in this location and included comment on the causes of the erosion evidenced along this section of stream bank. This assessment concluded that the overall stability of the river bank as being in a marginal condition, and at risk of a deep seated circular type failure following river flooding.

The study investigated three different options to address the bank stability:

- Relocation of the existing levee;
- Provide scour protection;
- Undertake river bank stabilisation works.

Relocation of the existing levee was not considered a viable option due to the lack of available land to which the levee could be relocated to. The scour protection option recommended placing rock fill or rock filled gabion walls to provide scour protection along a regraded bank slope. This option was considered questionable due to the lack of suitable rock material locally, and would still not fully address the underlying bank stability issues.

The riverbank stabilisation works recommended two options:

- Installation of contiguous, secant or sheet pile walls along the bank crest to retain earth to the west and to prevent further erosion;
- Installation of soil anchors into the exiting bank slope and provision of scour protection as outlined above.

The cost of these options was considered substantial due to the supply and installation of the pile walls, the disposal of excavated bank material, and the resultant aesthetic impact of a piled wall. However, this option was recommended for further consideration, with preliminary cost estimates to undertake these works included in the study.

The study went on to investigate the susceptibility of the levee system to over topping from a range of design flood events in the Murrumbidgee River. RMA-2, a two-dimensional finite element model, was used to simulate the flood behaviour. The study developed a 2-dimensional flood model for the Murrumbidgee River at Darlington Point, extending from approximately 8 kilometres upstream of Darlington Point, to approximately 15.5 kilometres downstream of Darlington Point.

The study used topographic and hydrographic data of the Murrumbidgee River channel and floodplain in the vicinity of Darlington Point from a number of sources. Thirty-one cross-sections were taken across the floodplain extending from approximately 2.8 kilometres upstream of Darlington Point to approximately 15.4 kilometres downstream of Darlington Point. The topography of the floodplain away from the main river channel was defined using airborne laser scanning (*ALS*) techniques. Crest levels along the existing levee alignment at

Darlington Point were defined by the surveyed contours of the levee embankment provided by Council.

The study states that calibration of the RMA-2 model was undertaken by adjusting the roughness parameters until there was a good agreement between simulated flood levels and historic flood levels for the 1956 and 1974 flood events. Aerial and cross section photography and field observations of these historical events were used for this analysis. The calibration was found to be agreeable with historic events.

Design flood peak discharges at Darlington Point were determined using flood frequency analysis. Design flood estimates were adopted for the 20% AEP, 10% AEP, 5% AEP, 1% AEP, 0.5% AEP and 0.2% AEP, with the extreme flood modelled as 3 x 1% AEP design flood flows. The study indicates that based on the adopted distribution, the 1974 flood at Darlington Point had an approximate AEP of 1.1%.

The existing flood levee conditions were used as the base case of flood behaviour in the Murrumbidgee River. Simulations were undertaken of a post-upgrade scenario, with upgrades assumed as a structurally stable levee and built up to a level that includes an adequate freeboard above the design flood level. Comparison of these results would indicate the potential impact the levee upgrade works would have on existing flood behaviour.

The assessment indicated that the majority of the floodplain around Darlington Point will be inundated during a 100 year ARI design flood event, with the entire town predicted to be flooded in an extreme flood event.

Flood damages were estimated in the study, and were divided into residential, industrial and commercial flood damages for both Darlington Point and North Darlington Point. The location of buildings was determined by a variety of methods, including aerial photography and information from council. Ground levels were determined from the ALS survey data, with floor levels assumed at either 200mm or 400mm above the ground level. The Average Annual Damage (AAD) was calculated as $637,400, assuming the existing levee breaches at the 5 year ARI level.

Potential options for levee upgrade design were undertaken in the study, with a protection standard of the 100 year ARI plus a freeboard adopted by the Floodplain Management Committee. A freeboard of 0.75 to 1 metre applied to the 100 year ARI flood level was recommended by the study. Levee upgrade works recommended in the study include:

- construction of a standard earthen levee, upgrading and reshaping the existing levee where required;
- rehabilitation of existing stormwater drains through the levee;
- incorporation of a levee spillway.

The upgraded levee at Darlington Point was shown to increase flood levels at North Darlington Point. North Darlington Point was also shown to be impacted by flooding from the Murrumbidgee as frequently as the 20 year ARI design flood event. The study recommended a flood protection levee around North Darlington Point, with a crest level equivalent to the

100 year ARI plus one (1) metre freeboard. Cost estimates for both the levee options at Darlington Point and North Darlington Point were calculated, along with the benefit/cost ratio of each option.

The study included a section on levee maintenance requirements, to ensure the Darlington Point levee system continues to provide effective flood protection when required. This included annual inspections, watering and repair as necessary.

Community consultation was also undertaken throughout the study, including consultation with key stakeholders, the Floodplain Risk Management Committee and Council and State government representatives. The final draft of the report was placed on public exhibition in November 2008 and a public meeting held in Darlington Point in November 2008. Two written submissions were received during this process.

2.7.7 Other studies associated with levee upgrade works

A number of studies related to the detail design of the levee upgrade works were reviewed, including:

- Darlington Point Levee – Work as Executed Areas 5 and 6, completed by Engineering Technology, December 2019.
- Darlington Point Levee Detail Design – Areas 5 and 6 Contract Detail Design drawings revision C, completed by NSW Public Works for Murrumbidgee Shire Council for tender issue, December 2018.
- Darlington Point Levee Detail Design – Area 3 Contract Detail Design drawings revision D, completed by NSW Public Works for Murrumbidgee Shire Council for tender issue, January 2016.
- Darlington Point Levee Upgrade – Sheet Pile Levee Design drawings, completed by SMEC in 2012 for Murrumbidgee Shire Council for construction issue.

3 CONSULTATION

3.1 Community Consultation

3.1.1 Overview

Murrumbidgee Council recognises that the community plays an important part in the development of the floodplain risk management study and plan for the Murrumbidgee River at Darlington Point. As a result, consultation was completed with the community as well as key stakeholders at multiple stages through the floodplain risk management process.

Consultation was initially completed as part of the *'Murrumbidgee River at Darlington Point Flow Flood Study'* (BMT, 2018). This was supplemented with additional consultation as part of the current study to obtain additional information that may not have been reported during the flood study or may have come to light since the flood study was prepared. A summary of the outcomes of all consultation that was completed as part of this study is provided below.

3.1.2 Floodplain Risk Management Study (current study)

An information sheet and questionnaire were distributed to 650 households and businesses during the initial stage of the project. The information sheet informed people of the overall process involved in preparing a floodplain risk management study and plan for the Murrumbidgee River at Darlington Point as well as the major objectives of the project. A copy of the information sheet is included in **Appendix B**.

The questionnaire asked targeted questions about potential floodplain risk management options that could be implemented to manage flooding due to the Murrumbidgee River at Darlington Point. The questionnaire also asked questions on emergency management procedures and flood related planning controls, such as how people would respond during future floods and what key development and planning controls should be the focus of council's floodplain risk management objectives. A copy of the questionnaire is included in **Appendix B**.

A total of 32 questionnaire responses were received and a summary of all questionnaire responses is provided in **Appendix B**. A summary of the key outcomes of the questionnaire responses are provided below.

About the Property

Questions 1 to 3 of the questionnaire related to the type of development and the duration of occupation at that property. The responses to this question showed that there is a high degree of home ownership with long term tenancy in this catchment, which can be of benefit when planning community awareness and education opportunities in the future.

- More than 80% of the respondents are a resident and/or own the property.
- Approximately 6% of the respondents own a business within the study area.
- 2 respondents were from rural properties.

- More than 70% of the respondents have lived in the area for more than 10 years with over 40% living in the area for more than 20 years.
- Approximately 15% of the respondents have been in the area less than 5 years.

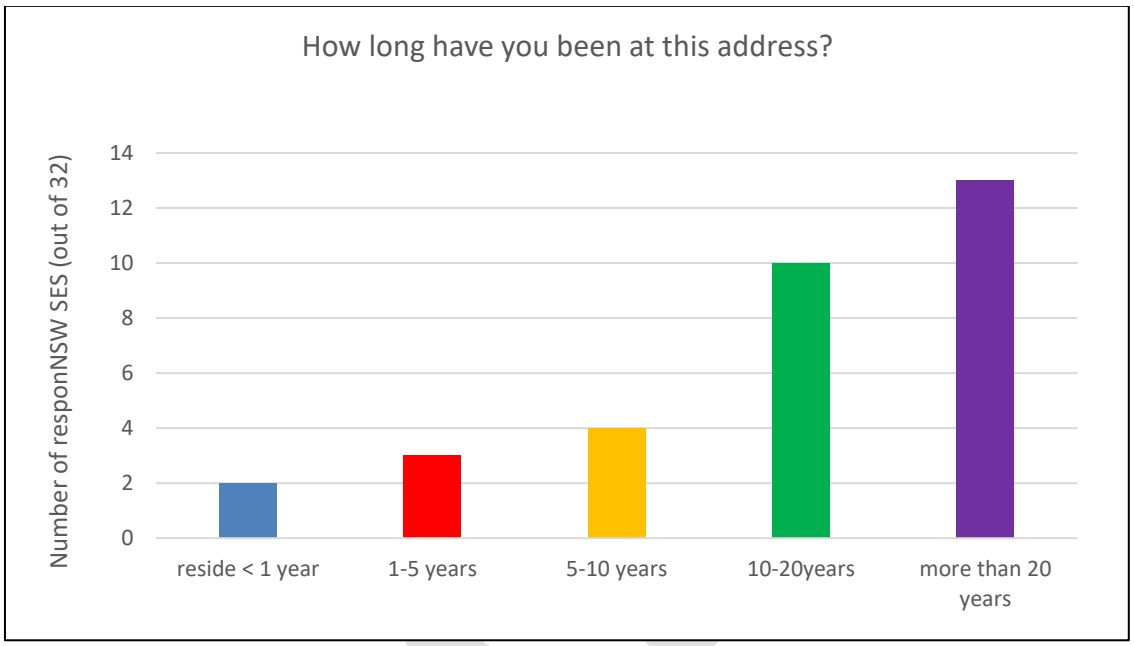


Plate 2 Length of residence in Darlington Point

Flood Awareness

Question 4 was aimed at understanding the level of flood awareness within the residents of the study area.

- 70% of the respondents indicated that their property could be flooded, whether it be from the river, if the levee breaches or due to flooding behind the levee.
- 6 out of the 32 respondents indicated their property could be flooded from multiple sources – river, behind the levee and/or if the levee breaches.
- All of those respondents who had indicated that they were not sure if their property was flood liable, had been living in the study area less than 5 years.

These results indicate that unless people experience a major flood, they do not seek information on the flood liability or flood constraints of a property. It seems in the study area that this information has not been promoted by existing residents when new residents move into their property.

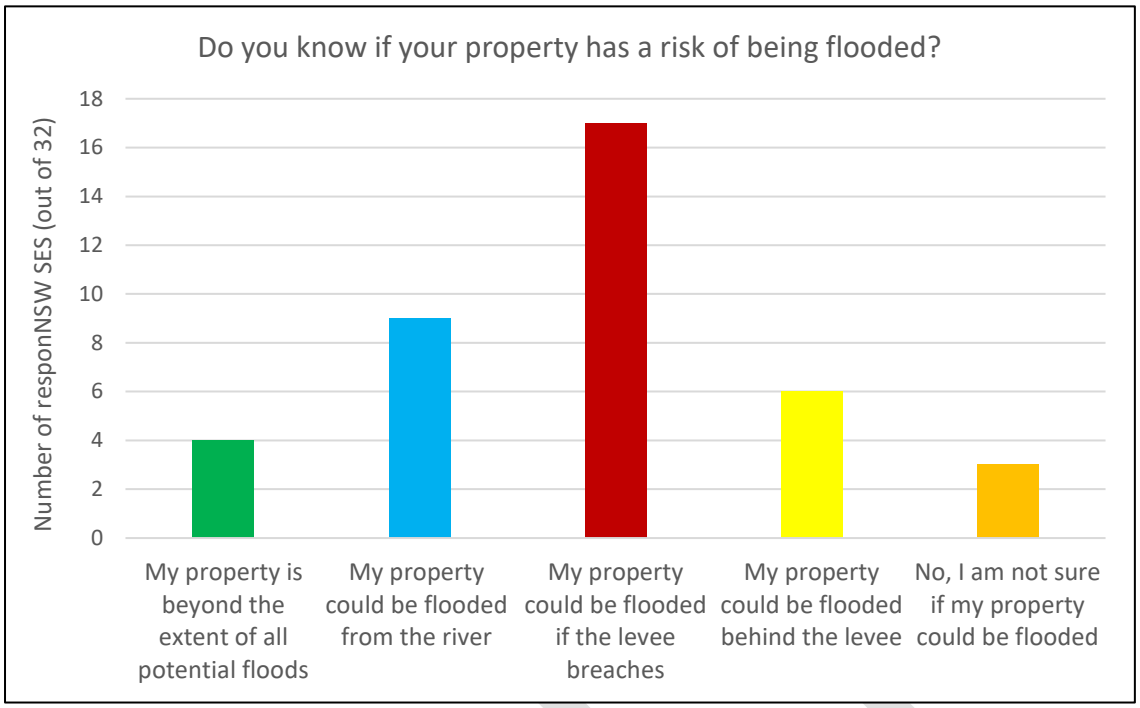


Plate 3 Knowledge of flood affectation of property in the study area

Flood experiences

Questions 5 to 14 aimed to gain an understanding of how much experience of flooding the respondents had had in the study area. **Appendix B** details these responses, with a summary presented below. Darlington Point has experienced several major floods in the past 40 years, and there appears to be a number of residents who have experienced some, if not all, of these flood events.

- More than 50% of the respondents had experienced 3 or more major flood events.
- Almost 30% of the respondents had experienced 4 or more floods – the 1974, 2010, 2012 and 2016 floods.
- 5 of the 32 respondents had experienced the 1956 flood.

The 1956 flood is considered one of the highest floods on record, followed by the 1974 flood, with the March 2012 flood considered the highest flood on record. The flood experience of the respondents indicates a high level of experience with flooding, which is reflected in the high level of awareness for the flooded vulnerability of the respondent's property. These experiences will be a great asset when formulating floodplain risk management strategies for Darlington Point.

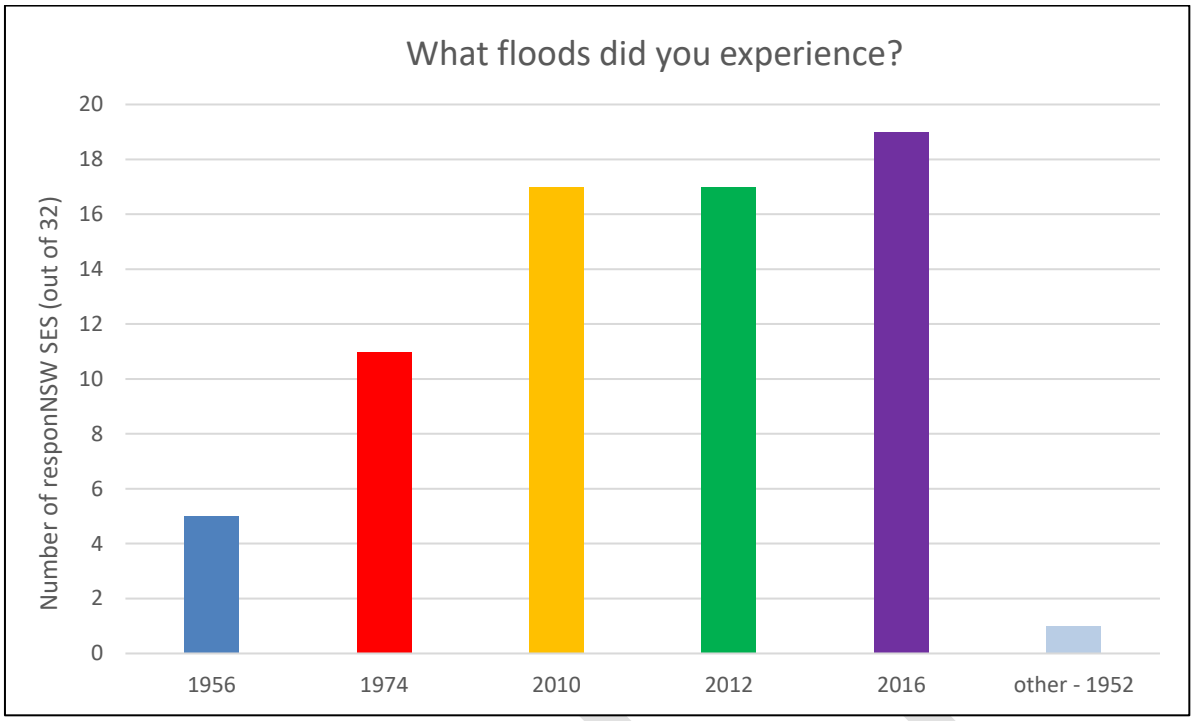


Plate 4 Flood experiences of respondents in study area

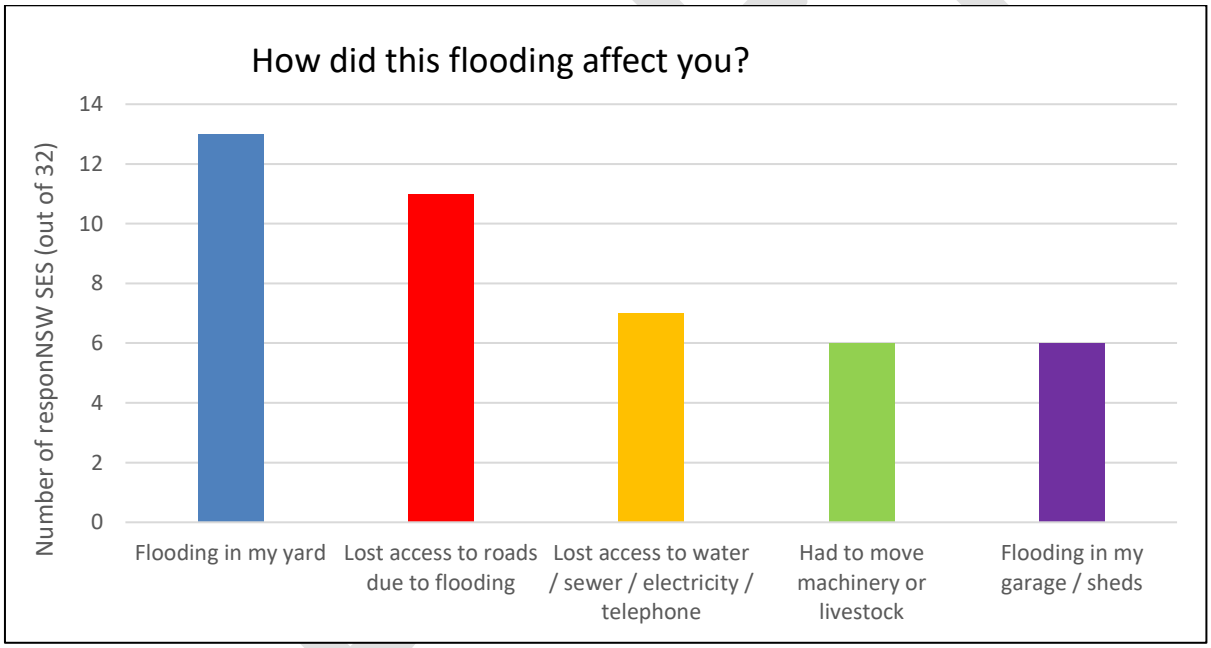


Plate 5 How flooding impacted respondents

There was quite a variation in the way those impacted by flooding responded in previous flood events with regard to evacuation. The 2012 flood event is the event that most respondents discussed in their responses when discussing flooding experiences in and around Darlington Point.

- Over 40% of respondents had been impacted by flooding in their yard.
- Almost 35% of respondents had been impacted or lost access to, or from, their property due to flooding of roads.
- 22% of respondents had lost access to water / sewer / electricity / telephone during a flood event, with almost 20% of respondents having to move machinery or livestock.

- Almost 50% of respondents evacuated out of Darlington Point during a flood event, with almost 75 % of these residents returning home after 5 + days. 3 residents indicated they returned home after a period of between 3 and 7 weeks.

Interestingly, 25% of the respondents thought the levee would breach during the flood event they experienced, with 35% of respondents not having confidence in the flood levels that were being predicted for the particular flood event. Of these latter respondents, 30% are residents who have been in Darlington Point for 20 or more years.

Flood Response

Questions 15 to 18 focused on future flooding with an aim to gain an understanding of how residents in Darlington Point would respond during future flood events.

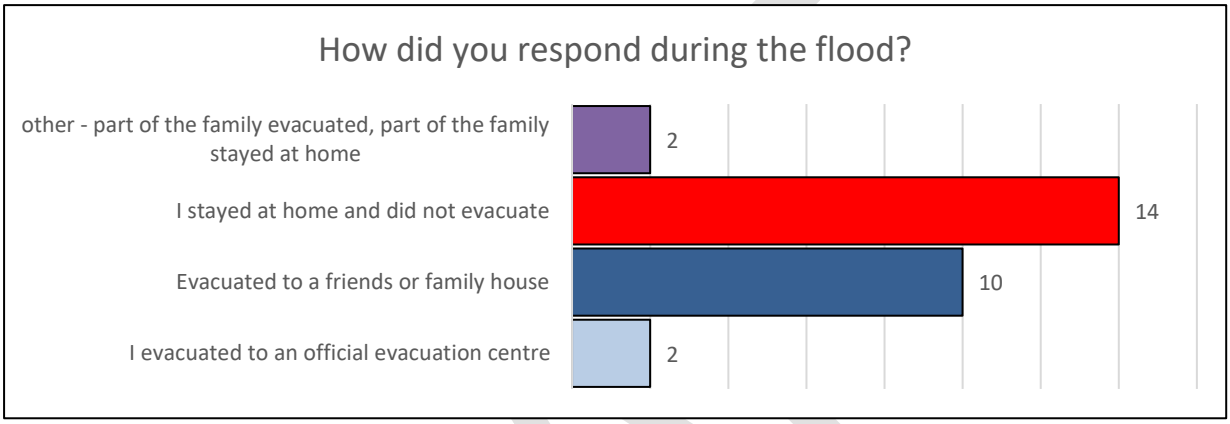


Plate 6 How the community responded during previous flood events

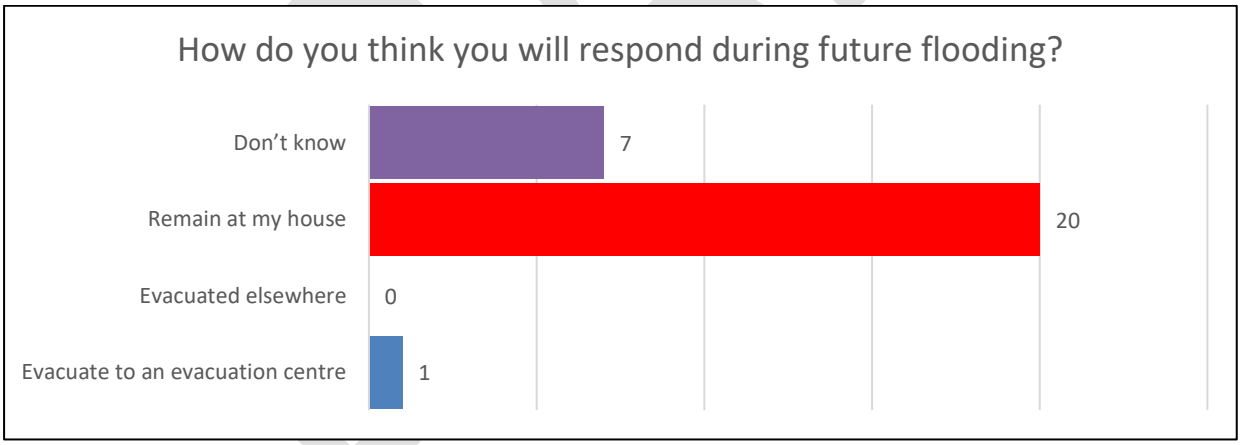


Plate 7 How the community would likely respond during future flood events

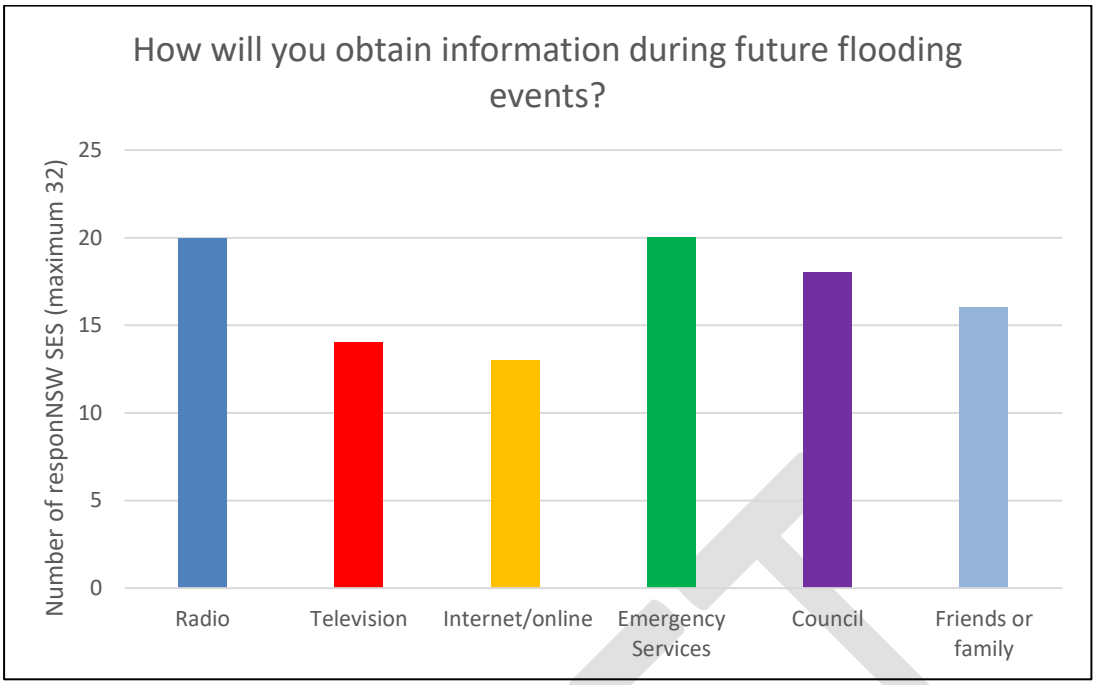


Plate 8 Community preferences for obtaining information during future flood events

The respondents have indicated that during future flood events, a variety of sources will be used to obtain information on the flooding. This information is particularly useful during this study, as community education and engagement of the flood risks in the study area will be an important outcome of this study.

Of concern is that no one indicted they would evacuate during a future flood, even those who have evacuated during previous flood events. Not one respondent indicated they would evacuate to a friend or family or official evacuation centre in a future event, all those who evacuated in previous flood events indicated they would remain at home in future flood events.

Development Controls & Communication

Questions 19 to 22 focussed on development controls and communications options. The responses to these questions indicate:

- There is very strong support for advising residents on a regular basis of the potential flood risks at each property.
- Almost 40% of respondents feel that the property owner should have the choice to develop their floodprone property if made aware of the flood risks, so long as appropriate steps are taken to minimise the potential flood threats.
- There was almost equal support for prohibiting all new development on flood prone land and/or placing restrictions on new development on floodprone land that reduce the potential for damages, such as floor level controls or using flood compatible building materials.
- There is very strong support to prioritise residential development for floodplain risk management measures, followed by critical utilities. A number of respondents did not prioritise the land use type, rather they indicated that all developments should be protected – residential, commercial, essential community facilities, roads and critical utilities.

- There was minimal support for the protection of new development or for the voluntary purchase of the most flood affected properties.

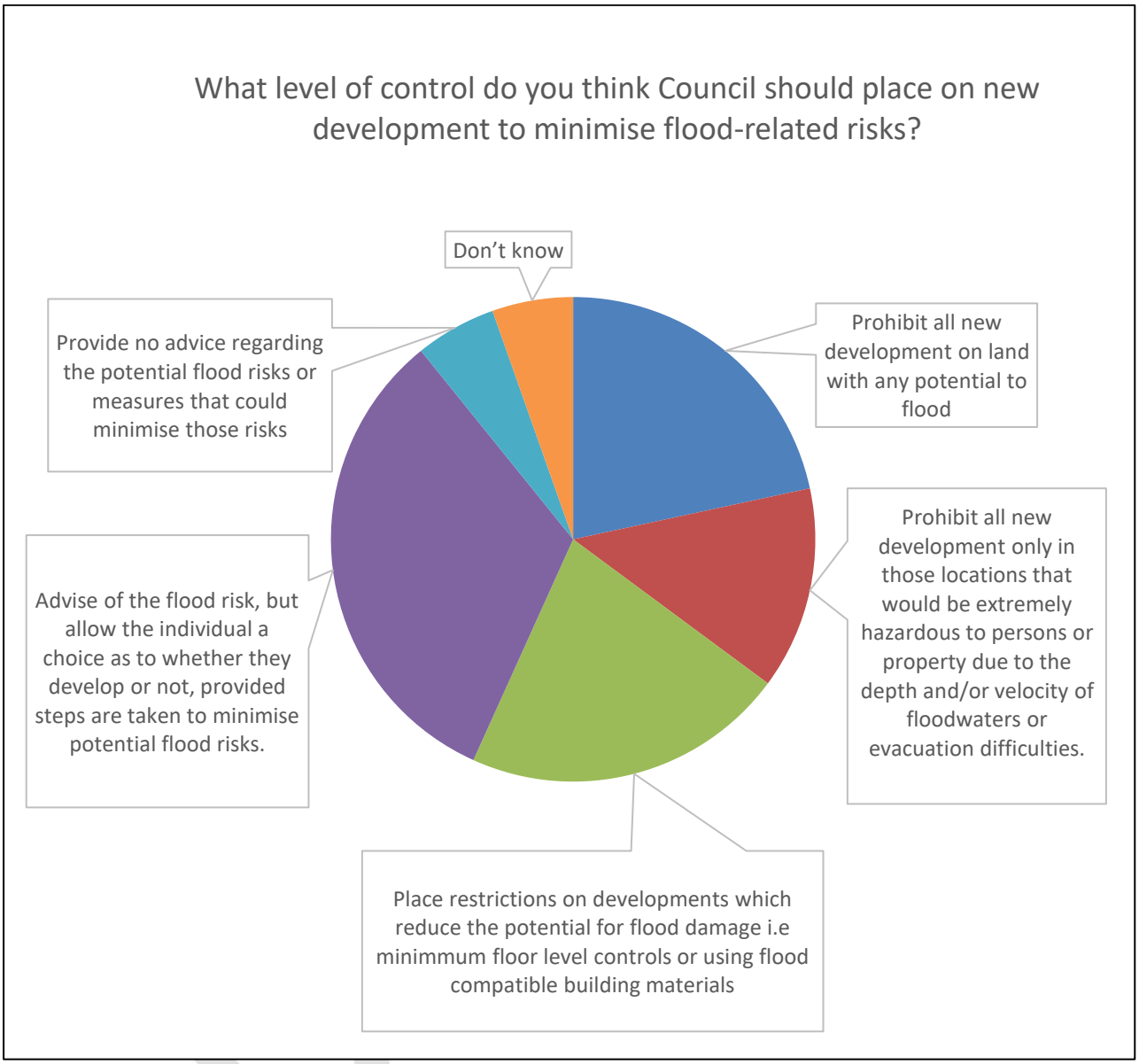


Plate 9 Community Support for Development controls on future development in the floodplain

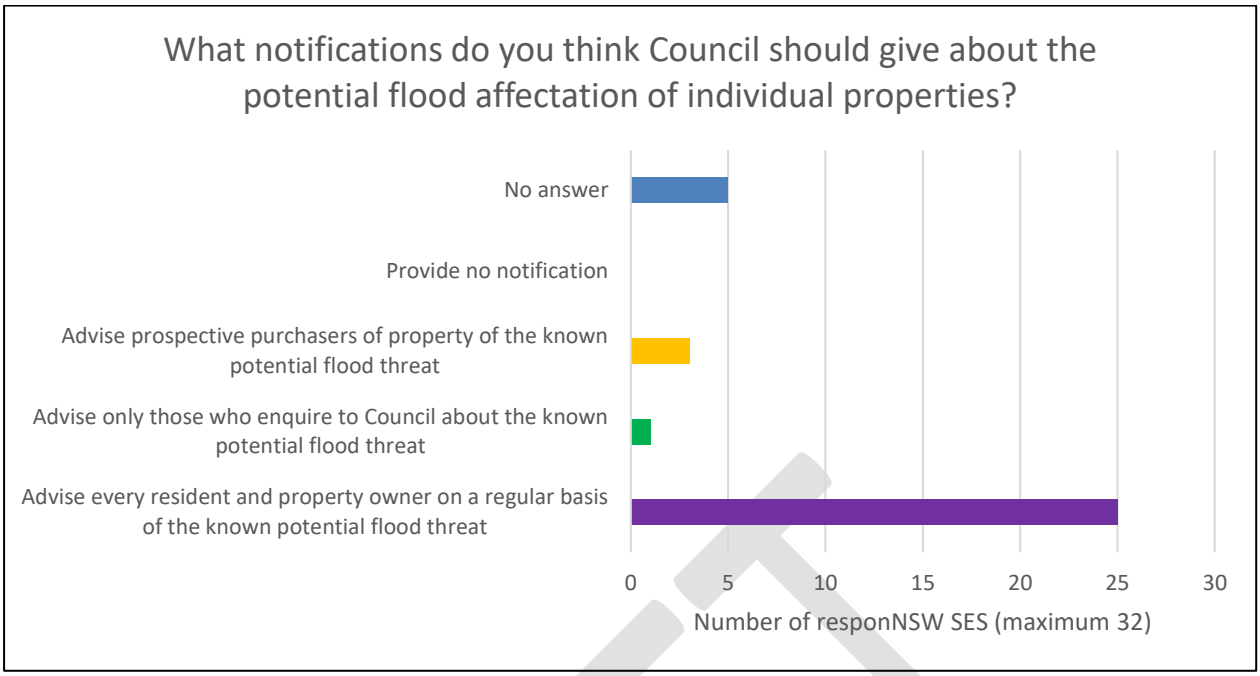


Plate 10 Community Support for Council notification of flood affectation on properties

Potential Flood Risk Management Measures

In terms of options for better managing/mitigating the flood risk (question 23), most of the suggested options were supported by the community. A summary of these responses is presented below.

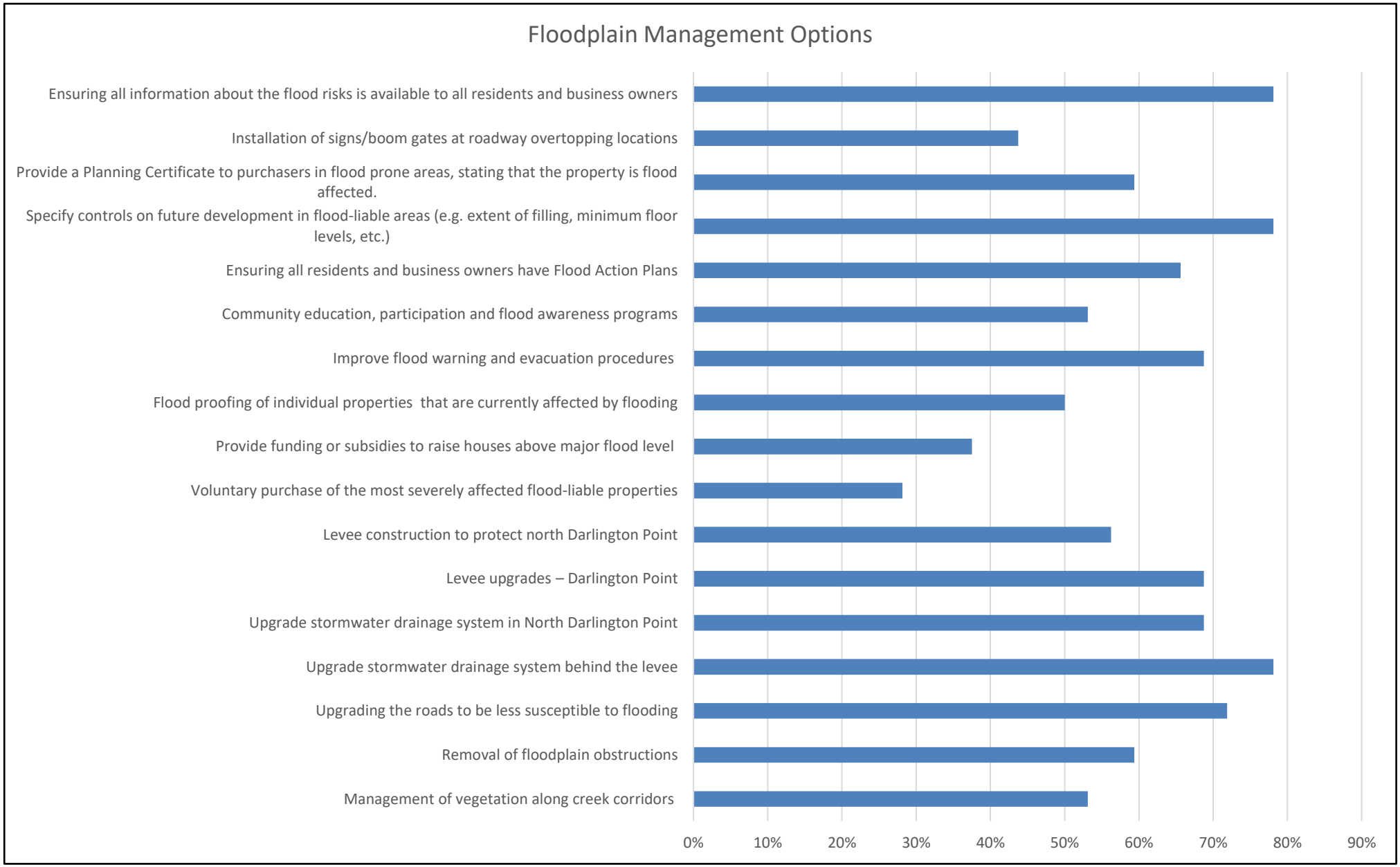


Plate 11 Community Support for Potential Floodplain Risk Management Options

3.2 Key Stakeholder Consultation

Targeted consultation was also completed with key stakeholders as part of the project. This included:

- Murrumbidgee Council Engineers
- Murrumbidgee Council Planners
- Darlington Point Floodplain Risk Management Committee
- Department of Planning, Industry & Environment
- State Emergency Service
- Roads and Maritime Services
- Bureau of Meteorology
- Riverina Local Land Services
- Department of Planning, Industry and Environment - Water
- Griffith Local Aboriginal Land Council
- Altina Wildlife Park
- Lions Club of Darlington Point

Letters and/or emails were distributed to each of the above agencies during the initial stages of the project advertising the commencement of the project and seeking feedback on particular issues that each agency would like investigated as part of the study.

Key outcomes of the stakeholder consultation are provided below.

3.2.1 Council Engineers

The Engineers noted the following flood related issues for the study area that require review or consideration during the floodplain risk management study:

- Freeboard on the upgraded levee
- Would be beneficial to separate or define flood planning area for riverine and flood planning area for local flooding.
- Flood planning areas applicable to overland flooding, and appropriate freeboards. The relationship between freeboards applied within a flood planning area of mainstream flooding, and freeboards applied within the flood planning area of overland flow flooding need to be carefully considered. The 0.5m freeboard applied to a mainstream flood level is not always practical or suitable to be applied to overland flow flooding.

3.2.2 Council Planners

Council's Planner noted the following flood related issues in the study area;

- Flood planning areas and opportunity for development within the defined flood planning area.
- Opportunities for development within the upgraded levee area.
- Opportunities for development within North Darlington Point considering the flood hazards in the area, and potential mitigation options that could help manage these hazards so that development was possible.

- Clear guidelines on development, such as rezoning or subdivision, within flood prone land is required.
- Clear mapping indicating flood prone land, flood hazard and flood planning area are required. These would make development opportunities for each parcel of land in the study area clear to council and residents.
- Recommendations for planning and development controls must also consider other floodplain risk management studies that have been completed within the LGA.

3.2.3 Department of Planning, Industry and Environment (DPIE)

A representative from the Department of Planning, Industry and Environment (DPIE) raised a number of issues for consideration during this study:

- Best practice floodplain management principles must be followed during the development of the study.
- Department of Planning, Industry and Environment (DPIE) is currently working on updating the NSW Floodplain Development Manual (FDM) (2005). The new FDM may be released during the course of this study, so be conscious of this release and aware of any changes it may introduce.
- Freeboard to be applied when determining flood planning area. Jerilderie Floodplain Risk Management Study and Plan proposed specific freeboard and flood planning area considerations that should be taken into account during this study.
- DPIE recommends that the standard 1% AEP plus a 0.5 metre freeboard be used to define the flood planning level for residential development subject to riverine flooding. Anything different would require Council to demonstrate “exceptional circumstances”.
- Flood risk for isolated properties outside of the levee area and generally to the north need to be considered during this study.
- Ensure all NSW SES requirements are included in the outputs for the study.
- A levee freeboard assessment needs to be undertaken and recommendations made for the levee freeboard.
- A spillway analysis needs to be undertaken to assess the actual need for a spillway and if so, determine its size and location.
- Mapping associated with flood extents and characteristics such as hazard need to clearly delineate areas impacted by riverine flooding and areas impacted by overland flooding.

3.2.4 State Emergency Services

A representative from the NSW State Emergency service (NSW SES) raised a number of issues for consideration during this study:

- The NSW SES is aware of the issues associated with the forced evacuation of North Darlington Point during the 2012 flood event. At the time, the NSW SES had minimal local knowledge of local flood hazards and the integrity of the existing levee was unknown. NSW SES have undertaken internal reviews after this event. The updated 2018 flood study and the outcomes of this floodplain risk management study and plan will assist the NSW SES in developing a more comprehensive local flood plan in conjunction with the local community.
- The NSW SES is aware of the vulnerability to flooding of the road network in and around Darlington Point. Outputs from this study, including detail information on flood depths

and times to reach these depths, will enable the NSW SES to develop a comprehensive flood evacuation plan for the area.

- A detailed freeboard assessment will also enable the NSW SES to include this into the flood emergency planning for the area.
- A spillway analysis will also enable the NSW SES to consider all potential risk opportunities in the study area and apply the final outcome / recommendations to the local flood emergency planning for the area.

3.2.5 Transport for NSW

Transport for NSW did not have any formal records of impacts of flooding to their assets in any of the previous flood events within the study area. Transport for NSW did acknowledge that a number of their assets incurred significant damage during the 2012 event, however no formal records were maintained on what repair and upgrades were undertaken as a result of this damage. Transport for NSW did also acknowledge that their road assets have incurred damage as a result of previous major flooding in the Murrumbidgee River catchment prior to 2012, however records were not kept of this damage.

Transport for NSW did indicate that another government agency undertook aerial photography survey around Darlington Point during the 2012 flood event which was later obtained for use in this study.

3.2.6 Bureau of Meteorology

The Bureau of Meteorology provided information on the existing flood forecasting and flood warning system for Darlington Point. This includes the forecast locations for the Murrumbidgee River, the average travel time between Narrandera and Darlington Point and the target lead time for flood forecasting at Darlington Point.

The Bureau of Meteorology also believe that the current peak height correlations between Narrandera and Darlington Point have provided a reliable level of accuracy in previous flood events. The majority of floodwaters that impact Darlington Point travel along the Murrumbidgee River from Narrandera. The topography around Darlington Point (wide and flat) would not be expected to produce significant rainfall runoff impacts for the local Darlington Point area. The Bureau of Meteorology are currently of the opinion that additional rain or water level gauges in this part of the catchment would not provide a significant improvement to this system.

3.2.7 Altina Wildlife Park

Altina Wildlife Park were contacted to discuss their current emergency management planning. They provided information on their current flood emergency management planning that includes protection from flooding via a levee that runs along the property boundary with the Murrumbidgee River. This levee has provided protection to the property during past flood events, and the management of Altina Wildlife Park anticipate it will provide protection during future flood events.

4 THE EXISTING FLOOD RISK

4.1 Overview

In order to identify and evaluate potential options for managing the flood risk, it is first important to understand the nature and extent of the existing flood risk. This is typically achieved through the preparation of a flood study, which provides information on key flood characteristics (e.g., flood depths, levels and velocities) for a range of floods up to and including the probable maximum flood. Murrumbidgee Council commissioned the "Murrumbidgee River at Darlington Point and Environs Flood Study" (BMT, 2018) to fulfil this requirement. An overview of the outcomes of the flood study are provided in Section 2.7.1. As noted in Section 2.7.1, the models developed as part of the flood study were reviewed as part of the current study and the outcomes of this review process are summarised below. The flood models were then used to confirm the nature and extent of flooding across the catchment with the minor updates that were recommended.

Once existing flood behaviour was defined, it was then necessary to use this information to gain an understanding of the risk to which the community may be exposed during the full range of potential floods. This allows a targeted assessment of areas where the flood risk is considered to be unacceptable and where flood risk management options may be best implemented to reduce the flood risk to more tolerable levels. In this regard, a flood risk and damage assessment will be prepared and will be documented in the following sections.

4.2 Existing Flood Behaviour

4.2.1 Review of Flood Study

The models that were developed as part of the *'Murrumbidgee River at Darlington Point and Environs Flood Study'* (BMT, 2018) were reviewed as part of this study to ensure they would serve as a suitable baseline for describing existing flood behaviour. The outcomes of the model review are summarised in **Appendix A**.

As outlined in **Appendix A**, two models were developed for the flood study. A TUFLOW HPC model was developed to provide a fully two-dimensional (2D) representation of the channel and floodplain of the Murrumbidgee River floodplain at Darlington Point. A local TUFLOW HPC model was developed to represent the Darlington Point township behind the levee with a XP-RAFTS model to simulate the rate of local storm runoff behind the levee.

Design rainfall intensities in the XP-RAFTS model were obtained using procedures outlined in the 2016 version of 'Australian Rainfall and Runoff' (Engineers Australia, 2016). Design rainfall depths were based on the generation of intensity-frequency-duration (IFD) design rainfall curves utilising the procedures outlined in ARR 2016. Input data for the design rainfall analysis was obtained online through the ARR 2016 Data Hub and used to determine the average design rainfall depths applicable to the centre of the Darlington Point township based on the ARR 2016 IFDs. The PMP was estimated using the Generalised Short Duration Method (GSDM) derived by the Bureau of Meteorology (1998).

Initial and continuing loss values for impervious and pervious catchment areas (including pre-burst rainfall depths) were determined in accordance with methods outlined in ARR 2016 for a catchment located in the Murrumbidgee River basin. However, it should be noted that a new version of ARR is now available (ARR 2019). In transitioning from ARR 2016 to ARR 2019, the *'Review of ARR Design Inputs for NSW'* (2019) was completed to review and advise on addressing under-estimation bias being experienced when using standard ARR 2016 design event methods with default data from the ARR data hub. Further information is provided in **Appendix A.** Therefore, the design rainfall losses should be reviewed in line with ARR 2019 as part of this study.

Each of these models were found to have been developed in accordance with modern best practice and the results generated by the model are considered to provide a reliable description of the existing flood behaviour. Minor updates are recommended to both the broad-scale Murrumbidgee River TUFLOW model and the local Darlington Point TUFLOW model to ensure the most accurate and up to date information is used as the basis for defining existing flood behaviour as part of the current study. These changes are summarised in **Table 6.**

Table 6 Recommended Model Updates

Model	Recommended Updates
Darlington Point XP-RAFTS Model	• Review and update specific values for the pervious/impervious subareas within each sub-catchment. • Revise and update pervious 'n' (PERN) values, as necessary. • Review and modify rainfall inputs (depths, losses, etc) in the model based on the latest ARR2019 guidelines. • Re-assess the suitability of the critical duration/temporal pattern combinations based on modified model.
Broad-scale Murrumbidgee River TUFLOW Model	• Extend the model domain laterally to remove "glass walling" in larger magnitude floods. • Add additional structures in and around Darlington Point to enable flow through embankments where structures are identified in Council's GIS database. • Review and update structure blockage based on ARR2019 guidelines. • Assess the sensitivity of the model to the modification of the Manning's "n" values for the river channel value of 0.015, which is below recommended values from literature.
Detailed Darlington Point TUFLOW Model	• Reduce the model grid size from 4m to 2m. • Review and update structure blockage based on ARR2019 guidelines. • Modify the representation of stormwater pits to "Q" type 1D nodes. • Modify 1D/2D connections at 1D culverts to remove "CN" connections and apply SX point directly at the ends of structures. • Adjust initial water level within the treatment ponds in the Sewerage Treatment Plant to assume ponds are full at the start of the flood simulation and do not provide any flood storage.

4.2.2 Flood Model Updates

Update to Murrumbidgee TUFLOW model

The following updates were completed to the TUFLOW model to best reflect current catchment conditions:

- The model was updated to extend approximately 7 kilometres to the south so as to include a representation of the floodplain areas beyond the Sturt Highway to the south, and extended northwards to include a greater floodplain area to the north of Darlington Point. **Figure 9** outlines the area covered by this model update.
- Work-as-executed survey of the recently completed levee upgrade works has become available that differs slightly from some of the "design" information that was included in the 2018 flood model. Therefore, it was considered worthwhile to update the TUFLOW flood model to better reflect contemporary catchment conditions.
- Information on hydraulic structures was updated, including adding in several existing structures around the periphery of Darlington Point that are located outside of the area protected by the levee. These updates are indicated on **Figure 10.**
- The implementation of the levee crest for the events larger than the design protection level and for the assessment of flood damages was updated. The model adopted from the 2018 flood study included inadvertently lowering the terrain within the levee area as part of the assessment when the levee freeboard was removed. The levee crest without freeboard was implemented directly as part of the model update.

Further details on these updates are provided in **Appendix C.**

Update to local Darlington Point hydrological RAFTS model

The RAFTS model was updated to better represent the subcatchments and their characteristics for the areas of Darlington Point protected by a levee. CatchmentSIM was used to update the delineation of the subcatchment and the parameters assigned to each of these subcatchments, such as catchment area and percentage of impervious and pervious area, slope, and flow path length. Design rainfall information was updated based on the most recent version of Australian Rainfall and Runoff 2019.

Further details on these updates are provided in **Appendix C.**

Update to local Darlington Point TUFLOW model

The local Darlington Point TUFLOW model was updated using the updated hydrological information. The updated local TUFLOW model was used to simulate a range of design events including the 20% AEP, 10% AEP, 5% AEP, 2% AEP, 1% AEP, 0.5% AEP and 0.2% AEP design flood events in accordance with ARR 2019. Calibration or validation of the local township TUFLOW model was not completed during the original 2018 flood study due to a lack of calibration data, and so calibration or validation of the local township TUFLOW model was not undertaken during the model update process. Additional hydraulic structures were added into the local Darlington Point TUFLOW model, as indicated on **Figure 10.**

Further details on these updates are provided in **Appendix C.**

The updated hydraulic model provides the basis for defining the flood risk in Darlington Point behind the levee.

4.2.3 Floodwater Levels and Depths

The updated TUFLOW model was used to simulate the 20% AEP, 10% AEP, 5% AEP, 2% AEP, 1% AEP, 0.5% AEP, 0.2% AEP and extreme design flood events for mainstream river flooding. These same design flood events were used to define the flood risk for the area protected by the levee.

Peak floodwater depths were extracted from the results of the revised modelling and are presented in **Figures 11** to **17** for the local catchment flooding in the area protected by the levee**.** Updated mainstream Murrumbidgee River flooding depths are presented on **Figures 18** to **25**.

Filtering with a depth cut-off of 0.10 metres has been applied to the flood information presented in these figures for the areas impacted by flooding behind the levee. The justification for this filtering has been included in **0**.

Table 7 Design flood levels vs gauge level at Darlington Point bridge gauge 410021

Gauge level (metres)	Reduced level (mAHD)	Approximate design Flood Event
6.44	124.30	20% AEP
7.01	124.87	10% AEP
7.33	125.19	5% AEP
7.64	125.51	2% AEP
7.78	125.64	1% AEP
7.86	125.73	0.5% AEP
7.94	125.81	0.2% AEP
8.25	126.11	Extreme flood event

The updated flood modelling is generally consistent with the design flood information presented in the 2018 flood study but gives further details on the flooding characteristics at the northern and southern extents of the floodplain around Darlington Point. These updates provide a more detailed definition of the flooding characteristics in the outer extents of the floodplain away from the main channel areas in parts of the floodplain that generally only become active in floods greater than the 1% AEP design flood event. The information provided in this flood study update also refines the local catchment flooding information for the areas protected by the levee.

Implementation of the breach of the levee crest was also refined in this flood study update. The methodology used in the 2018 flood study had resulted in slightly lower terrain adjacent to the spillway location. This influenced the routing of the floodwaters behind the levee and subsequently flood water depths behind the levee as a result of flooding from the Murrumbidgee River.

The 2018 flood study provided a comprehensive description of the flood characteristics of the Murrumbidgee River at Darlington Point. This report will not repeat that information, however the following flooding characteristics have become evident with the update and expansion to the area the model covers.

The results of the hydraulic modelling also highlight the following areas as being impacted by floodwaters:

- During the 1% AEP design flood event, flooding is generally contained with the area bounded by the Sturt Highway to the south. In the north, the deeper floodwaters are contained by Whitton Darlington Point Road and Murrumbidgee River Road with shallower water extending out past these roads and spreading out across the rural areas up to depths of 0.5 metres.
- The flood behaviour experienced during the 0.5% AEP design flood extent is similar to those experienced during the 1% AEP design flood event, albeit with increased depths throughout all sections of the floodplain. Floodwaters start to backup behind the Kidman Way to the south of Darlington Point, over an approximate width of nine (9) kilometres.
- The modelling for the 0.5% AEP design flood event has assumed a breach in the levee, with the areas behind the levee inundated by floodwaters from the Murrumbidgee River. A levee breach scenario is assumed to be the primary levee failure mode and is important for emergency management purposes to gain an understating of the more vulnerable areas behind the levee.
- The update to the way the breach has been modelled in the hydraulic model has updated the flood behaviour immediately behind the levee and the location of the areas that become inundated behind the levee.
- During the 0.2% AEP design flood event, floodwaters expand over greater areas to the south of Darlington Point beyond the Sturt Highway, inundating large sections of the rural areas with up to 0.5 metres of floodwaters. Floodwaters to the north of Darlington Point generally maintain a consistent area of inundation to those impacted during the 0.5% AEP design flood event, however with depths increasing up to 1.0 metres. Floodwater depths across the Sturt Highway and the Kidman Way are also significant, making evacuation difficult and access along the roads hazardous.
- The modelling for the 0.2% AEP design flood event has assumed a breach in the levee, therefore floodwater depths for areas behind the levee are greater than those experienced during the 0.5% AEP design flood event.
- During the extreme design flood event, floodwater depths up to 0.25 metres inundate most of the floodplain. Whilst the depths greater than 1 to 2 metres are maintained within the main channel of the Murrumbidgee River, the larger expanses of the floodplain to the north and south of Darlington Point experience floodwater depths up to 1 metre. In the southern section of the floodplain, deeper depths are observed to occur through a series of depressions that essentially form a high level flowpath for the Murrumbidgee River. This flowpath commences around 3.5 kilometres east of Altima Wildlife Park, and continues overland, generally parallel to the Murrumbidgee River alignment over the rural lands, for approximately 22 kilometres, with floodwaters depths up to 1 metre estimated to occur.

- Floodwaters are predicted to cut several of the roadways at multiple locations, including the Sturt Highway, The Kidman Way, Whitton Darlington Point Road and Murrumbidgee River Road, making evacuation difficult and access along these roads hazardous.
- The modelling for the extreme design flood event has assumed a breach in the levee, with the entire area of Darlington Point behind the levee estimated to be inundated by floodwater from the Murrumbidgee River during the extreme design flood event.

4.2.4 Hazard Categories

Flood hazard defines the potential impact that flooding will have on development, vehicles and people across different sections of the floodplain. More specifically, it describes the potential for floodwaters to cause damage to property or loss of life/injury (AIDR, 2014).

Provisional flood hazard

Provisional hazard categories were prepared as part of the *'Murrumbidgee River at Darlington Point and Environs Flood Study'* (BMT, 2018) based on criteria contained within the Australian Institute for Disaster Resilience's (AIDR) *'Technical Flood Risk Management Guideline: Flood Hazard'* (2014). The hazard curves are reproduced in **Plate 12** and are also described in **Table 8**. As shown in **Plate 12**, the hazard curves assess the potential vulnerability of people (of differing physical abilities), cars and structures based upon the depth and velocity of floodwaters at a particular location.

These guidelines were used to update the hazard maps with the results of the updated modelling. The resulting provisional hazard category maps are included in **Figures 26 - 28** for the 5% AEP, 1% AEP and extreme design flood events for the local catchment flooding behind the levee. **Figures 29 - 31** present the provisional hazard category maps for the mainstream Murrumbidgee River flooding at Darlington Point for the same design events.

These provisional hazard maps have been further updated in this study to form the final flood hazard categories for the Murrumbidgee River at Darlington Point.

Table 8 Description of Adopted Flood Hazard Categories (Australian Government, 2014)

Hazard Category	Description
H1	Generally safe for vehicles, people and buildings. Relatively benign flood conditions. No vulnerability constraints
H2	Unsafe for small vehicles
H3	Unsafe for vehicles, children and the elderly
H4	Unsafe for vehicles and people
H5	Unsafe for vehicles and people. All building types vulnerable to structural damage. Some less robust building types vulnerable to failure
H6	Unsafe for vehicles and people. All building types considered vulnerable to failure.

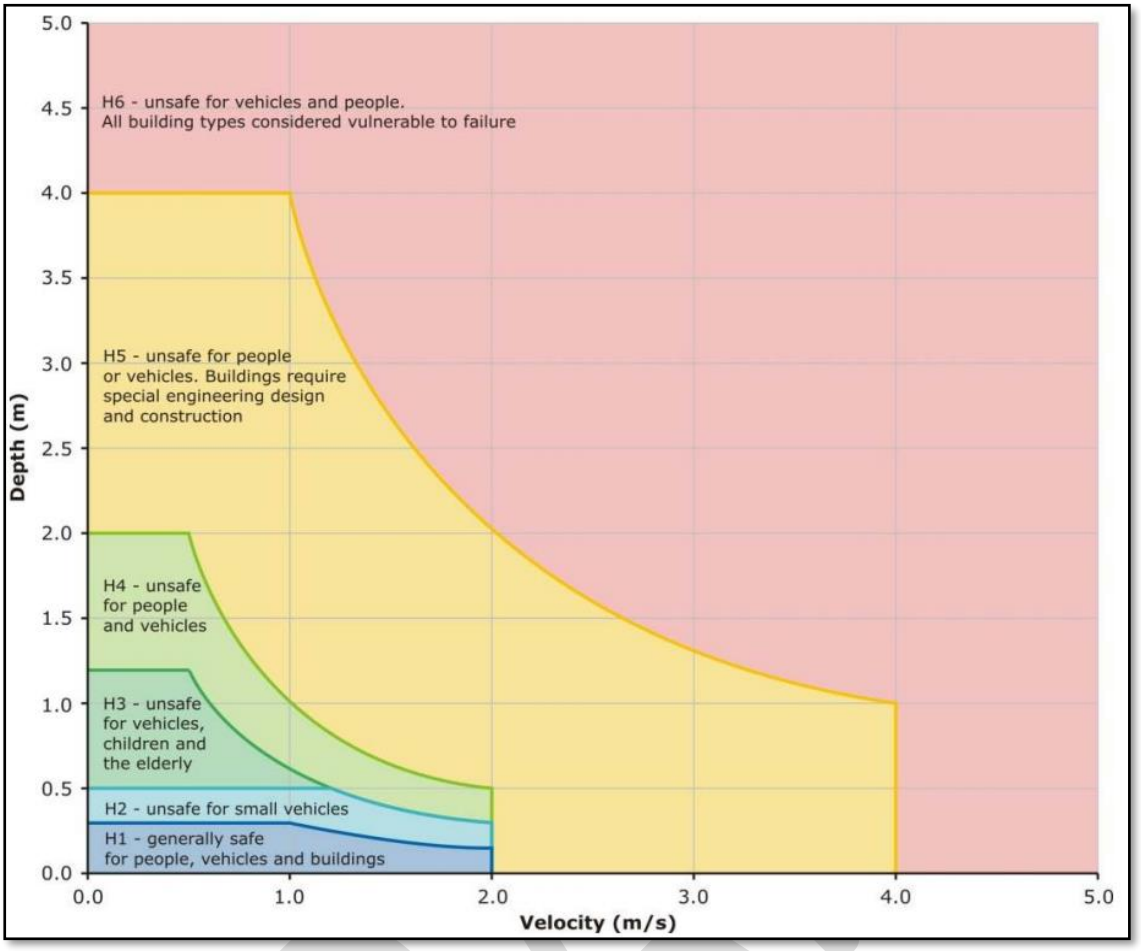


Plate 12 Flood Hazard Vulnerability Curves (AIDR, 2014)

Within the study area, flood hazard category H1 and H2 is generally experienced in the outer extent of the floodplain during the 5% and 1% AEP design flood events. In floods as frequent as the 5% AEP event, areas experiencing flood hazards of H3 and H4 occur between the main Murrumbidgee River channel and adjacent flowpaths and gullies, such as Waddi Creek to the south-east of Darlington Point and Gum Creek to the north-west. During the 1% AEP design flood event, these areas are predicted to be H5 hazard, which are considered too hazardous for people or vehicles, and most building types.

The flood hazard mapping indicates that the areas predicted to experience flood hazards of H6 during the 5% AEP, 1% AEP and the extreme design flood events are generally contained to defined watercourses (refer **Figures 29 to 31**). Flood hazards of H6 are considered the most hazardous to people and vehicles, with all building types considered vulnerable to failure.

Accordingly, during a 1% AEP design flood and less frequent flooding, some sections of the floodplain in the study area would not be safe for vehicles or people regardless of their physical ability.

For the areas of Darlington Point behind the levee, flood conditions during the 5% AEP up to the 1% AEP design flood event are generally predicted to be maintained at or below H1 or H2 flood hazard conditions. This is primarily due to the small depths of flooding anticipated as a

result of rainfall over the local catchment only. During the local extreme flood event, small areas behind the levee are expected to reach flood hazard levels of H4, with the northern part of Darlington Point impacted by flood hazards of H3 and the remainder of the areas protected by the levee anticipated to be impacted by H2 and H1 flood hazards.

During an extreme flood event in the Murrumbidgee River, the model has included a breach of the levee around Darlington Point, which would result in the inundation of almost the entire area behind the levee. This flooding is predicted to result in most sections of Darlington Point located behind the levee to experience flood hazards of H3 and H4, with some areas predicted to experience H1 and H2 flood hazards.

Final flood hazard categorisation

Section 4.2.4 refers to the provisional flood hazard categorisation that was undertaken as part the update to the flood study. An assessment was undertaken of additional factors that can influence the flood hazard to determine the final flood hazard for the Murrumbidgee River at Darlington Point. As listed in the NSW Governments Floodplain Development Manual (2005), these factors are as follows:

- Size of flood – the size of the flood and the damage it can cause varies with each event. A small flood is more frequent however causes less damage. A larger flood is less frequent however can cause significant flood damage.
- Effective warning time – the effective warning time is generally less than the total warning time available to the emergency services as it relates to the time needed to inform people of the imminent flood risk, and the time taken for those affected people to act. Consequences of flooding can be reduced if adequate warning time is available and is well utilised.
- Flood awareness – flood awareness of the population influences the time taken by flood affected people to effectively respond to flood warnings. A high level of flood awareness in a community would enable efficient and effective responses to a flood warning, from the individual to the community scale.
- Rate of rise of floodwater – the rate of rise of floodwaters affects the consequences of the flood. A rapid rise in floodwaters may result in greater damages than floodwaters that rise slowly.
- Depth and velocity of floodwaters – the speed and depth of floodwaters influence the risk to people and property. Obstructions in the flowpath and floodwaters can also affect the depth and speed of flooding, therefore influence the flood damage.
- Duration of flooding – the duration of flooding or length of time an area or community is cut-off can have a significant impact on the costs and disruptions associated with flooding.
- Evacuation difficulties – the amount of flood damage and disruptions caused by flooding are influenced by the difficulty of evacuating flood affected people and property. These can relate to:
    - the number of people requiring assistance,
    - the mobility of the people being evacuated,
    - inability to contact emergency services,
    - lack of suitable evacuation equipment, such as heavy trucks,

- the depth and velocity of the floodwaters,
- driving or wading problems, such as uneven ground, debris, localised high velocities,
- distance to flood free ground,
- the time of day and existing weather conditions.

- Effective flood access – effective flood access includes an exit route that remains trafficable for sufficient time to evacuate people and possessions, considering both vehicular and pedestrian access. Access routes must consider floods beyond the flood planning level. Access routes should provide a level of protection that provides adequate time for evacuation and reduces the risk to acceptable levels, when combined with an effective warning time.
- Type of development - the type of development and resident mobility influence the degree of flood risk. These considerations can include the existence of special evacuation needs, the level of occupant awareness, isolated residential development, hazardous industries or land uses, land use potential to cause or influence flood damage and development over watercourses.

Table 9 Factors considered to determine final flood hazard

Parameter	Weighting applied in this study	Comment
Size of flood	low	During the more frequent food events, up to approximately the 1% AEP design flood event, the flooding is generally contained within the Murrumbidgee River floodplain with damages primarily confined to properties around north Darlington Point. In larger floods, particularly those above the 0.5% AEP design flood event, a significant number of properties are impacted in Darlington Point (once the levee breaches) north Darlington Point and the surrounding rural areas.
Effective warning time	low	There are several weeks from the onset of rainfall in the upper parts of the Murrumbidgee catchment to the arrival of floodwaters at Darlington Point. More accurate information, based on flooding at Narrandera, would provide more than 4 days for flood warning. This provides abundant time for the residents of Darlington Point to prepare for flooding.
Flood awareness	low	The results from the community consultation undertaken as part of this study indicate there is a high level of awareness of the flood hazards in and around Darlington Point. Floods in 2010, 2012 and 2016 have maintained and strengthened people's awareness and recognition of the flood hazards that can occur in the area.
Rate of rise of floodwater	low	It can take the floodwaters 4 to 10 weeks to rise to a peak at Darlington Point after the onset of rainfall in upstream parts of the catchment. In conjunction with the effective warning time and an effective warning system, this allows sufficient warning for residents and business in the floodplain to protect, raise or remove their contents and evacuate themselves from the floodplain, if needed.
Depth and velocity of floodwaters	low	The rate of rise of the floodwaters from the Murrumbidgee River at Darlington Point is relatively slow, generally with low velocities. Depths in the main river channel can exceed 4 metres during the more extreme flooding events. The local overland flooding within the areas protected by the levee would rise and fall relatively quickly, and are estimated to be completely receded within 12 to 24 hours after the onset of local rainfall. Depths of

		overland floodwaters are generally less than 1 metre and travel over short distances, which limits the impact of flood damages.
Duration of flooding	High	The duration of flooding from the Murrumbidgee River at Darlington Point is in the order of weeks. This can impact on the normal day to day activities and travel around the area for the residents. It can also impact on traffic flow through Darlington Point, for commercial purposes , which would result in significant detours. This duration of flooding can also impact on the accessibility of individual properties in the area, which is an issue when residents cannot travel out of their own property.
Evacuation difficulties	High	For the majority of residents, evacuation to the north or south should be relatively easy as the Sturt Highway remains flood free up to the 0.2% AEP design flood event. The Kidman Way to the north does become inundated in the larger flood events, however with the effective warning time and rate of rise of floodwaters, residents should have sufficient time to evacuate, if directed to do so. Considering the information provided in **Table 5** and the response to the community survey in **Section 3.1.2,** approximately 40% of the population in this study area would be considered as vulnerable. This needs to be taken into consideration during evacuation planning to ensure evacuation difficulties are not encountered.
Effective flood access	Low	The main evacuation roads around Darlington Point (The Kidman Way, Sturt Highway, Hay Road) are all sealed roads that present no unexpected hazards if they have been maintained adequately. Some of the private access roads or driveways may not be sealed and may increase flood hazard once they are covered in floodwaters.
Type of development	Low	The area protected by the levee is zoned RU5 – Village. There is a cluster of more urban development at North Darlington Point and the junction of the Kidman Way and the Sturt Highway, to the south of Darlington Point that is zoned RU5 – Village and R5 – Large Lot Residential. The remaining area around Darlington Point is zoned RU1 – Primary Production. The types of land use and development appear to be commensurate with the flood hazard in all areas of the floodplain in this study area.

NOTE: High = Tendency to increase provisional hazard Low = tendency to reduce provisional hazard

Based on the parameters presented in **Table 9**, the final flood hazard would not increase across the study area. Therefore, the provisional flood hazard is considered to reflect the final flood hazard, and is presented in **Figures 29** to **31** for mainstream flooding and **Figures 26** to **28** for local catchment flooding.

4.2.5 Hydraulic Categories

Hydraulic categories provide an indication of the potential for development across different sections of the floodplain to impact on existing flood behaviour and highlights areas that should be retained for the conveyance and storage of floodwaters as failure to do so will likely have an adverse impact on existing flood behaviour.

The NSW Floodplain Development Manual defines the hydraulic categories as follows:

- **Floodway** - Areas and flowpaths where a significant portion of floodwaters are conveyed (including all bank-to-bank creek sections) volume of water flows during floods.

- **Flood Storage** - Areas where floodwaters accumulate before being conveyed downstream. These areas are important for detention and attenuation of flood peaks.
- **Flood Fringe** - Areas that are low velocity backwaters within the floodplain. Filling of these areas generally has little consequence to overall flood behavior.

Criteria for defining hydraulic categories developed as part of the *'Murrumbidgee River at Darlington Point and Environs Flood Study'* (BMT, 2018) are summarised in **Table 10**. The flood study included various analyses to confirm the suitability of these criteria (e.g., encroachment analysis to confirm floodway extents). As part of the flood study update in this study, the hydraulic categorisation criteria was revised. The revision to the definition of floodway also took into consideration the hydraulic categorisation criteria that has been applied (and subsequently adopted by Council) in the Jerilderie Flood study (GHD, 2014) and previous work undertaken by Catchment Simulation Solutions in other study areas.

Table 10 Qualitative and Quantitative Criteria for Hydraulic Categories

Hydraulic Category	2018 Flood Study Adopted Criteria	2020 Floodplain Risk Management Study and Plan
Floodway	VxD > 0.25 m^2/s at the 1% AEP event	1. Velocity x depth > 0.25m^2/s and the velocity must be greater than 0.25 m/s, OR 2. Velocity is greater than 1 m/s OR 3. Depth of flooding > 1m.
Flood Storage	VxD > 0.19 m^2/s at the 1% AEP event	Areas outside of the floodway where depth > 0.5 metres.
Flood Fringe	The extent of the 1% AEP floodplain not classified as floodway or flood storage.	Areas of the floodplain that are not defined as floodway or flood storage.

NOTES: V = Velocity, D = Depth

The updated hydraulic category maps for the 5% AEP, 1% AEP and extreme flood are shown in **Figures 32** to **34** inclusive for mainstream Murrumbidgee River flooding. Hydraulic categorisation has not been carried out for the areas behind the levee due to the small areas that are inundated as a result of local flooding.

Figures 32 to 34 indicate the floodway extends out from the main Murrumbidgee River channel into the vegetated floodplain areas to the east and west in events as frequent as the 5% AEP design flood event. The additional criteria added to define the floodway as part of this study has resulted in a more clearly defined and consolidated floodway area with less incursion of flood storage areas in the middle of the floodway. This delineation represents a more realistic condition of the function of floodways and the role they play in the conveyance of floodwater.

This location and extent of floodway area across the total floodplain area across several different design flood events provides an indication of the importance of maintaining the conveyance capacity of these areas into the future.

5 IMPACTS OF FLOODING ON THE COMMUNITY

5.1.1 The Cost of Flooding

To assist in quantifying the financial impacts of flooding on the community, a flood damage assessment was also completed. The flood damage assessment aimed to quantify the potential flood damage costs incurred to private and public property during a range of design floods across the catchment. A detailed description of the approach used to establish the flood damage cost estimates is provided in **Appendix F.**

As outlined in **Appendix F**, flood damage estimates were prepared using flood damage curves in conjunction with design flood level estimates and building floor levels for each of the following property/asset types:

- Residential properties
- Commercial & industrial properties
- Infrastructure

As part of the damage cost calculations, the number of properties subject to above floor inundation was calculated. This information is summarised in **Table 11**. The number of properties subject to property damage (even if above floor flooding is not predicted) are also provided in **Table 11**. This includes damage to external items such as fences, sheds and garages. The frequency of above floor flooding (i.e., the design event at which above floor flooding is first predicted to occur) was also mapped and is shown in **Figure 39**.

It should also be noted that the levee around Darlington Point was assumed to breach at levels greater than the 1% AEP design flood event. As such, flood damages for areas behind the levee would be realised from mainstream Murrumbidgee River flooding in events greater than the 1% AEP design flood event.

Table 11 Number of Properties Incurring Flood Damages as a result of local flooding behind the levee only

Flood Event	Number of Properties Impacted by flooding			
	Residential		Commercial/ Industrial	Total
	External Damage only	Above floor Flooding		
20% AEP	16	0	1*	**17**
10% AEP	18	0	1*	**19**
5% AEP	21	0	1*	**22**
2% AEP	25	0	1*	**26**
1% AEP	30	2	2	**34**
0.5% AEP	32	3	2	**37**
0.2% AEP	39	4	2	**45**

Extreme Flood	97	158	24	**279**

*This property is one of the community open space areas in Darlington Point behind the levee that only consists of open space with no buildings.

Table 12 Number of Properties Incurring Flood Damages as a result of Murrumbidgee River flooding only

Flood Event	Number of Properties Impacted by flooding			
	Residential		Commercial/ Industrial	Total
	External Damage only	Above floor Flooding		
20% AEP	0	0	0	**0**
10% AEP	0	0	1**	**1**
5% AEP	2	1	1**	**4**
2% AEP	11	8	5	**24**
1% AEP	17	15	5	**37**
0.5% AEP	86	146	29	**261**
0.2% AEP	98	179	33	**310**
Extreme Flood	106	306	40	**452**

**Darlington Point Caravan Park

Table 11 indicates that above floor inundation is not predicted to occur across any residential properties in the areas of Darlington Point behind the levee until the 1% AEP design flood event for local flooding behind the levee. However, there are a number of properties that would experience external damage to the property without experiencing over floor flooding for the areas behind the levee in events as frequent as the 20% AEP design flood event. Sixteen (16) properties are estimated to experience external damage in floods as frequent as the 20% AEP design flood event, increasing up to thirty (30) during the 1% AEP design flood event. During the extreme local flood event, 158 residential properties are estimated to be impacted by over floor flooding, 24 commercial and industrial and an additional 97 residential properties impacted by external flood damage.

Table 12 indicates that above floor inundation is not predicted to occur across any residential properties until the 5% AEP design flood event due to flooding in the Murrumbidgee River. During the 1% AEP event, 15 properties predicted to be impacted by above floor inundation as a result of a 1% AEP design flood event in the Murrumbidgee River. However, an additional 17 properties are estimated to be impacted by external flood damage. One (1) commercial property is anticipated to be impacted by over floor flooding in events as frequent as the 10% AEP design flood event in the Murrumbidgee River. This property is the Darlington Point caravan park. Five (5) commercial and industrial properties are estimated to be impacted by over floor flooding in the 1% AEP design flood event in the Murrumbidgee River. During the extreme Murrumbidgee River flood event, 306 residential properties and 33 commercial and industrial properties are estimated to be impacted by over floor flooding, and an additional 106 residential properties impacted by external flood damage. During this extreme flood event, properties behind the levee would be impacted by mainstream flooding as the levee has been designed to breach before the flood levels reach the extreme food level in the Murrumbidgee River.

Table 13 indicates the estimated flood damages that would occur under existing conditions as a result of flooding for those properties located behind the levee in Darlington Point. It indicates that if a 1% AEP local overland flood was to occur, approximately $574,740 worth of damage could be expected.

Table 14 summarises the estimated cost of flood damage as a result of flooding from the Murrumbidgee River under existing conditions. It indicates that if a 1% AEP flood was to occur, just over $1.7 million worth of damage could be expected across the study area. These damage impacts are estimated to increase a significant amount for flooding above the 1% AEP design flood event, with flood damage estimated at over $13 million during the 0.5% AEP design flood event, rising to over $30 million during the extreme flood event.

The damage estimates were also used to prepare an Average Annual Damage (AAD) estimate for each property. The AAD provides an estimate of the average annual cost of inundation across the study area over an extended timeframe (in effect, how much money would be need to set aside each year in order to pay for flood damage costs). The AAD for the study area for existing conditions were calculated as follows:

- AAD for mainstream flooding = **$165,188**
- AAD for local flooding behind the levee= **$81,176**

Table 13 Flood Damages Cost Estimates as a result of local flooding behind the levee only.

Flood Event	Flood Damages ($)		
	Residential	Commercial/ Industrial	Total Damages
20% AEP	$197,660	$23,154	**$220,814**
10% AEP	$289,206	$23,132	**$312,338**
5% AEP	$359,926	$24,562	**$384,488**
2% AEP	$419,978	$25,629	**$445,670**
1% AEP	$530,389	$44,342	**$574,740**
0.5% AEP	$637,739	$45,504	**$683,343**
0.2% AEP	$776,362	$47,213	**$823,575**
PMF	$12,718,881	$792,729	**$13,511,610**

Table 14 Flood Damage Cost Estimates as a result of Murrumbidgee River flooding only

Flood Event	Flood Damages ($)		
	Residential	Commercial/ Industrial	Total Damages
20% AEP	0	0	**$ -**
10% AEP	0	$33,096	**$33,096**
5% AEP	$105,791	$69,219	**$175,010**
2% AEP	$638,948	$296,802	**$935,750**
1% AEP	$1,347,270	$389,238	**$1,736,508**
0.5% AEP	$12,252,069	$1,209,652	**$13,461,721**
0.2% AEP	$14,531,866	$1,621,824	**$16,153,690**
Extreme Flood	$27,162,342	$3,258,438	**$30,420,780**

These numbers are the best estimate of the extent of damage as a result of flooding within the study area only. These estimates do not consider the impact of flooding below floor level on agriculture or more rural activities that are undertaken on the larger properties surrounding Darlington Point. Those impacts will be assessed as part of the review of the rural floodplain management plan for the Murrumbidgee River.

It should also be noted that the primary objective of the flood damages assessment is to gain an understanding of the flooding in the study area that is likely to be experienced under current conditions. These estimates are also used for comparative purposes of the economic benefits of potential flood modification measures.

5.1.2 Flood Emergency Response Precincts

In an effort to understand the potential emergency response requirements across different sections of the floodplain, flood Emergency Response Precinct (ERP) classifications were prepared in accordance with the flow chart shown in **Plate 13** (Australian Emergency Management Institute, 2014) for the study area. The ERP classifications can be used to provide an indication of areas which may be inundated and/or isolated during floods. This information, in turn, can be used to quantify the type of emergency response that may be required across different sections of the floodplain during future floods. This information can be useful in emergency response planning.

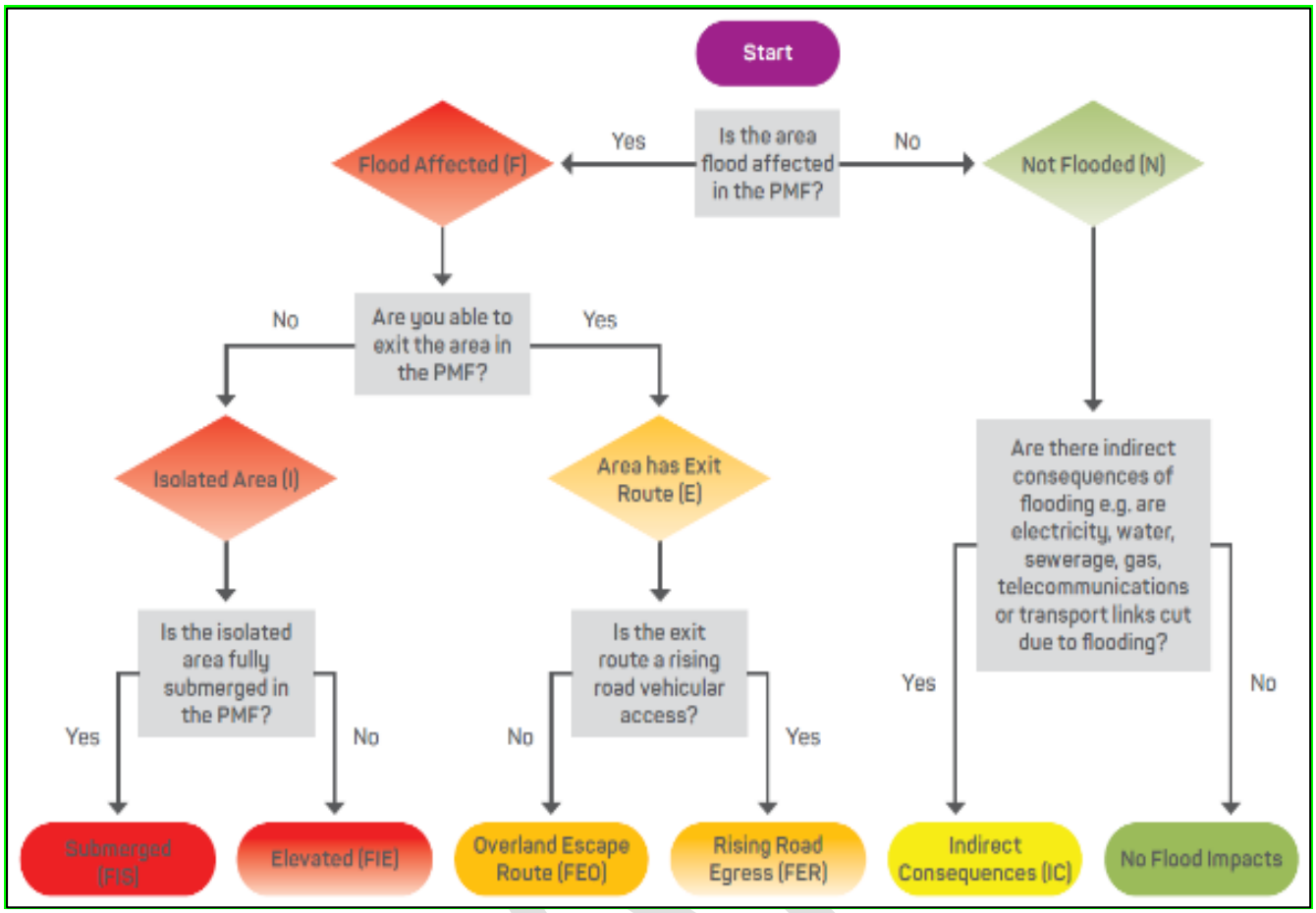


Plate 13 Flow Chart for Determining Flood Emergency Response Classifications (AEMI, 2014).
NOTE: PMF in figure above refers to extreme flood event" considered in this study.

Each lot within the study area was classified based upon the ERP flow chart for the 5% AEP, 1% AEP and the extreme design flood event. This was completed using the TUFLOW model results, digital elevation model and a road network GIS layer in conjunction with proprietary software that considered the following factors:

- Whether evacuation routes/roadways get "cut off" by the depth of inundation (a 0.15 m depth threshold was used to define a "cut" road).
- Whether evacuation routes continuously rise out of the floodplain.
- Whether properties become inundated.

Figures 36 to **38** reflect the estimated emergency response classification for the 5% AEP, 1% AEP and extreme flood events for the areas around Darlington Point. These figures reflect that emergency response classifications were done for each lot in the study area as per the cadastral information supplied by Council, although one ownership may stretch across several of the lots represented in the figures. A range of other datasets were also generated as part of the classification process to assist Council and the NSW SES. This includes roadway overtopping locations, which are discussed in more detail in **Section 5.1.3**.

The formal definition for "flooded exit route overland escape" route include evacuation routes that rely on an overland escape route that rise out of the floodplain. For this study, this definition has been updated to include evacuation routes that rely on informal roads or tracks within a property that may be used during non-flood times for access around the property

that appear to rise out of the floodplain (with the digital terrain information currently available).

The individual lots within Darlington Point have not been assessed on an induvial basis for Emergency Response Classification Precincts. The Emergency Response Classifications for Darlington Point properties protected by the levee are considered as a whole, and are based on the access roads in to and out of town. These are discussed in **Section 5.1.3**.

Two residential properties within the area of Darlington Point protected by the levee are impacted by local flooding in the 1% AEP design flood event, with flood depths less than 20mm estimated to occur across their floor levels. The current design flood estimation includes flooding within Darlington Point as a result of a breach in the levee during events greater than the 1% AEP design flood event. Breaching of the levee is estimated to impact a number of properties within Darlington Point, and is considered the control design flood event with regard to the emergency management and evacuation from the Darlington Point properties behind the levee.

Figures 36 to **38** reflect the estimated emergency response classification for the 5% AEP, 1% AEP and extreme flood events for the areas around Darlington Point. These figures reflect that emergency response classifications were done for each lot in the study area as per the cadastral information supplied by Council, although one ownership may stretch across several of the lots represented in the figures.

Figure 36 indicates that even in events as frequent as the 5% AEP design flood event, properties along the Sturt Highway to the south east of Darlington Point are considered as "flooded isolated submerged" (FIS). A number of properties to the south east and north of Darlington Point are considered as "flooded exit route overland escape" during the 5% AEP design flood event, which would involve having to travel over informal roads or tracks within the property towards a formal road or land that is flood free. This is not an ideal situation during a flood event if the track has not been maintained or cannot be easily traversed or has locked gates along its path.

Figure 37 indicates the number of properties considered as "flooded isolated submerged" (FIS) increases during the design 1% AEP design flood event, with a number of these properties located in north Darlington Point. There are a number of properties considered as "flooded isolated elevated" to the north and south of Darlington Point during the 1% AEP design flood event, which indicates that evacuation routes are likely to be cut during these design flood events although parts of the lot remain elevated above the extreme flood level.

Figure 38 indicates that a significant number of properties around Darlington Point would be considered "flooded isolated submerged" (FIS) across a large geographic area during an extreme flood event. A review of the flood hazard mapping was completed to determine whether the buildings located in these areas are likely to remain structurally stable and, therefore, whether there was potential to seek refuge in place rather than trying to evacuate in an extreme flood with the current emergency service resources available.

Figures 40 and 41 indicate areas where the high hazard flooding (hazard categories H4, H5 and H6 as per **Section 4.2.4)** and the emergency response classifications to get an indication

of where the high flood risk precincts are located. The biodiversity constraints are also included on these figures, which gives a clearer understanding of where high flood risk area are estimated to be located for development such as buildings and structures and were development would be excluded due to biodiversity constraints.

This assessment determined that only a few of the lots where there is currently development would actually be exposed to high flood hazard where the structural integrity of building cannot be guaranteed. A further detailed review of these lots indicates the Darlington Point Caravan Park is located within this high flood risk precinct, and the remainder of the lots are zoned RU1 – Primary Production. Where the lots are zoned RU1 – Primary Production, almost the entire lot is covered by agricultural development. Thus, any future development on these lots should take into account the flood emergency response classification of that lot, and the potential to improve on this classification as a result of the location of that development. The existing emergency response requirements of these lots, the NSW SES should be made aware of where any buildings or structures are located on these lots identified as high flood risk precinct, and consider evacuation essential from those buildings or structures, rather than refuge in place, during future large flood events.

5.1.3 Transportation Links

The Sturt Highway and the Kidman Way are two important transport links in the Riverina region and the main route in to and out of Darlington Point. As such, they would both be required for evacuation and emergency services access during flood events. It is important to understand the impacts of flooding on these roads so that appropriate emergency response planning can occur.

An assessment of the location where roadways are first predicted to be overtopped was completed as part of the Flood Emergency Response Precinct classifications discussed in **Section 5.1.2**. **Plate 14** below identifies the roadway over topping locations considered in this study. The roadway overtopping locations are also shown as yellow dots in **Figures 36** to **38** as part of the mapping for the Flood Emergency Flood Precincts**.**

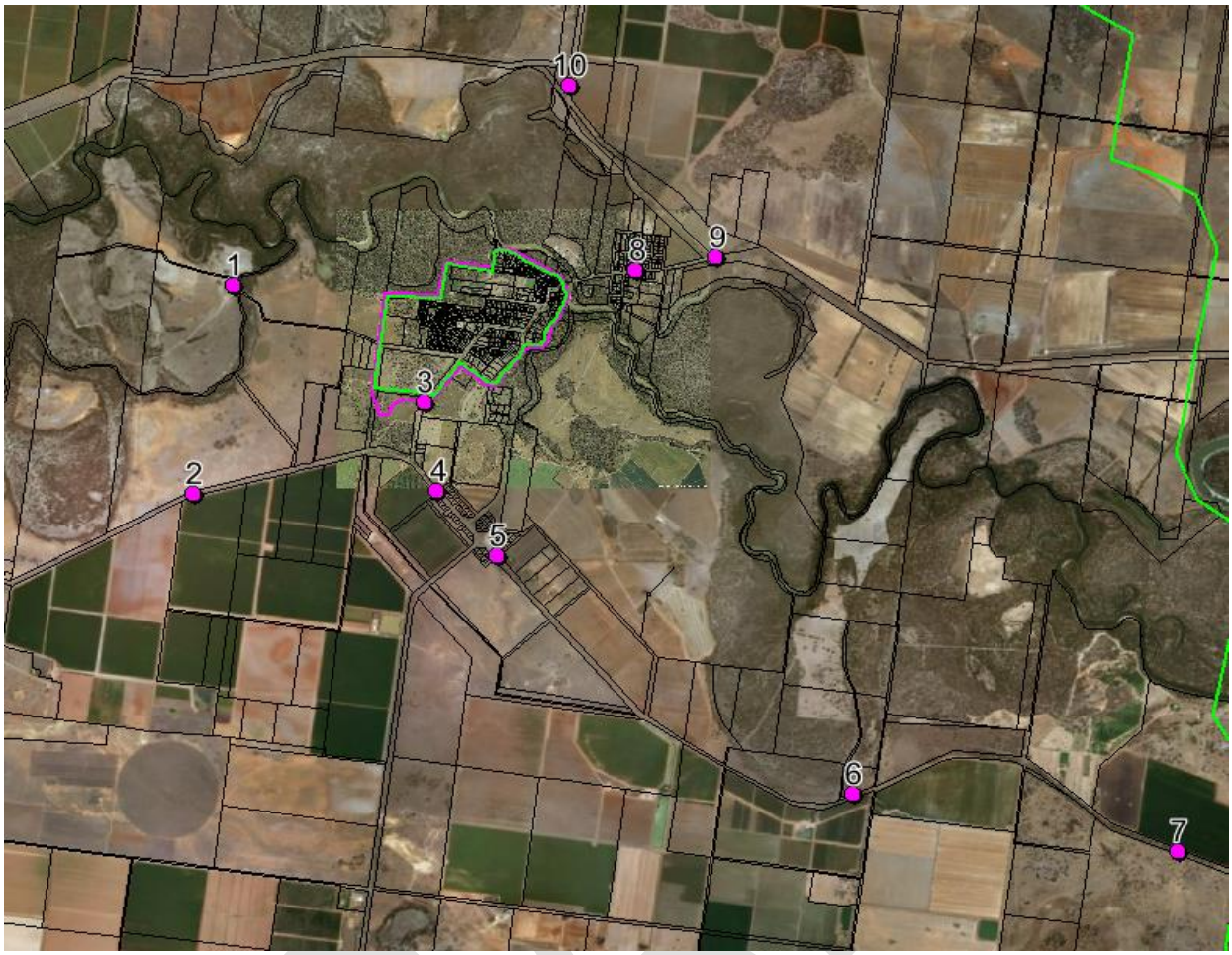


Plate 14 Road Over topping locations identified in this study

Table 15 Road Segments Where Access Would be Cut During a Design Flood event

Location	Description
1	Western Exit on Britts Road near Uri Creek crossing
2	South Western Exit on Sturt Highway
3	South on the exit from levee on Hay Road
4	South on the Sturt Highway near Bundre St
5	South on the Sturt Highway Kulkie St
6	South East exit on Sturt Highway near Cavaso
7	South East exit on the Sturt Highway near Altina Wildlife Park
8	North East exit on Intersection of Narrand St and The Kidman Way
9	North East exit on Whitton Darlington Point Rd
10	North Exit on Kidman Way

Table 16 Gauge and Flood levels at which road segments would be Cut

Flood level (mAHD)	Height at Murrumbidgee Gauge 410021 (m)	Consequences
125.25	7.39	Access cut on Location 9
125.42	7.55	Access cut on Location 1,9
125.77	7.91	Access cut on Location 1,3,5,9,10
125.94	8.08	Access cut on Location 1,3,5,6,7,9,10
126.10	8.24	Access cut on Location 1,2,3,4,5,6,7,8,9,10

Due to the importance and the highly trafficked nature of The Sturt Highway and the Kidman Way, any inundation on these roads is likely to cause significant disruption during the less frequent flood event. This in turn increases the potential for motorists to attempt to drive through floodwaters.

The Kidman Way is vulnerable to flooding at Mirrool Creek, which passes under The Sturt Highway approximately 18 kilometres north of north Darlington Point. The study completed for Griffith City Council "Griffith Main Drain and Mirrool Creek Floodplain Risk Management Study and plan" by BMT in 2015 states that the Kidman Way remained trafficable during the 2012 flood event, with the 2012 estimated as approximately a 0.5% AEP flood event at this location. Therefore, for floods greater than the 0.5% AEP, The Kidman Way is vulnerable to flooding in areas north of Darlington Point.

It is also to be highlighted that The Sturt Highway has been inundated by floodwaters in historical flood events outside the extent of this study area to both the east and the west. The location and extent of flood impacts at these locations is outside the scope of this study and cannot be accurately defined and reproduced here based on flood information currently available. The Narrandera Floodplain Risk Management Study and Plan, prepared by Lyall and Associates, on behalf of Narrandera Shire Council in 2019, includes consideration of flooding of the Sturt Highway, however this information does not extend to the Murrumbidgee Shire LGA boundary. As such, although the above information presents the flood risks on the roads based in this study area, there may be greater flood risks on the roads just outside of the study area that have not been identified.

It should be noted that under no circumstances should vehicles attempt to drive through floodwaters regardless of the floodwater depth or the type of vehicle they are driving.

5.1.4 Vulnerable and Critical Infrastructure

Darlington Point is home to a range of property types and infrastructure. This includes facilities where the occupants may be particularly vulnerable during floods, such as schools. In addition, some facilities will play important roles for emergency response and evacuation purposes during future floods. Therefore, it is important to understand the potential vulnerability of these facilities during a range of floods.

A summary of vulnerable and critical facilities located within the study area was provided in **Section 2.4.3** and the location of each facility is shown on **Figure 8**. All but 2 of these of

vulnerable and critical facilities are located within the areas protected by the levee. The Darlington Point Caravan Park and the electricity sub-station along the northern sections of The Kidman Way to the north of north Darlington Point are located outside of the levee and are both vulnerable to flooding.

The flood modelling results were interrogated to extract the following information:

Table 17 Critical and Vulnerable Facilities outside the levee vulnerable to flooding.

Design flood event	Depth of flooding estimated across property	
	Darlington Point Caravan Park	Electricity sub station
10% AEP	0.15m	N/A
5% AEP	0.53m	N/A
2% AEP	0.90m	N/A
1% AEP	1.05m	0.04
0.5%AEP	1.15m	0.09
0.2% AEP	1.24m	0.12
Extreme flood event	1.59m	0.37

The information presented in **Table 17** highlight the vulnerability of the Darlington Point caravan park to flooding. It is subject to at least partial inundation during events as frequent as the 10% AEP design flood event. The depth and velocity of floodwater is unlikely to pose a hazard to people during the 5% AEP design flood event and is currently estimated as H3 flood hazard. This flood hazard at the caravan park dramatically increases to H4 and H5 during the 1% AEP design flood event, which is not safe for people or vehicles. Less robust buildings are vulnerable to failure during the H5 design flood event.

The electricity sub-station to the north of north Darlington Point is first impacted by floodwaters during the 1% AEP design flood event, however the Kidman Way (Location number 10 on **Plate 14**) is more vulnerable to flooding and is impacted by floodwaters during more frequent events.

6 Existing Planning Information

6.1 National Planning Provisions

6.1.1 National Construction Code

The National Construction Code (NCC) is a performance-based code containing all Performance Requirements for the design and construction of buildings. It is based on a hierarchy of guidance and compliance with specified codes, with the design and construction of buildings and their elements having to satisfy the Performance Requirements. The 2019 edition of the NCC incorporated the Building Code of Australia (Volumes 1 and 2) and Plumbing Code of Australia (Volume 3).

The 2016 edition of the Building Code of Australia (BCA) introduced new requirements related to building in Flood Hazard Areas (FHAs), which provide a minimum construction standard across Australia for specified building classifications in FHAs up to the Defined Flood Event (DFE).

The Defined Flood Event (DFE) is equivalent to the flood planning flood event and in NSW is generally the 1% Annual Exceedance Probability (AEP) design flood. Flood Hazard Areas (FHA) are defined in the BCA as encompassing land lower than the flood hazard level (FHL), which in turn is defined as 'the flood level used to determine the height of floors in a building and represents the DFE plus the 'freeboard'. Therefore, FHAs would typically be defined as those areas falling within the flood planning area.

Volume One, Sections BP1.4 and Volume Two, Sections P2.1.2 of the NCC specify the Performance Requirements for the construction of buildings in FHA. They only apply to buildings, or parts of buildings, of Classes 1, 2, 3, 4 (residential), 9a (health-care) and 9c (aged-care). These Performance Requirements require a building in a Flood Hazard Area to be designed and constructed to resist flotation, collapse and significant permanent movement resulting from flood actions during the Defined Flood Event. The actions and requirements to be considered to satisfy this performance requirement include but are not limited to:

- Flood actions;
- Elevation requirements;
- Foundation and footing requirements;
- Requirements for enclosures below the flood hazard level;
- Requirements for structural connections;
- Material requirements;
- Requirements for utilities; and
- Requirements for occupant egress.

The Deemed-to-Satisfy (DTS) provisions of Volume One, B1.6 and Volume Two, 3.10.3.0 require buildings in the Classes described above and located in FHAs to comply with the ABCB *Standard for Construction of Buildings in Flood Hazard Areas 2012* (the ABCB Standard).

The ABCB Standard specifies detailed requirements for the construction of buildings to which the BCA requirements apply, including:

- Resistance in the Defined Flood Event to flood actions including hydrostatic actions, hydrodynamic actions, debris actions, wave actions and erosion and scour;
- Floor height requirements, for example that the finished floor level of habitable rooms must be above the Flood Hazard Level;
- The design of footing systems to prevent flotation, collapse or significant permanent movement;
- The provision in any enclosures of openings to allow for automatic entry and exit of floodwater for all floods up to the Flood Hazard Level;
- Ensuring that any attachments to the building are structurally adequate and do not reduce the structural capacity of the building during the Defined Flood Event;
- The use of flood-compatible structural materials below the Flood Hazard Level;
- The siting of electrical switches above the Flood Hazard Level, and flood proofing of electrical conduits and cables installed below the Flood Hazard Level; and
- The design of balconies etc. to allow a person in the building to be rescued by emergency services personnel, if rescue during a flood event up to the Defined Flood Event is required.

Building Circular BS13-004 (NSW Department of Planning and Infrastructure, 2013) summarises the scope of the Building Code of Australia and how it relates to NSW planning arrangements. The scope of the ABCB Standard does not include parts of Flood Hazard Area that are subject to flow velocities exceeding 1.5 m/s or are subject to mudslide or landslide during periods of rainfall and runoff or are subject to storm surge or coastal wave action.

It is particularly noted that the Standard applies only up to the Defined Flood Event, which typically will correspond to the level of the 1% AEP flood plus 0.5 m freeboard. The Building Circular emphasises that because of the possibility of rarer floods, the Building Code of Australia provisions do not fully mitigate the risk to life from flooding.

The ABCB has also prepared an *Information Handbook for the Construction of Buildings in Flood Hazard Areas*. This Handbook provides additional information relating to the construction of buildings in Flood Hazard Area but is not mandatory or regulatory in nature.

In the NSW planning system, the Building Code of Australia (BCA) takes on importance for complying development under the *State Environmental Planning Policy (Exempt and Complying Development Codes) 2008*. The Building Circular also indicates that following development approval, an application for a construction certificate (CC) will require assessment of compliance with the BCA.

6.1.2 Flood Information to Support Land Use Planning

Australian Disaster Resilience Handbook 7 *Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia* (AIDR 2017) identifies the essential role of land-use

planning in limiting the growth in flood risk associated with new land uses and development in the floodplain. Guideline 7-5, *Flood Information to Support Land Use Planning*, sets out a method for translating products from flood studies into Flood Planning Constraint Categories (FPCCs) to better inform land-use planning activities.

This guideline delineates flood liable land into one of four major "constraint" categories (with several subcategories) based upon key flooding considerations such as flood hazard, flood function and emergency response. The resulting categories can serve to inform land use planning activities. The guideline notes that the categorisation is intended to support community/precinct scale decisions where flow paths and flood extents can be readily defined and was not developed to support change of land use or development at the lot/site scale.

The Guideline's Flood Planning Constraint Categories are set out in **Table 18** below. A FPCC of "1" implies a more flood constrained section of land relative to FPCC category "2", and so on.

The flood hazard categories for the Murrumbidgee River at Darlington Point were defined in **Section 4.2.4**. Australian Disaster Resilience Handbook 7 *Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia* (AIDR 2017) describes hazard categories H4, H5 and H6 have as unsafe for people and vehicles. Hydraulic categories for the Murrumbidgee River at Darlington Point were defined in **Section 4.2.5.** The higher flood hazard categories of H4, H5 and H6 have been overlapped with the Emergency Response Categories for the study area and are presented on **Figures 40 and 41** for the 1% AEP design flood event and the extreme flood event respectively.

The information presented on **Figures 40 and 41** closely represent the Guideline's Flood Planning Constraint Categories 1 and 2 for the 1% AEP design flood and extreme flood event. Within the study area, there are a number of properties where the Emergency Response Categories has been identified as "Flood Isolated Submerged" and "Flood Isolated Elevated" and overlap with the H4 and H5 hazard categories. H6 hazard categories are generally maintained within the banks of the Murrumbidgee River and anabranches and are generally considered to fall within the FPCC of 1.

The aim of presenting the information on **Figures 40 and 41** without formally identifying them as Flood Planning Constraint Categories is to highlight the areas where careful consideration is required for future planning and development. With proposed future development needing to be compatible with the flood hazard, these constrained areas indicate that any type of critical or vulnerable developments would not be suitable to be located within them. These constrained lands are generally covered by the RU1 Primary Production zone and E1 National Parks and Nature Reserve zone and are a good indication of where more permanent structures or facilities associated with these land uses should not be located as part of any future development.

Table 18 Flood Planning Constraint Categories (AIDR, 2017)

FPCC	Description	Discussion
1a	Flow conveyance and storage areas in the DFE	Majority of development and uses vulnerable to failure and/or likely to have adverse flood impacts. Most development in these areas should be limited and any development must be designed to maintain the current flood function.
1b	H6 hazard in the DFE	
2a	Flow conveyance in events larger than the DFE	Many uses in these areas will be vulnerable to high flood hazard during large floods and/or have the potential to be isolated leading to evacuation difficulties. Vulnerable land uses not suitable for these areas and new development of any new development should be limited to those compatible with higher hazard conditions (i.e., special development conditions should be applied).
2b	Flood hazard H5 in the DFE	
2c	Emergency response—isolated and submerged areas	
2d	Emergency response—isolated but elevated areas	
2e	Flood hazard H6 in floods larger than the DFE	
3	Outside FPCC2 — generally below the DFE and the freeboard	Compatible with most development types/land uses subject to appropriate development controls being applied to reduce potential for flood damage/exposure. Generally, not suitable for vulnerable land uses.
4	Outside FPCC3, but within the probable maximum or extreme flood	Compatible with most development types. Vulnerable facilities may still require development controls

6.2 NSW State Planning Provisions

6.2.1 Environmental Planning and Assessment Act 1979

The NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) provides the over-arching legislative framework for planning and development in NSW. It creates the mechanism for development assessment and protection of the environment from adverse impacts arising from development. The EP&A Act 1979 outlines the level of assessment required under State, regional and local planning legislation and identifies the responsible assessing authority.

Section 9.1 Directions – Direction No. 4.3 (Flood Prone Land)

NSW flood related planning requirements for local councils are set out in Ministerial Direction No. 4.3 Flood Prone Land, issued in 2007 under the then Section 117 (now Section 9.1) of the EP&A Act 1979. It requires councils to ensure that development of flood prone land is consistent with the NSW Government's Flood Prone Land Policy as set out in the *Floodplain Development Manual* (NSW Government, 2005). It requires provisions in a Local Environmental Plan on flood prone land to be commensurate with the flood hazard of that land. In particular, a planning proposal must not contain provisions that:

- Permit development in floodway areas;
- Permit development that will result in significant flood impacts to other properties;
- Permit a significant increase in the development of that land;
- Are likely to result in a substantially increased requirement for government spending on flood mitigation measures, infrastructure or services; and

- Permit development to be carried out without development consent except for the purposes of agriculture, roads or exempt development.

The Direction also requires that councils must not impose flood related development controls above the residential flood planning level (FPL, typically the 1% AEP flood plus 0.5m freeboard) for residential development on land, unless a relevant planning authority provides 'adequate justification' for those controls to the satisfaction of the Director-General.

The question as to whether flood behaviour in the Murrumbidgee River at Darlington Point warrants the imposition of flood related development controls above the residential flood planning level is considered in **Section 6.2.5**.

At the time of preparing this report (September 2020), the NSW Department of Planning, Industry and Environment was undertaking a review of the Direction related to Flood Prone Land.

6.2.2 Environmental Planning and Assessment Regulation 2000

The *Environmental Planning and Assessment Regulation 2000* supports the implementation of the *Environmental Planning and Assessment Act 1979 (*EP&A Act 1979). It provides a number of key provisions for the state-based planning legislation, including planning instruments and development control plans, planning proposals, planning certificates and requirements for environmental assessment under Part 5 of the EP&A Act 1979.

Planning certificates are a means of disclosing information about a parcel of land by providing information on how the land may be used and the restrictions on development of that land. Two types of information are provided in planning certificates: information under Section 10.7(2) and information under Section 10.7(5) of the EP&A Act 1979. The information that can be included on a Section 10.7(2) certificate is prescribed by the *Environmental Planning and Assessment Regulation 2000 (Schedule 4).*

A planning certificate under Section 10.7(2) discloses matters relating to the land, including whether or not the land is affected by a policy that restricts the development of land. Those policies can be based on identified hazard risks (*Environmental Planning and Assessment Regulation 2000*, Clause 279 and Schedule 4 Clause 7), and whether development on the land is subject to flood-related development controls (EP&A Regulation, Schedule 4 Clause 7A). A lot that is a 'flood control lot' under the Codes SEPP is a prescribed matter for the purpose of a certificate under Section 10.7(2). If no flood-related development controls apply to the land (such as for residential development in areas above the flood planning level), information describing the flood affectation of the land would not be indicated under Section 10.7(2).

A planning certificate may also include information under Section 10.7(5). This allows a council to provide advice on other relevant matters affecting land. This can include past, current or future issues that are considered relevant to that parcel of land.

Inclusion of a planning certificate containing information prescribed under section 10.7(2) is a mandatory part of the property conveyancing process in NSW. The conveyancing process does not mandate the inclusion of information under section 10.7(5) but any purchaser may request such information be provided, often pending payment of a fee to the issuing council.

Some Councils issue the Section 10.7(5) certificate concurrently with the Section 10.7(2) certificate.

6.2.3 Other state government legislation

There is a range of state government legislation that would have to be considered during the design of floodplain risk management options in this study area. These include:

Fisheries Management Act 1994

The objectives of the *Fisheries Management Act 1994* (*FM Act 1994*) are to conserve, develop and share the fishery resources of the State for the benefit of present and future generations. Approval is required under the *FM Act 1994* for any proposed dredging or reclamation works on water land.

Water Management Act 2000

The objective of the *Water Management Act 2000* (*WM Act 2000*) are to provide for the sustainable and integrated management of the water sources of the State for the benefit of both present and future generations. This legislation seeks to ensure that water is provided for the environmental health of rivers and groundwater systems while providing more secure access to water users. Controlled activities carried out in, on, or under waterfront land are regulated by the *WM Act 2000*. A controlled activity approval must be obtained from the NSW Government before commencing any controlled activity.

It is to be noted that this current study differs to Floodplain Management Plans (FMP) prepared under Part 3 of the *WM Act 2000* (historically prepared under Part 8 of the *Water Act 1912)*, commonly referred to as rural floodplain management plans.

Local Land Services Act 2013

Clearing of native vegetation on rural land is legislated by the *Local Land Services Act 2013* and the *Biodiversity Conservation Act 2016* (discussed below). The objectives of the *LLS Act 2013,* are, amongst several others, to ensure the proper management of natural resources in the social, economic and environmental interests of the State, consistently with the principles of ecologically sustainable development.

Travelling stock reserves are also managed under the *LLS Act 2013*. Part 6 of the *LLS Act 2013* provides for the management and regulation of the use of travelling stock reserves that are fully controlled by Local Land Services and those that are not fully controlled but are management by Local Land Services and of public roads.

Biodiversity Conservation Act 2016

The purpose of the *Biodiversity Conservation Act 2016* is to maintain a healthy, productive and resilient environment for the greatest well-being of the community, now and into the future, consistent with the principles of ecologically sustainable development. *The BC Act 2016* applies to animals and plants and not marine vegetation or fish. The *BC Act 2016* establishes a framework for assessing and reporting biodiversity impacts as a result of development, and offsetting of any adverse biodiversity impacts predicted as a result of the proposed development.

Heritage Act 1977

The objectives of the NSW *Heritage Act 1977* include the conservation of the heritage and the identification and registration of items of both local and State heritage significance. The Heritage Act 1977 relates to a place, building, work, relic, moveable object or precinct, means significance to the State in relation to the historical, scientific, cultural, social, archaeological, architectural, natural or aesthetic value of the item.

National Parks and Wildlife Act 1974

Aboriginal Cultural Heritage is managed through the *NSW National Parks and Wildlife Act 1974*. This includes the identification, assessment and management of Aboriginal cultural heritage items and land and for the proper care, preservation and protection of these items or lands.

At the time of writing, the NSW Government was in the process of developing a new system for the management and conservation of Aboriginal Cultural heritage.

6.2.4 State Environmental Planning Policies

State Environmental Planning Policies (SEPPs) are the highest level of planning instrument and generally prevail over Local Environmental Plans.

SEPP (Housing for Seniors or People with a Disability) 2004

State Environmental Planning Policy (Housing for Seniors or People with a Disability) 2004 aims to encourage the provision of housing (including residential care facilities) that will increase the supply of residences that meet the needs of seniors or people with a disability. This is achieved by setting aside local planning controls that would prevent such development.

Clause 4(6) and Schedule 1 indicate that the policy does not apply to land identified in another environmental planning instrument (such as Murrumbidgee LEP 2013) as being, amongst other descriptors, a floodway or high flooding hazard.

SEPP (Infrastructure) 2007

State Environmental Planning Policy (Infrastructure) 2007 aims to facilitate the effective delivery of infrastructure across the State by identifying development permissible without consent. *SEPP (Infrastructure) 2007* overrules local planning provisions, including Murrumbidgee LEP 2013. *SEPP (Infrastructure) 2007* allows Council to undertake stormwater and flood mitigation work without development consent and Transport for NSW to undertake certain roadworks without development consent.

SEPP (Exempt and Complying Development Codes) 2008

An important SEPP is *State Environmental Planning Policy (Exempt and Complying Development Codes) 2008*, which defines development which is exempt from obtaining development consent and other development which does not require development consent if it complies with certain criteria.

Clause 1.5 of this 'Codes' SEPP defines a 'flood control lot' as:

'*a lot to which flood related development controls apply in respect of development for the purposes of industrial buildings, commercial premises, dwelling houses, dual occupancies, multi dwelling housing or residential flat buildings (other than development for the purposes of group homes or seniors housing)*'.

These development controls may apply through a LEP or DCP. Exempt development is not permitted on flood control lots, but some complying development is permitted.

Part 3 of the 'Codes' SEPP relates to the *General Housing Code*, which applies to land zoned R1, R3, R4 or RU5. Part 3A of the 'Codes' SEPP relates to the *Rural Housing Code*, which applies to land zoned RU1, RU2, RU3, RU4, RU6 and R5.

Clause 3.1 to 3.6 relates to development that is considered as complying development under the 'Codes' SEPP, with Clause 3.5 related to complying development on flood control lots. Clause 3A.38 of the *Rural Housing Code* lists the same details for flood control lots of the land it applies to. Clause 3.5 and 3A.38 states that complying development is permitted on flood control lots where a Council or professional engineer can certify that the part of the lot proposed for development is not a:

- flood storage area,
- floodway area,
- flow path,
- high hazard area or
- high-risk area.

The Codes SEPP specifies various controls in relation to floor levels, flood compatible materials, structural stability (up to the PMF if on-site refuge is proposed), flood affectation, access, and car parking.

In addition, Clause 1.18(1)(c) of the Codes SEPP indicates that complying development must meet the relevant provisions of the Building Code of Australia.

In order to facilitate the process of applying for complying development, the preparation and sharing of the following spatial information is advantageous:

- Land that is a flood control lot. This will reflect the standards set in the Local Environmental Plan (LEP) and Development Control Plan (DCP), which shape the flood planning area.
- Land where Council is confident a Complying Development Certificate (CDC) could be issued, that is, where the land in a flood control lot is not a flood storage area, floodway area, flow path, high hazard area or high-risk area. Consideration of 'risk' implies that factors in addition to flood hazard, such as available warning time and evacuation constraints and the role of the levee in setting flood planning levels are important considerations in mapping where CDCs could be issued.

6.2.5 NSW Flood Related Manuals

Flood Prone Land Policy and Floodplain Development Manual, 2005

The overarching policy context for floodplain management in NSW is provided by the NSW Flood Prone Land Policy, contained within the *Floodplain Development Manual* (NSW Government, 2005). The Policy aims to reduce the impacts of flooding and flood liability on individual owners and occupiers of flood prone property and to reduce private and public losses resulting from floods, using ecologically positive methods wherever possible. The Manual espouses a merit approach for development decisions in the floodplain, taking into

account social, economic, ecological and flooding considerations. The primary responsibility for management of flood risk rests with local councils. The Manual assists councils in their management of the use and development of flood prone land by providing guidance in the development and implementation of local floodplain risk management plans.

At the time of preparing this report, the NSW Floodplain Development Manual was under review by the NSW Department of Planning, Industry and Environment.

Guideline on Development Controls on Low Flood Risk Areas, 2007

The *Guideline on Development Controls on Low Flood Risk Areas – Floodplain Development Manual* (the Guideline) was issued on 31 January 2007 as part of Planning Circular PS 07-003 at the same time as the Section 117 (now Section 9.1) Direction described previously. The Guideline is intended to be read as part of the *Floodplain Development Manual*.

It stipulates that *"unless there are exceptional circumstances, councils should adopt the 100-year flood as the flood planning level (FPL) for residential development"* and that "*unless there are exceptional circumstances, councils should not impose flood related development controls on residential development on land … that is above the residential FPL*".

Flood related development controls are not defined but would include any development standards relating to flooding applying to land, that are a matter for consideration under Section 4.15 (previously Section 79C) of the EP&A Act.

The Guideline states that councils should not include a notation for residential development on Section 10.7 (previously Section 149) certificates for land above the residential flood planning level if no flood related development controls apply to the land. However, the Guideline does include the reminder that councils can include 'such other relevant factors affecting the land that the council may be aware [of]' under Section 10.7(5) of the *EP&A Act 1979*.

In proposing a case for exceptional circumstances, a council would need to demonstrate that a different Flood Planning Level was required for the management of residential development due to local flood behaviour, flood history, associated flood hazards or a particular historic flood. Justification for exceptional circumstances would need to be agreed by relevant State Government departments prior to exhibition of a draft local environmental plan or a draft development control plan that proposes to introduce flood related development controls on residential development above the default FPL.

At the time of preparing this report, the Guideline was under review by the NSW State Government.

6.3 Local Planning Provisions

Murrumbidgee Local Environmental Plan 2013 (Murrumbidgee LEP 2013) is the statutory planning document used by Murrumbidgee Council for planning and development in the Murrumbidgee LGA. Murrumbidgee LEP 2013 is made up of a written instrument with maps. Murrumbidgee LEP 2013 outlines the zoning of land, permissible development within each land use zone and any special provisions that apply to land within the LGA.

There are no Flood Planning Area Maps that accompany the written instrument (as provided on the http://www.legislation.nsw.gov.au website) for the Murrumbidgee LGA.

6.3.1 Murrumbidgee Local Environmental Plan 2013

Figure 5 shows the current zonings incorporated in Murrumbidgee LEP 2013 relevant to the study area. Most of the area of Darlington Point protected by the levee is zoned RU5 - Village. There are small areas behind the recently upgraded levee, in the north-west and southern parts of Darlington Point that are zoned RU1 - Primary Production. Most of north Darlington Point is also zoned RU5 - Village. There are some small areas within Darlington Point zoned RE1 - Recreation, and the area between Darlington Point and north Darlington Point, primarily occupied by the caravan park, is zoned RE1 - Public Recreation. Some of the land bordering the Murrumbidgee River is zoned as E3 - Environmental Management and E1 – National Parks and Nature Reserves.

Flood planning is addressed in Clause 6.2 of Murrumbidgee LEP 2013 and it replicates the standard model local provision Clause 7.3 developed by the NSW Department of Planning. This clause is reproduced in **Plate 15** below. There is no flood planning map related to Clause 6.2 of Murrumbidgee LEP 2013.

The appropriateness of the Murrumbidgee LEP 2013 for managing flood risk in the study area is considered under the following headings:

- Compatibility of existing land use with flood hazard
- Management of full range of flood risk
- Wording of Clause 6.2 of Murrumbidgee LEP 2013

6.2 Flood planning

(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 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.

(5) In this clause—

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

Plate 15 Extract from Murrumbidgee LEP Clause 6.2

Compatibility of existing land use with flood hazard

An assessment of the compatibility of the existing land use zoning under Murrumbidgee LEP 2013 with the national flood hazard categories, as defined in **Section 4.2.4**, was undertaken. The results of this assessment for the 1% AEP is presented on **Figure 42**, and **Figure 43** for the extreme riverine flood event**.**

Of most interest in reviewing the information presented in **Figures 42** and **43** is identification of land that is currently zoned for more urban development within flood hazard H5 and H6, as the depth and velocity of floodwater in these areas is sufficient to cause structural failure of buildings. Flood hazard H4 is also of interest as these flood hazards are also considered unsafe for people.

The results presented on **Figures 42** indicate that the current zoning is broadly compatible with the flood hazard in the study area for the 1% AEP design riverine flood event. The areas that are estimated to experience flood hazards of H4, H5 or H6 during the 1% AEP design riverine flood event are generally zoned RU1 Primary Production and E1 National Parks and Nature Reserves.

A greater area is subject to flood hazards of H4, H5 and H6 hazard during the extreme riverine flood event. Most of the land estimated to experience these high flood hazards is currently

used for rural and agricultural purposes, with few dwellings or structural buildings currently located within them. However, the current zoning and development controls may allow development in the future in these areas that are predicted to experience H4, H5 and H6 flood hazards during the extreme flood event. Therefore, consideration should be made to include floods greater than the 1% AEP design flood event in planning and development decisions.

There does not appear to be any critical or vulnerable development currently located within the high flood hazards areas of H4, H5 or H6 during both the 1% AEP design flood extent and extreme flood extent.

However, intensification of land uses within the floodplain, and particularly below the (proposed) flood planning level should be discouraged. Accordingly, the area around the junction of The Kidman Way and the Sturt Highway, to the south of Darlington Point, is currently zoned as RU5 Village and R5 Large Lot Residential and is located within the floodplain. **Figure 30** indicates the flood hazards during the 1% AEP design flood event as ranging from H1 to H3 across these lots. **Figure 31** indicates that the lots are generally covered in H3 flood hazards during the extreme food event. There are several existing residential developments on some of these lots, however the current zoning permits more residential development.

Therefore, it is recommended that Council consider changing the zoning in these areas from RU5 and R5 to a non-residential, or less intense residential land use, to minimise flood risk to future developments.

Management of full range of flood risk

Management of the residual risk involves consideration of floods greater than the planning design flood event, in this study area recommended to be the 1% AEP design flood event, up to and including the extreme flood event. Based on the level of flood risk that exists between these design flood events; inclusion of planning and development controls may be justified across the full extent of the floodplain. For the study area, residual food risk is considered to be closely associated with the evacuation management of the developments in the floodplain.

Evacuation challenges in the study area were considered in conjunction with the following matters:

- Effective flood warning time
- Flood duration
- Rate of rise of floodwaters
- Flood awareness

Effective flood warning time

Flood modelling undertaken as part of this study indicate that both the Kidman Way and the Sturt Highway could become inundated during a 1% AEP design flood event. Both of these roads would be used for evacuation purposes from Darlington Point, however this flooding would occur before the area behind the levee is impacted by riverine flooding. The floodwaters of the Murrumbidgee River take several weeks to reach Darlington Point once rainfall commences in the upstream parts of the catchment, and there is over 4 days of warning from Narrandera. Therefore, there is an effective warning time of at least 4 days, and

upwards to more than two weeks, of forthcoming flooding at Darlington Point. This is adequate time for residents, business owners, and the NSW SES to prepare for flooding in the study area.

Flood duration

Once the floodplain is inundated during the larger flood events, flood waters typically remain and inundate the floodplain around Darlington Point for a number of weeks. These floodwaters generally inundate the roads and the yards of many of the properties in the study area. In addition, 15 properties are estimated to be impacted by over floor flooding in the 1% AEP design flood event. This duration of inundation of the roads can have a negative influence on people's behaviour during a flood event, as they may be tempted to drive through flooded roads, particularly on the falling limb of the flood. This can be particularly troublesome as roads that have been inundated for a significant length of time are prone to surface and structure damage, as well as masking any debris that may have accumulated on the road surface. Vehicles traversing though these floodwaters pose a hazard to themselves and emergency services, should they require assistance if they get stuck.

Rate of rise of floodwaters

The rate of rise of floodwaters has been estimated as approximately 1.3 metres per day when the water is still within the Murrumbidgee River channel, dropping to 0.76 metres per day once bank full flow is reached and waters flow overland. Thus, there is adequate time to prepare for flooding, even once floodwaters can be seen flowing over the banks of the Murrumbidgee River.

Flood awareness

The community questionnaire undertaken during Stage 1 of this project highlighted a general awareness of the flood vulnerability of the Darlington Point and north Darlington Point area within members of the community. This is most likely due to a number of factors, including the frequency at which Darlington Point has experienced significant flooding (2010, 2012, 2016) and the duration of occupancy people reside in the study area (more than 70% of the respondents having lived in the area for more than 10 years and over 40% living in the area for more than 20 years). A good level of flood awareness will help reduce flood damages as people are generally more aware of the need to minimise personal and property losses before and during a flood event.

However, a large majority of the responses received during the community consultation undertaken during Stage 1 of this project stated that many residents will be preparing to stay during the next flood, and not evacuate, even if ordered to do so by the NSW SES. Thus, despite the extensive warning time available, the slow rate of rise of the floodwaters, and the high level of flood awareness throughout residents of the study area, it is anticipated that there may be evacuation difficulties with future flood events. This behaviour has the prospect of influencing others in the area to stay, who otherwise might have evacuated when ordered to do so.

Summary of the management of the full range of flood risk

This review of the management of the full range of flood risk in the study area indicates there is no obvious need for modification to the current Murrumbidgee LEP 2013 zones based on

residual flood risk in the study area. This assessment has been based on the residual flood risk as a result of current flood evacuation challenges and current land uses in the study area.

However, these current constraints indicate that the density of residential and commercial development should not be intensified for areas in the floodplain where evacuation during a flood may be necessary in future until the NSW SES has established a local unit or have updated their flood emergency management procedures for Darlington Point to a level where the NSW SES would support more residential development in the area. In addition, significant local flood awareness and education will need to be undertaken with the local community to ensure the residual flood risks are understood and emergency management procedures will be followed during future flood events. Evacuation is not a guarantee of reduction or elimination of flood risk, as it relies on human behaviour during a flood, which cannot be modelled or predicted accurately.

It needs to be noted that the NSW SES does not support the use of private evacuation plans as a condition of development consent. The NSW SES does not have the statutory authority to endorse, review or enforce private flood plans. The NSW Floodplain Development Manual 2005 also states that the use of private flood plans as part of development consent conditions, should be avoided.

Wording of clause 6.2 of Murrumbidgee LEP 2013

Clause 6.2 of the Murrumbidgee LEP 2013 stipulates a flood planning level that includes a 1% AEP design flood level and a 0.5 m freeboard. Specifying these amounts does not allow flexibility in the determination of the flood planning level or flood planning area. It is therefore recommended that Council seek to amend the definition of Flood Planning Level in the Murrumbidgee LEP 2013. Recommendations for these amendments are detailed in **Section 10.3.3**.

Other considerations on Murrumbidgee LEP 2013

There are a number of LEP clauses related to the environment and waterfront land that may impact on the feasibility of floodplain risk management in the study area. These include:

- Clause 6.3 - Terrestrial biodiversity
- Clause 6.5 - Riparian Lands and watercourses
- Clause 6.6 - Wetlands
- Clause 6.7 - Development on river front areas
- Clause 6.8 - Development on river beds and banks

Summary

This review indicates that the current Murrumbidgee LEP 2013 zoning appears to be broadly appropriate when considered in conjunction with the current flood hazards in the study area. That is, there is no obvious need for modification to the current Murrumbidgee LEP 2013 zones based on existing flood hazards and existing land use. Nevertheless, intensification of development that would result in more intense residential land uses below the flood planning level should be discouraged.

6.3.2 Murrumbidgee Development Control Plan 2013

Murrumbidgee *Development Control Plan No. 1 – Village* sets the design and construction standards that apply when carrying out development within Darlington Point and

Coleambally. It supports *Murrumbidgee* LEP 2013, which regulates the uses that are permissible on the land. The DCP relates to Clause 6.2 of Murrumbidgee LEP, which states that the flood planning level is the 1% AEP design flood level and a 500mm freeboard. No map is included within the DCP that indicates the flood planning area or where these flood related development controls may apply.

Darlington Point DCP appears to originate from around the year 1990, however it is not clear from what date the DCP was originally applied.

The DCP applies to all lands zoned as Village, therefore applies controls for a range of land uses, including:

- Residential,
- Commercial,
- General Industrial,
- Light Industrial,
- Special USES,
- Public Open space,
- Environment Protection.

The objectives of each of these different land uses, referred to as "precincts" with the Village areas, are defined in the DCP.

Under the controls for "Specific Area", reference to the Flood Plain Development is included. This states that the 1986 version of the DCP is adopted for the purposes of development under this flood plan.

No further flood related development controls are included in the *Development Control Plan No. 1 – Village.*

This current DCP is out of date and is not consistent with current best practice for development control plans in terms of objectives, consideration and requirements for development and standards. It does not reflect the current zonings of Murrumbidgee LEP 2013.

Current best practice for flood related development controls include consideration of:

- Controls to manage flood impacts.
- Controls to manage risk to life, including emergency management requirements.
- Flood planning levels and minimum floor level requirements for developments. These minimum floor levels may vary with different land uses and vulnerabilities to flooding.
- Appropriate building design and materials.
- Location of development relative to True Flood hazard.
- Requirements for flood impact assessments.
- Consideration of cumulative developments in the floodplain.
- Sustainable development, including consideration of climate change impacts on flooding.
- Requirements for flood impact assessments.
- Considerations for variations in development control standards.

Contemporary development control plans for flood related development controls include prescriptive controls that specify what development outcomes need to be achieved. In addition, if variation of these prescriptive controls is sought from an applicant, then a "heads of consideration "for a merits based assessment" is often included in the DCP.

As such, it is recommended that the Murrumbidgee Village DCP is updated to better reflect contemporary development control plan documents, in both format and content.

Preliminary information that could be included in the updated DCP or Flood Policy have been included in **Appendix I.** It is recommended that these updates are undertaken as early as practicable, due to the outdated nature of the existing development controls.

6.3.3 Darlington Point Structure Plan

In July 2017, Murrumbidgee Council developed the Darlington Point Structure Plan. The aim of the Structure Plan was to provide direction for the future development of land in Darlington Point over the next 20 years. The Structure Plan was to provide a framework that guided land use planning and the provision of infrastructure and community facilities. The Structure Plan covered the areas of Darlington Point, north Darlington Point and the areas down to the intersection between the Kidman Way and The Sturt Highway.

The Structure Plan provides background and regional context on the establishment and development of Darlington Point. It provides information on the current demographics, industry, employment, infrastructure and services available. Issues and opportunities were identified for the future development and growth of Darlington Point. Flood constraints were listed as an issue, including the lack of levee protecting north Darlington Point and the limiting factor of flooding to the ongoing growth and expansion of the town itself.

Opportunities for rezoning and future development that are impacted by, or may impact upon flooding were listed as actions, including:

- Action 4.1.2 - Rezoning land west of King Street to RU5 – Village once Councils sewerage works have been relocated (or with an appropriate buffer) and the land is protected by a flood levee bank.
- Action 4.1.4 - Subject to consideration of a flood levee or other flood mitigation works, investigate rezoning land in the south east portion of North Darlington Point for R5 Large Lot Residential with a 2,000m^2 minimum lot size, consistent with the current development pattern of this area.
- Action 4.1.5 - Investigate opportunities to rezone land south of Britts Road for large lot residential development. This should only be considered after Environmental and Cultural Heritage assessments have been undertaken.
- Action 4.2.1 - Rezone land to the south of the town adjoining the Sturt Highway for commercial and/or industrial purposes, due to its proximity to key transport routes and its spatial separation distance from residential uses. Recommended zones for investigation are B6 –Enterprise Corridor, B7 – Business Park, IN1 General Industrial or IN2 Light Industrial.
- Action 4.2.1 - Investigate the former saw mill site in North Darlington Point as an 'Opportunity Site' for redevelopment and possible future use. Such development should only occur however where it has flood free access.

- Action 4.4.1 and 4.6.1 - Further investigate and continue to construct a flood levee bank around the town, so as to ensure its ongoing protection during periods of peak flooding.
- Action 4.4.2 - Upon finalising all the relevant flood studies for Darlington Point, Council amend its Local Environmental Plan to incorporate a 'Flood Planning Map' to more accurately define the areas subject to flooding.
- Action 4.6.5 - Subject to completion of a flood study for the town, prepare suitable development controls within Council's Development Control Plan to guide decisions relating to the development of flood prone land.

6.3.4 Future development

A more detailed analysis has been undertaken on land Council has identified for potential rezoning in future is included in **Appendix E.**

7 EXISTING EMERGENCY MANAGEMENT PROTOCOLS

7.1 Local Flood Plan

The *Murrumbidgee Local Flood Plan* (NSW SES, 1994) (LFP) sets out procedures to follow before, during and after a flood including who is responsible for each of these activities within the *Murrumbidgee* local government area. A summary of pertinent components of the LFP for the Murrumbidgee River at Darlington Point are provided in **Table 19.**

The whole of the Murrumbidgee Local Flood Plan requires an update to align with the structure and contents of the new NSW SES Local Flood Plan template and to include more up to date flood information, from both actual events (2010, 2012, 2016 in particular) and floodplain risk management studies and plans.

Part 1 of the local flood plan details the area the plan covers and organisational responsibilities for managing flooding hazards. Almost all of the information in this section requires updating. It currently refers to government agencies and departments that are now defunct or renamed. As this local flood plan was prepared prior to the amalgamation of Murrumbidgee Shire and Jerilderie Shire, the areas referred to in this plan do not include those from the former Jerilderie Shire.

Part 2 of the local flood plan describes preparedness. This section is in need of an update, both to align the structure and contents with the new NSW SES local flood plan template, and to incorporate flood intelligence from more recent flood studies, floodplain risk management studies, and actual floods. In particular, it currently refers to the Murrumbidgee Local Controller, however there is no local Darlington Point NSW SES Unit and no local Darlington Point controller. As such, there needs to be clear guidance on roles for NSW SES personnel that come from other areas, until such time as a local NSW SES Unit is re-established. The local flood plan also says very little about flooding risks from local overland flow, which can be included based on the information provided in this floodplain risk management study.

Part 3 of the local flood plan describes response arrangements. This section also needs significant updates to align the structure and contents with the new NSW SES local flood plan template, and to incorporate up to date information. This section references the Murrumbidgee Local Controller and the Murrumbidgee NSW SES Division Headquarters, neither of which currently exist. The information produced in this floodplain risk management study, and the updated flood protection provided by the upgraded levee, should also be included in this section. The section is also relatively vague with respect to when warnings and evacuation orders should be issued. Therefore, this section should be updated using information from this floodplain risk management study. The volume includes a list of gauges to be monitored prior to and during flooding. Information provided in this table should be verified to ensure it is the most up to date information for those gauges (Annex C). The list of media outlets should be reviewed (Annex E). Additionally, Annex F should be updated based

on the upgrades that have been completed to the levee around Darlington Point. All flooding maps should also be updated to include the information produced in this floodplain risk management study. Finally, considerable effort is needed to provide the detail consistent with the new NSW SES LFP template.

Part 4 details the recovery arrangements. Again, considerable effort will be needed to provide the detail consistent with the new NSW SES LFP template. This section references Murrumbidgee Local Controller and will require updating and clear instructions on those NSW SES Units coming into Darlington Point from elsewhere during an event, until such time that a local NSW SES unit is established.

There is a range of information that can be included in the each of the Annexes, with a summary of this information outlined in **Table 19**.

Table 19 Comments on Current Murrumbidgee Local Flood Plan 1994 – Volume 2

Section	Description	Comment
Volume 2 Hazard and Risk in Murrumbidgee LGA		
Annex A	Characteristics of flooding	Peak design flood levels determined in this FRMS should be included. This includes floods rarer than the 1% AEP event for the Murrumbidgee River at Darlington Point.
Annex A	Flood History	Should be updated to include reference to more recent floods (e.g., 2010, 2012, 2016)
Annex A	Flood Mitigation Systems	Information on the upgraded levee and the level of protection it provides should be included, including a figure of its location with crest heights.
Annex B	Effects of Flooding on the Community	Information in this FRMS should be used to describe the effects of flooding on the community, including: • Information on the location and type of buildings with over-floor flooding at the various design flood levels. • Flood impacts to critical facilities and vulnerable developments. • Locations where roads get cut by floodwaters
Volume 3 NSW SES Response Arrangements		
Annex D	Dissemination of NSW SES Flood Bulletins	The list of media outlets for flood bulletins needs to be updated.
Annex E	Dissemination of Flood Warnings and other Flood information.	The list of media outlets for flood warning dissemination needs to be updated.
Annex F	Vulnerable Facilities	Should be updated based upon the information contained in **Section 2.4.3** of this report. This includes Darlington Point Caravan Park and the Altina Wildlife Park, north Darlington Point and the area behind the levee.
Annex G	Roads Subject to Flooding	The list of roads should be updated based on information contained in **Section 5.1.3** of this report. Also, the Sturt Highway outside of the study area has the potential to be cut by floodwaters and should also be included.

Section	Description	Comment
Maps	Maps	The maps should be updated to include a map dedicated to Darlington Point.
Missing Information		Volume 3 is also missing a number of key components, particularly: • A breakdown of the local NSW SES response arrangements (e.g. sectors) and response strategies whilst there is no local NSW SES Unit. • Resupply arrangements for isolated properties.

7.2 Emergency Services' Capability

As of September 2020, there was no NSW SES unit based in Darlington Point. Darlington Point is serviced by the NSW SES units stationed in Coleambally and Griffith.

There is an effective warning time of a number of weeks before floodwaters reach Darlington Point from upstream areas, with a minimum of 4 days warning available from Narrandera. There is also a high level of flood awareness amongst the residents of Darlington Point. Thus, there is adequate time for the NSW SES to provide warnings and advice about preparing for the flood, and for residents to prepare themselves for flooding. Should evacuation be required, then there is adequate warning time for the NSW SES to undertake this prior to the floodwaters inundating the land around Darlington Point. Therefore, it is unlikely that adverse flooding consequences would occur in Darlington Point before emergency services personnel can be deployed. However, due to the characteristics of flooding in the Murrumbidgee River and general Riverina area, NSW SES personnel may be required at several locations throughout the area due to flooding in numerous areas. Therefore, it is critical that the Darlington Point community is able to cope with flooding without reliance on the emergency services from other areas.

Discussion with the NSW SES Deputy Local Controller throughout the course of this study indicates that the reliance on NSW SES resources from other areas is not sufficient to manage the flood risk across Darlington Point. The NSW SES consider that the most efficient way to improve the flood emergency management in Darlington Point is to set up a local unit at Darlington Point.

7.3 Response Strategy

7.3.1 Theory

A major point of contention in contemporary flood emergency management planning relates to the advantages and disadvantages of evacuation compared to seeking on-site refuge.

The Australian Fire and Emergency Services Authorities Council (AFAC) (2013) '*Guideline on Emergency Planning and Response to Protect Life in Flash Flood Events*' is considered to represent best practice on this issue. It recognises that the safest place to be in a flood is well away from the affected area. Provided that evacuation can be safely implemented, this is the most effective strategy. Properly planned and executed evacuation is the most effective strategy in terms of a reliable public safety outcome.

However, AFAC recognises that evacuating too late may be worse than not evacuating at all because of the dangers inherent in moving through floodwaters. If evacuation has not occurred prior to the arrival of floodwater, taking refuge inside a building may generally be safer than trying to escape by entering the floodwater.

Nevertheless, AFAC argues that remaining in buildings likely to be affected by flooding is not low risk and should never be a default strategy for pre-incident planning: 'where the available warning time and resources permit, evacuation should be the primary response strategy' (p.4). The risks of a 'on-site refuge' strategy include:

- Floodwater reaching the place of shelter (unless the shelter is above the extreme flood level);
- Structural collapse of the building that is providing the place of shelter (unless the building is designed to withstand the forces of floodwater, buoyancy and debris in an extreme flood event);
- Isolation, with no known basis for determining a tolerable duration of isolation;
- People's behaviour (drowning if they change their mind and attempt to leave after entrapment);
- People's immobility (not being able to reach the highest part of the building);
- The difficulty of servicing medical emergencies (pre-existing condition or sudden onset e.g. heart attack) during a flood;
- The difficulty of servicing other hazards (e.g. fire) during a flood.

For evacuation to be a defensible strategy, the risk associated with the evacuation must be lower than the risk people may be exposed to if they were left to take refuge within a building which could either be directly exposed to or isolated by floodwater (Opper et al., 2011). Pre-incident planning therefore needs to include a realistic assessment of evacuation timelines (both time available and time required for evacuation), including assessment of resources available. Successful evacuation strategies require a warning system that delivers enough lead time to accommodate the operational decisions, the mobilisation of the necessary resources, the warning and the movement of people at risk.

7.3.2 Darlington Point Practice

The current Darlington Point Local Flood Plan precedes the upgrades to the levee at Darlington Point, and predates the most recent major flood event of 2012 where there was significant NSW SES involvement.

The Local Flood Plan does state that there would be at least 3 days warning of any flood that is likely to necessitate evacuations from the Darlington Point area. There is a number of weeks warning available from when significant rainfall occurs in the upper parts of the catchment, until this runoff reaches Darlington Point via the Murrumbidgee River. Therefore, this provides between 4 days and several weeks over which the residents can be made aware of the impending flood.

The Local Flood Plan refers to the Riverside Caravan Park and north Darlington Point as areas that would need to be evacuated should particular thresholds (different for each location) of flood levels be expected to be exceeded. Evacuation would be to the Darlington Point Public

School, located on Hay Road behind the levee. The Local Flood Plan goes on to state that if levee overtopping or levee failure may be possible, then evacuation would be to Griffith for all residents of Darlington Point.

If the NSW SES wishes to maintain an evacuation strategy, then significant work needs to be undertaken to ensure that successful evacuation can be achieved. This includes at a minimum:

- The identification of locations of roads where access is predicted to be cut during different flood events. This includes the Kidman Way in north Darlington Point, where floodwaters are anticipated to inundate the road at several locations.
- Targeting those properties who are anticipated to be impacted with over floor flooding during different design flood events, as included on **Figure 39** of this report.
- The upgraded levee has a significantly improved protection level to that provided prior to its upgrade (and experienced during the 2012 flood event) and the information included in the NSW SES Local flood Plan. The upgraded levee provides a greater level of protection to the township of Darlington Point and has the potential to change the evacuation requirements included in the Local Flood Plan. This updated levee information needs to be carefully reviewed by the NSW SES staff responsible for evacuation planning before and during an event to ensure the most up to date information is considered.
- Upgraded levee has the potential to increase complacency in residents – residents of Darlington Point may now believe there is a greater level of flood protection with the upgraded levee and less likelihood of levee failure. If evacuation is required, it may now occur after floodwater has inundated the area and be more unsafe than prior to the levee upgrade.
- As discussed in **Section 11.2**, after the events of the 2012 flood event when a number of people evacuated from Darlington Point and north Darlington Point, there is significant community engagement work the NSW SES need to undertake with the residents for the evacuation strategy having any opportunity of being successful in future. This would be greatly assisted by the establishment of a local NSW SES unit in Darlington Point and regular community engagement initiatives.

8 Categories Of Floodplain Risk Management Options

8.1 Introduction

As outlined in **Section 4**, there are a number of existing properties within the Murrumbidgee River floodplain at Darlington Point that are predicted to be exposed to a significant flood risk and/or significant financial impacts during floods events. Accordingly, the following chapters outline options that could be potentially implemented to build upon current floodplain risk management measures to better manage this flood risk.

This chapter provides an overview of the types of floodplain risk management options currently available to manage the flood risk at Darlington Point.

8.2 Potential Options for Managing the Flood Risk

Options for managing the flood risk can be broadly grouped into one of the following categories:

- **Flood Modification Options**: are measures that aim to modify existing flood behaviour, thereby, reducing the extent, depth and velocity of floodwater across flood liable areas. Flood modification measures will generally benefit a number of properties and are primarily aimed at reducing the existing flood risk.
- **Property Modification Options**: refers to modifications to planning controls and/or modifications to individual properties to reduce the potential for inundation in the first instance or improve the resilience of properties should inundation occur. Modifications to individual properties are typically used to manage existing flood risk while planning measures (e.g., land use/development controls) are employed to manage future flood risk.
- **Response Modification Options**: are measures that can be implemented to change the way in which emergency services as well as the public responds before, during and after a flood. Response modification measures are the key measures employed to manage the continuing flood risk

8.3 Options Considered as part of this study

An initial list of potential flood risk management options was developed based upon consideration of the following factors:

- Location of high flood risk/high flood damage properties
- Recommendations in previous reports
- Council recommendations and
- Community feedback.

8.4 Options Assessment Approach

Each flood risk management option will generally be a compromise as it is unlikely that an option will provide only benefits (e.g., there may be an adverse environmental impact or significant costs associated with the implementation of the option). In general, if the advantages associated with implementing the option outweigh the disadvantages, it will afford a net positive outcome and may be considered viable for future implementation. Therefore, each option was evaluated against a range of criteria to provide an initial appraisal of the potential feasibility of each option.

Each flood and property modification option was evaluated against the following criteria, where sufficient information was available:

- Hydraulic impacts
- Emergency responses impacts
- Change in number of buildings inundated above floor level
- Technical feasibility
- Environmental impacts
- Economic feasibility
- Community acceptance

Further details on each of these evaluation criteria is presented below. The scoring system that was used to rank each option against these criteria is also provided in **Table 20**.

The response modification options were generally not evaluated against these criteria as they will generally have negligible hydraulic and environmental impacts, are difficult to quantify in monetary benefits (i.e., response modification options will generally not reduce flood damages) and will generally improve emergency response.

8.4.1 Hydraulic Impacts

Flood modification options will alter the distribution of floodwaters. Although this aims to reduce the extent and depth of inundation across populated areas, it may divert floodwaters elsewhere, thereby increasing the flooding risk across other areas. Therefore, it is important that the potential flood impacts associated with implementing each option is understood.

To assess the hydraulic impact of each flood modification option, the TUFLOW hydraulic model that was used to define existing flood behaviour was updated to include each flood modification option. The updated TUFLOW models were then used to re-simulate each of the design floods. The flood level and extent results from the revised simulations were compared against the flood level and inundation extent results from the existing conditions / do nothing scenario to prepare "difference mapping". The difference mapping shows the magnitude and location of changes in flood levels and inundation extents associated with implementation of the option.

8.4.2 Change in Number of Buildings Inundated Above Floor Level

An assessment of the change in the number of buildings subject to above floor inundation during each design flood was also completed for each option. A focus was placed on the change in number of buildings inundated during the 1% AEP flood and larger for most of the options, as the levee around Darlington Point would only become active at events greater than the 1%

AEP design flood event. However, smaller and larger floods were also considered in the assessment.

8.4.3 Emergency Response Impacts

Emergency response is arguably one of the most important measures for managing the continuing flood risk across any study area, particularly during very large floods where flood modification options may not be overly effective. Therefore, the potential for each option to impact on current emergency response processes was considered as part of the assessment of each option.

8.4.4 Technical Feasibility

If a structural option is proposed, it needs to be physically possible to construct the option giving consideration to the option itself as well as any local constraints. Therefore, an assessment of any technical impediments was completed for each option to determine if there would be any "show stoppers" that may render the option impractical.

8.4.5 Environmental Impacts

Any flood risk management option that involves structural works on the floodplain has the potential to impact on local flora and/or fauna. At the same time, some options may provide an opportunity to improve the local environment (e.g., some options may reduce gross pollutants reaching downstream waterways). Therefore, the potential environmental impact was considered as part of the evaluation of each structural option.

8.4.6 Economic Feasibility

A preliminary economic assessment of each flood modification and selected property modification options was completed to assist in determining the financial viability of each option. The assessment was completed by estimating the 'costs' and 'benefits' that could be expected if the option was implemented. This enabled a benefit cost ratio (BCR) to be prepared for each option. A BCR of greater than 1.0 shows that the present value of benefits outweighs the present value of costs of the option and provides an indicator that the option may be financially viable.

From a flooding perspective, economic 'benefits' were quantified as the reduction in flood damage costs if the option is implemented. The benefits of each option were estimated by preparing damage estimates for each design flood event with the option in place and using this information to prepare a revised average annual damage (AAD) estimate. In order for a BCR to be estimated, it is necessary to modify the 'base' AAD estimates (which reflect the average damage that is likely to be incurred in a single year) to a total damage that could be expected to occur over the life of each flood risk management option. Accordingly, the AAD estimates were accumulated over a 50-year period and then discounted to a present-day value by applying a discount rate of 7%.

Cost estimates have also been prepared for each option. The cost estimate includes capital costs as well as ongoing costs (e.g., maintenance) to provide a total life cycle cost for each option. It was assumed that each option has a design life of 50 years for the purposes of establishing the life cycle cost.

The cost estimates were prepared using the best available information. However, precise cost estimates can only be prepared following detailed investigations and once design plans have

been prepared. Therefore, the cost estimates presented in this report should be considered approximate only. Nevertheless, they are considered suitable for providing an initial appraisal of the financial viability of each option.

8.4.7 Community Acceptance

Floodplain risk management options do have the potential to impact on the broader community in both beneficial and adverse ways. For example, a levee may reduce the potential for inundation of a property but may also remove water views. Therefore, the community's attitudes towards each option can have a significant impact on the viability of an option.

A community questionnaire was distributed to residents and business owners within the catchment during Stage 1 of the project. The questionnaire provided the community with a preliminary list of flood risk management options that were being considered as part of the study and sought feedback from the community regarding each of these options (i.e., whether they opposed or supported the option). A summary of the responses to the questionnaire are included on each option in **Section 3.1.2** to gain an understanding of the community's attitudes towards each option.

Table 20 Adopted Evaluation Criteria and Scoring System for Assessment of Flood Risk Management Options

Criteria	Ranking/Score				
	-2	-1	0	+1	+2
Hydraulic Impacts	Significant increases in levels (>0.1m) / extents	Minor increases in levels (<0.1m) / extents	Negligible changes in levels / extents	Minor decreases in levels (<0.1m) / extents	Significant decreases in levels (>0.1m) / extents
Change in number of buildings inundated above floor level	Significant increase in number of buildings impacted by above floor flooding	Small increase in number of buildings impacted by above floor flooding	No Change in number of buildings impacted by above floor flooding	Small decrease in number of buildings impacted by above floor flooding	Significant decrease in number of buildings impacted by above floor flooding
Emergency Response Impacts	Significant adverse impact on emergency response	Small adverse impact on emergency response	Negligible impact on emergency response	Small improvement to emergency response	Significant improvement to emergency response
Technical Feasibility	Significant technical challenges	Moderate technical challenges	Minor technical challenges	Negligible technical challenges	No technical challenges
Environmental Impacts	Significant negative environmental impact	Small negative environmental impact	Negligible environmental impacts	Small opportunity for environmental enhancement	Significant opportunity for environmental enhancement
Economic Feasibility	BCR <0.5 and / or high capital / ongoing costs	0.5 < BCR < 0.8	0.8 < BCR < 1.0	1.0 < BCR < 1.2	BCR > 1.2 and / or low capital / ongoing costs
Community Acceptance	Majority of community opposed	Some opposed	Neutral	Some community support	Majority of community support

9 Flood Modification Options

9.1 Introduction

Flood modification options are measures that aim to modify existing flood behaviour, thereby, reducing the extent, depth and velocity of floodwater across developed floodplain areas. Flood modification measures will generally benefit a number of properties and are primarily aimed at reducing the existing flood risk.

Flood modification options considered as part of the study included:

- Levees
- Channel Modifications
- Drainage Upgrades

Further discussion on the flood modification options that were considered to assist in managing the existing flood risk are presented in the following sections.

9.2 Outline of flood modification options

The following sections provide a summary of the assessment that was undertaken for each floodplain risk management option. **Plate 16** provides an overview of the location of each of these options. Further details for each of these options can be found in **Appendix H**.

9.3 Levees

9.3.1 General

Levees are man-made structures that aim to prevent inundation of floodplain communities by providing a physical barrier between the waterway and the community. The barrier can take the form of a permanent earthen embankment/wall or a temporary structure that can be assembled/disassembled before/after a flood. In general, temporary levees are only suitable when there is sufficient warning time available to erect the levee.

A levee will be designed to provide a specific level of protection (e.g., protection from a 1% AEP flood). A freeboard is also typically included in the design height of the levee to account for uncertainties in the estimation of the design flood level as well as construction tolerances (e.g., settlement).

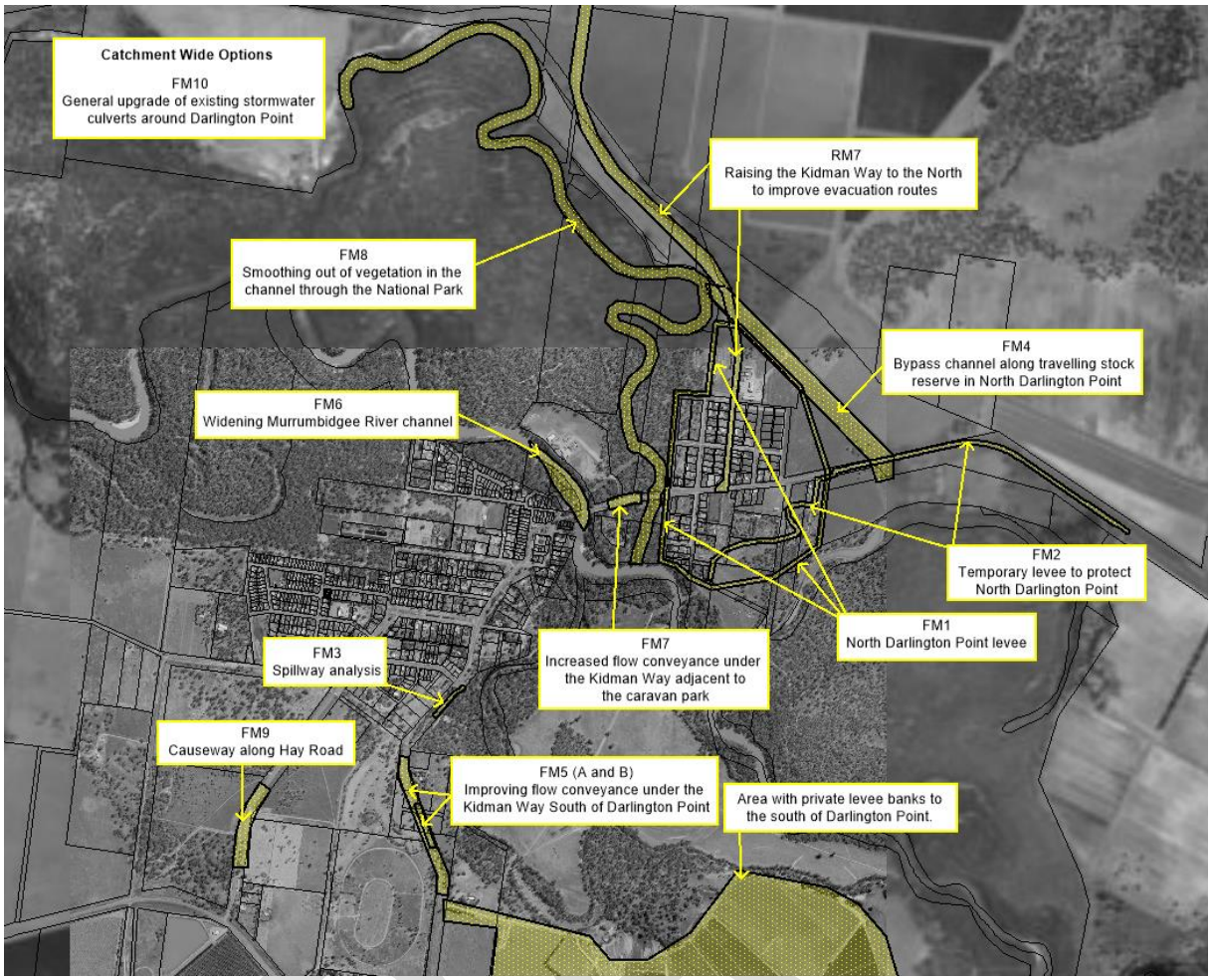


Plate 16 Overview of flood modification options that were assessed

The construction of a levee (regardless of the height) will generally provide a reduction in the existing flood risk. However, there are a number of other factors that need to be carefully considered when evaluating the suitability of a levee to reduce the flood risk, including:

- Levees provide a physical barrier to the flow of water. Although this is beneficial in terms of reducing the potential for inundation from major watercourses, it can also provide a physical barrier to local overland flow. Accordingly, care needs to be exercised to ensure local overland flooding is not exacerbated (e.g., through installation of pumps or flood gates).
- Levees can also prevent flood flows from reaching existing environmental areas (e.g., wetlands). This, in turn, may adversely impact on flora and fauna living in these environmental areas. Accordingly, the potential environmental impacts of any levee needs to be carefully considered, particularly if endangered species are at risk.
- There is potential for water that is displaced by the levee to be diverted across other floodplain communities, particularly if the levee is located in a major conveyance area.
- Levees typically require a significant up-front capital investment. Funds must also be available for the ongoing maintenance of the levee to ensure it fulfils its design intent.
- It is typically not possible to design a levee to provide protection during all floods up to and including the Probable Maximum Flood (PMF). As a result, many levees will be overtopped during their design life. Therefore, it is important that the levee is designed to withstand the potential for overtopping without failure and appropriate emergency

response measures are in place for those located behind the levee should over topping of the levee be predicted.

- A spillway should also be included in the design and construction of a levee. A spillway is designed so that it would be the first location the levee would be over topped should a flood greater than the levee design standard occur. A spillway would allow controlled inundation of the area behind the levee, whilst seeking to maintain the integrity of the levee itself as long as possible once the levee design standard has been exceeded.
- Levees are typically highly visible, which can be reassuring for the population located behind the levee. At the same time, the presence of a levee can also provide a false sense of security and may lead to complacency by those who it protects, which can arguably increase the continuing flood risk. It may also provide a significant visual obtrusion and remove water views.

9.3.2 Previous Investigations

Levees have been considered at various locations across the catchment as part of previous studies. This includes:

- The levee around Darlington Point was constructed during the 1955 flood and was subject to investigation in 2009 as part of a rehabilitation project (Patterson Britton and Partners, 2000).
- The same study from 2009 recommended a levee around north Darlington Point, based on current flooding conditions and agreeable local landform characteristics.
- The existing levee around Darlington Point has been progressively updated since 2010, based on the recommendations from earlier studies. This upgraded levee has resulted in a ring levee around the town of Darlington Point that provides a level of protection for the 1% AEP design flood event with an estimated 750mm freeboard.

In general, the levee options that were investigated as part of the previous studies were considered viable as they generally resulted in insignificant impacts on flood behaviour. The levee considered for north Darlington Point provided an acceptable level of protection to the properties in North Darlington Point. Therefore, a more detailed analysis was undertaken to determine the potential attributes of a levee around north Darlington Point.

9.3.3 FM1 - North Darlington Point Levee - Earthen levee

9.3.3.1. Concept Design of FM1

As discussed in **Section 4**, north Darlington Point, particularly south of Narrand Street, can be impacted by flooding in events as frequent at the 5% AEP design flood event. This flooding is primarily driven by floodwaters that overflow from Darlington Lagoon and first inundate the vacant land on the eastern side of north Darlington Point. As the flood levels continue to rise and the capacity of the culvert under Whitton Darlington Point Road is exceeded, floodwaters travel across Whitton Darlington Point Road and continue overland in a north-westerly direction. These flows pass under the Kidman Way and join back into the floodplain that traverses through the National Park on the right overbank areas of the Murrumbidgee River.

Previous studies had recommended investigations into a flood protection levee around north Darlington Point, with an approximate alignment presented in the 2009 Worley Parsons report, as summarised in **Section 9.3.2** of this report. The report recommended a crest level of the 1% AEP design flood level a one (1) metre freeboard added. The estimated length of

levee was 3 kilometres long with an estimated design and construction cost of $5.8 million (2009 dollars).

Plate 17 FM1 concept design

The option of a levee around north Darlington Point is reviewed as part of this study, using the design recommendations from previous studies as a basis for these investigations. The alignment of the levee has been refined based on the location of existing development south of Narrand Street and the characteristics of the floodwater behaviour across a range of design flood events. Land would need to be acquired along the full length of the levee, so the opportunity to minimise land acquisition requirements along the levee alignment, whilst maintaining appropriate level of flood protection was also taken into consideration.

- An earthen levee with an approximate length of 3.5 kilometres.
- Levee crest level of the 1% AEP design flood level with a freeboard of one (1) metre added on top of the existing 1% AEP design flood level.
- Where road crossings traversed the levee, a general rising road access along an approximate length either side of the levee of 100 metres was included in the design.

- A general levee crest width of three (3) metres with embankments at 3H:1V side slopes
- Cost to construct - $7.68 million
- Cost to maintain - 2% of the construction cost - approximately $154,000 per year.

9.3.3.2. Hydraulic Impact of FM1

The assessment of the hydraulic impact of this option on reducing the flood risk include:

- Elimination of riverine flooding at north Darlington Point up to the 1% AEP design flood event, however may introduce local flooding issues behind the levee.
- Flood level increases up to 0.06 metres around north Darlington Point
- Increase flood levels adjacent to existing levee around Darlington Point up to 0.04 metres.
- A review of the results of all design flood simulations indicate the number of properties subject to changes in property inundation or above floor inundation are predicted as:

Table 21 Hydraulic Impact of FM Option 1

Design Flood Event	Change in number of properties impacted by over floor flooding	Change in number of properties impacted by flood waters (in addition to above floor flooding)
5% AEP	-1	-2
2% AEP	-9	-9
1% AEP	-15	-9
0.5% AEP	+4	-20
0.2% AEP	-21	-12
Extreme flood event	-14	-28

- Reduce flood damage costs by $469,000 over the 50-year design life of the levee
- Estimated reduction in annual average damages of approximately $33,942.
- Preliminary benefit-cost ratio of less than 0.1

9.3.3.3. Summary of FM1 Assessment

Overall, the north Darlington Point levee appears to afford some benefits, however these come at a significant financial cost. The levee does not provide a significant reduction in flood damages due to the small number of properties that currently experience over floor flooding in the area that would be beneficially impacted by this option. The levee would afford the additional benefit of providing flood free access around the north Darlington Point road network, however there is potential for the roads beyond this area to be inundated with floodwaters. Further investigations are not recommended.

Table 22 Evaluation outcomes of north Darlington Point levee

Evaluation Criteria	Rating	Comments
Hydraulic Impacts	+1	Beneficial reductions in flood levels and extents across north Darlington Point, however some minor increases in flood levels anticipated at the existing Darlington Point levee and properties to the east of north Darlington Point.
Inundated Buildings	+1	15 buildings no longer inundated above floor level during 1% AEP design flood event.
Emergency Response	0	Reduced inundation depths across most of north Darlington Point including road access, however roadways to the north and east would still be inundated during flood events greater than the 1% AEP design flood event. May encourage residents to stay in their homes, increasing demand on NSW SES if levee is over topped.
Technical Feasibility	-1	There may be some technical limitations associated with the acquisition of the land/easement for the full length of the levee that is required. There may be issues associated with the footprint of the required levee due the location of the existing buildings and infrastructure.
Environmental Impacts	-1	May involve removal of some vegetation to implement. May be opportunities to reinstate vegetation after construction in some areas.
Economic Feasibility	-2	Low BCR with a high capital cost and relatively high ongoing maintenance costs.
Community Acceptance	+1	Just over 50% of the community indicated support for this option.
SCORE	**-1**	

Recommendation: Not recommended for further investigation.

9.3.4 FM 2 - North Darlington Point Levee - Temporary levee

9.3.4.1. Concept design of FM2

The option of a temporary levee was investigated for North Darlington Point after the benefit-cost ratio (BCR) was determined for a permanent earthen levee around Darlington Point, to see if the BCR for a levee protecting the properties of north Darlington Point could be improved.

The alignment of the temporary levee has been refined based on the location of existing development and structures in the area and the characteristics of the floodwaters as they travel into and around north Darlington Point. Floodwaters can remain around north Darlington Point for a number of weeks, so a temporary flood levee would only be in place

and provide protection until these floodwaters started to recede and roads become flood free and driveable. The potential alignment of the temporary levee is outlined on **Plate 18** below.

The concept design for this temporary levee arrangement includes:

- Temporary levee crest level along the section between Darlington Street and Beach Road of approximately one (1) metre high that traverses open space on the private properties.
- Temporary levee along Narrand Street / Whitton Road would have an approximate height of 0.50 metres.
- Cost to buy and implement – between approximately $1.2 million to $2 million
- Cost to maintain – No allowance for maintenance

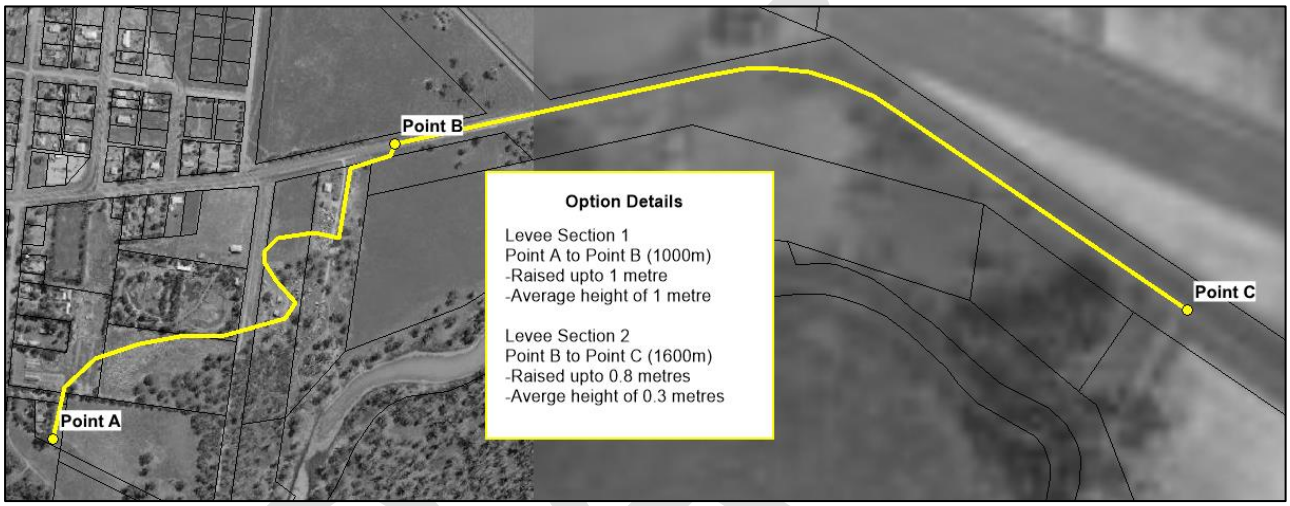


Plate 18 FM2 concept design

9.3.4.2. Hydraulic Impact of FM2

The assessment of the hydraulic impact of this option on reducing the flood risk include:

- Elimination of riverine flooding at north Darlington Point up to the 1% AEP design flood event, however may introduce local flooding issues behind the levee.
- Flood level increases in the range of 0.02 metres to 0.03 metres upstream, with some localised increases of between 0.15 metres to 0.20 metres estimated to occur adjacent to the Kidman Way and Hay Road (close to the junction with The Sturt Highway).
- Reduction in the depths of floodwaters on the Kidman Way in the northern section of north Darlington Point, reducing depths of flooding across this section of road to less than 0.300 metres during the 1% AEP design flood event
- Reduce flood damage costs by $26,000 over a 50-year period
- Estimated reduction in annual average damages of approximately $1,857.
- Preliminary benefit-cost ratio of less than 0.1
- A review of the results of all design flood simulations indicate the number of properties subject to changes in property inundation or above floor inundation (for the higher of the two temporary levee formations) are predicted as follows:

Table 23 Hydraulic Impact of FM Option 2

Design Flood Event	Change in number of properties impacted by over floor flooding	Change in number of properties impacted by flood waters (in addition to above floor flooding)
5% AEP	0	0
2% AEP	-5	-1
1% AEP	-11	-8
0.5% AEP	+24	+3
0.2% AEP	+31	+4
Extreme flood event	+40	-39

9.3.3.4. Summary of FM2 Assessment

Although benefits of this option have been quantified in terms of a reduction in flood damage to properties, this potential damage reduction could vary depending on the performance of the temporary levee. Each supplier of a proprietary levee device provides assertions to its performance during a flood event if the product is employed within its guarantee period and used as per its design intent. However, neither of these details can be guaranteed as part of the implementation of the recommendations from this study for a future flood event. As such, this option should be considered in the ability to provide a positive impact on the trafficability of the roads in and around north Darlington Point, particularly The Kidman Way during prolonged periods of inundation by floodwaters. This option provides a significant reduction in floodwaters that inundate The Kidman Way going north to Griffith, which is identified in the NSW SES Local Flood Plan as an evacuation route. The potential benefits this provides are difficult to provide with a quantifiable monetary amount.

Overall, the temporary levee around north Darlington Pont appears to afford some benefits, however these come with adverse impacts in other parts of the catchment and with fairly substantial financial impact. However, it does appear to alleviate some of the flooding issues from the north Darlington Point area in the larger flood events and assist with improving the trafficability of the Kidman Way for the duration of longer flood events (which can last for several months). Despite these benefits, this option has a very low cost-benefit ratio which makes it difficult to support for further investigation.

Table 24 Evaluation outcomes on the north Darlington Point temporary levee option

Evaluation Criteria	Rating	Comments
Hydraulic Impacts	**+1**	Beneficial reductions in flood levels and extents across north Darlington Point and to the trafficability of the Kidman Way to Griffith, however some minor increases in flood levels anticipated upstream and adjacent to the Kidman Way and Hay Road south of Darlington Point,
Inundated Buildings	**+1**	11 buildings no longer inundated above floor level during 1% AEP event

Evaluation Criteria	Rating	Comments
Emergency Response	**+1**	Reduced inundation depths across most of north Darlington Point and close to elimination of floodwaters from access along the Kidman Way north to Griffith for floods up to and including the 0.2% AEP design flood event. Potentially very minor increase in flood depths across the Kidman way to the south of Darlington Point when in place. Would also afford additional evacuation time to the north, should floods greater than the 1% AEP design flood event be predicted.
Technical Feasibility	**-1**	Placement of structure during an event may not be in exact locations as included in the model, therefore potential for variation in outcomes of flood impacts. Acquisition and long-term maintenance of a temporary levee mechanism is costly. Potential to rent the device for the duration of flooding may reduce ongoing maintenance requirements and asset depreciation. Liability issues should the levee fail.
Environmental Impacts	**0**	Should involve minimal disturbance to vegetation and biodiversity constraints. Would only be in place during a flood event, so any impacts are temporary.
Economic Feasibility	**-2**	Low BCR with a reasonable capital cost and relatively high ongoing costs. Potential to rent the device for the duration of flooding may reduce ongoing maintenance requirements and asset depreciation.
Community Acceptance	**0**	Over 50% of the community indicated support for this option.
SCORE	**0**	

Recommendation: Not recommended for further investigation.

9.3.5 FM3 - Spillway analysis

9.3.5.1. Concept Design of FM3

The option of incorporating a spillway into the existing levee was investigated. This option considered the characteristics, location and impacts of the spillway included in the 2018 flood study and the factors considered in the freeboard analysis discussed in **Section 0**.

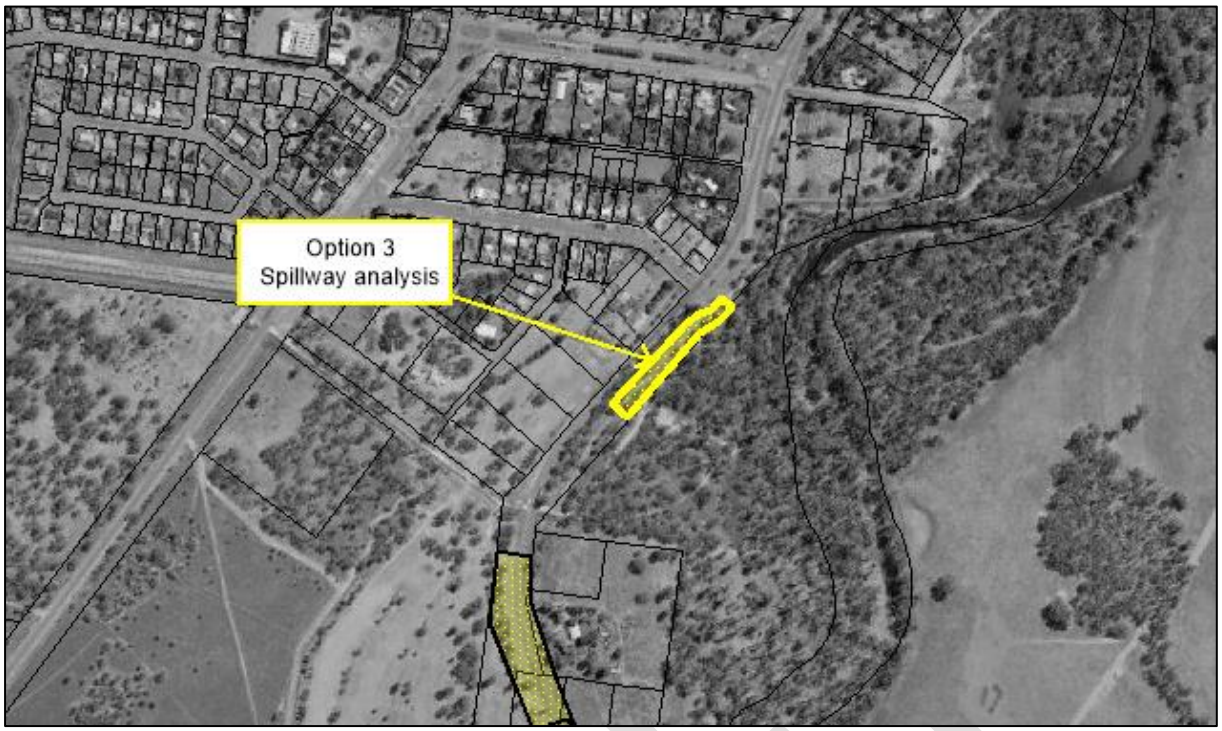


Plate 19 FM3 – Location of spillway

- Spillway located at the 1% AEP design flood level plus a freeboard of 0.45 metres
- Length of spillway – 200 metres (a variation of 100 metres was also assessed).
- Location of spillway – upstream end of Darlington Point (refer **Plate 19**)
- Construction Cost - $200,000
- Ongoing maintenance costs- $0 (part of Councils' general asset management maintenance of the levee so no increase on existing spending).

9.3.5.2. Hydraulic Impact of FM3

Ultimately, the area behind the levee would be inundated during the flood events greater than the 0.2% AEP design flood event only, should a spillway be introduced at a level of 0.45 metres above the 1% AEP design flood level (approximately 0.30 metres below the top of the existing levee). The design flood modelling for the existing condition incudes a breach at a similar level with a similar outcome of flooding for the area behind the levee.

There is limited range in the levels of the design flood events in floods greater than the 1% AEP design flood event at Darlington Point. **Plate 20** outlines the range of design flood heights that are estimated to occur adjacent to the existing levee, generally parallel to Stock Street. This plate outlines the limited flood range between all flood events, with the following differences estimated on average:

- between the 1% AEP and 0.5% AEP design flood events – 0.08 to 0.10 metres
- between the 1% AEP and 0.2% AEP design flood event – 0.15 metres
- between the 1% AEP and extreme flood event – 0.40 to 0.50 metres

It must be remembered that the breach included in the hydraulic modelling of the existing flood scenario is an assumed breach only based on current best practice for the modelling of

levees. In fact, the current levee crest includes a freeboard of 0.75 metres, that would theoretically provide a level of protection similar to the 0.2% AEP and 0.5% AEP design flood levels, without any freeboard. Therefore, the breach included in the existing flood modelling scenario has a significant influence on the determination of the vulnerability of above floor flooding to the properties behind the levee.

The spillway included in this option analysis removes the flood impacts associated with the breaching of the levee crest at lower levels, for the areas behind the levee. Therefore, the inclusion of a formal spillway in lieu of a breach automatically increases the level of protection afforded to the properties behind the levee and automatically reduces their vulnerability to above floor flooding scenario that is included in the existing modelling.

As such, it is difficult to compare the number of existing properties impacted by above floor flooding due to the (supposed) breach in the levee against the number of properties impacted by above floor flooding should a formal spillway be introduced. The improvements to the number of properties impacted by above floor flooding for this option would be misleading as it would not be a true comparison of the number of properties expected to be impacted in the existing condition.

Accordingly, the benefit cost ratio has not been determined for this option.

9.3.5.3. Summary of FM3 Assessment

Overall, this analysis has not exposed a clear hydraulic benefit to introduce a spillway into the upgraded levee at Darlington Point. The current levee provides a justifiable level of protection to the 1% AEP design flood event with a 0.75 metre freeboard.

It is to be noted that the spillway analysis and a freeboard analysis of the existing levee was carried out in this study and summarised in **Section 4** of the floodplain risk management study. The assumptions included in the freeboard analysis include a maintenance regime for the levee. This would involve the levee being appropriately maintained as per current best practice and general asset management principles, and as Council currently undertakes for infrastructure throughout the LGA. This will ensure that the levee will continue to function as designed and will safeguard the results and recommendation of the spillway analysis presented here.

Table 25 Evaluation of spillway option

Evaluation Criteria	Rating	Comments
Hydraulic Impacts	**0**	No changes in flood levels and extents for the areas behind the levee to existing design flood events. A spillway may facilitate less hazardous flooding conditions for the areas behind the levee should the levee be breached.
Inundated Buildings	**0**	No changes to buildings inundated above floor once the levee or spillway is breached.
Emergency Response	**0**	No changes to emergency response requirements as the levee maintains a level of protection of the 1% AEP design flood level plus a freeboard. Flooding predicted in excess of the 1% AEP

Evaluation Criteria	Rating	Comments
		design flood would still require the evacuation of Darlington Point.
Technical Feasibility	**-1**	Challenges associated with construction of a spillway in the recently upgraded levee embankment
Environmental Impacts	**0**	Negligible environmental impacts.
Economic Feasibility	**-1**	BCR not determined however can be costly to implement. Repair costs to levee would vary if a spillway was not introduced and the levee was breached in alternate and unknown location/s.
Community Acceptance	**0**	Appears to neither have support or critics from the community
SCORE	**-2**	

Recommendation: Not recommended for further investigation.

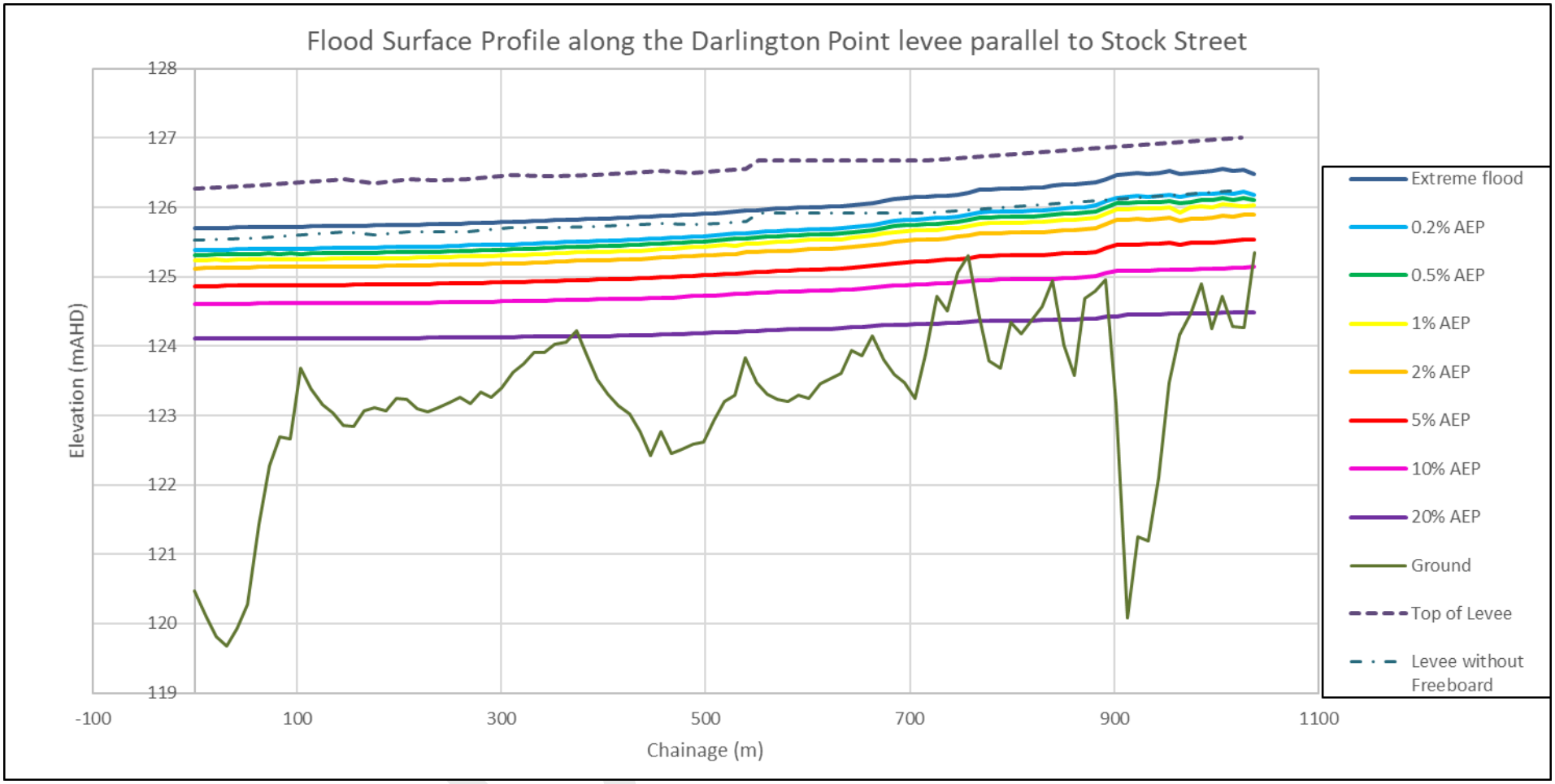


Plate 20 Flood surface profiles along the levee embankment parallel to Stock Street, Darlington Point

9.4 Channel Modifications

9.4.1 General

Channel modifications refer to alterations that aim to improve the flow carrying capacity of waterways or the creation of new flow paths. This aims to increase the amount of flow that can be carried by the channels, thereby reducing the depth, extent and velocity of flows across the adjoining floodplain. These works may include:

- Construction of auxiliary floodways
- Removal of vegetation
- Removal of blockages

The effectiveness of channel modification works is largely dependent on the local flood and channel characteristics. In general, channel modification works will be most effective on relatively small, steep streams with dense vegetation and relatively narrow floodplains (NSW Government, 2005).

As channel modification works aim to improve the conveyance of flood flows, there is potential that this may increase downstream flooding problems. The works may also permanently impact or destroy riverine habitat. Therefore, appropriate environmental investigations must be completed to ensure the potential for environmental impacts is quantified. Furthermore, every effort should be made to ensure that a suitable riparian ecosystem is provided post-construction to promote the establishment/re-establishment of flora and fauna. In this regard, concrete channels should be avoided.

To ensure the conveyance capacity of the channel is maintained throughout its design life, it is necessary for continual maintenance of the channel to ensure vegetation does not become overgrown and restrict flow. This can add significantly to the maintenance costs and the overall life cycle costs of these options. Care must also be exercised to ensure that the modifications to the flow carrying capacity of the channel do not adversely impact on upstream or downstream bank and bed stability.

9.4.2 FM4 - Travelling Stock Route flowpath

9.4.2.1. Concept Design of FM4

As discussed in **Section 4**, north Darlington Point, particularly south of Narrand Street/ Whitton Darlington Point Road, is vulnerable to flooding in events as frequent at the 5% AEP design flood event. This flooding is primarily driven from floodwaters first inundating land on the eastern side of north Darlington Point as floodwater overflows from Darlington Lagoon. The opportunity to use the Travelling Stock Reserve in the eastern section of north Darlington Point as a flowpath to help redirect floodwaters around north Darlington Point was assessed. These overland floodwaters travel northwards under and over Whitton Darlington Point Road, inundating the local roads and private property in the eastern section of north Darlington Point. These overland flows then re-join the Murrumbidgee River floodplain downstream of north Darlington Point, through the channels in the National Park area.

As shown in **Plate 21** , the concept design for the diversion channel incorporates:

- Two open channels with 15 metres width, with side earthen bunds with slopes of approximately 3H:1V to one (1) metre depth.
- Side levee embankments along the length of the Travelling Stock Reserve of one (1) metre height, with side embankments slopes of approximately 3H:1V.
- Turfing of embankments to help manage slope stabilisation.
- Excavation at southern end of Travelling Stock Reserve to provide a continuous downward grade from the south to the north of the flowpath.
- Low level bridge structure at Narrand Street/ Whitton Darlington Point Road crossing.
- Low level bridge structure at The Kidman Way crossing.
- Cost to construct - $6.1 million (bulk of these costs are associated with the supply of low-level bridge structures)
- Cost to maintain – included in Councils existing asset management costs

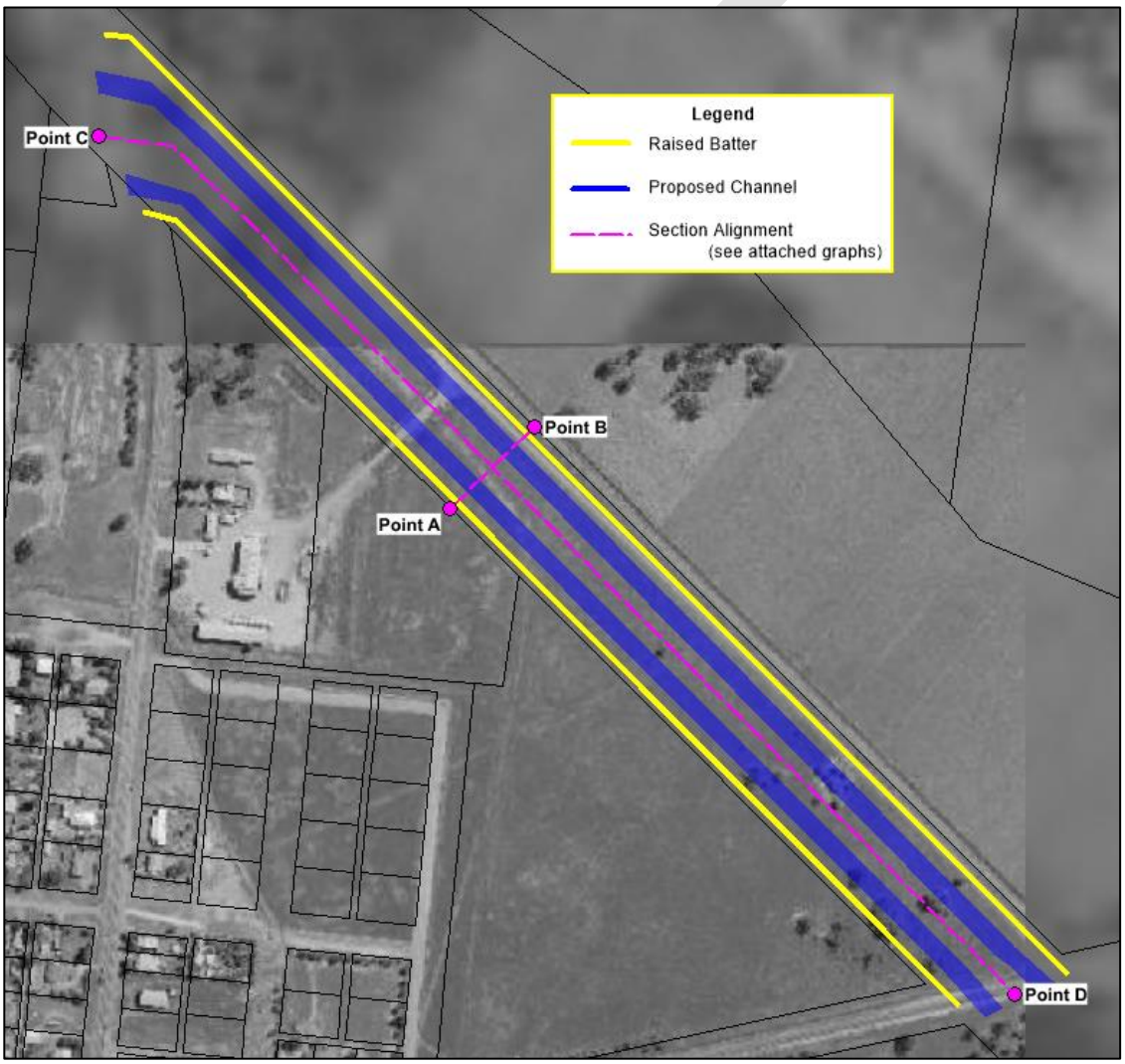


Plate 21 FM4 concept design. Graphs in Appendix H of this report

9.4.2.2. Hydraulic Impact of FM4

The assessment of the hydraulic impact of this option on reducing the flood risk include:

- Reduce flood levels to east of the flowpath up to 0.50 metres in 1% AEP design flood event.

- Smaller increases of 0.02 metres estimated along western section of north Darlington Point at downstream end of works, with a small localised area estimated to be impacted by up to 0.20 metres increase in the 1% AEP design flood event levels.
- The effectiveness of this option was highly influenced by the size of the openings at the downstream, and upstream ends of the flowpath under the existing roadways.
- A review of the results of all design flood simulations indicate the number of properties subject to changes in property inundation or above floor inundation are predicted as follows:

Table 26 Hydraulic Impact of FM Option 4

Design Flood Event	Change in number of properties impacted by over floor flooding	Change in number of properties impacted by flood waters (in addition to above floor flooding)
5% AEP	0	0
2% AEP	0	0
1% AEP	0	0
0.5% AEP	0	0
0.2% AEP	0	2
Extreme flood event	+1	1

- Increase in quantifiable flood damages of $4,000 over a 50-year period.
- Increase in in annual average damages of approximately $310.
- Preliminary benefit-cost ratio of 0.

9.4.2.3. Summary of FM4

Overall, the use of the Travelling Stock Reserve as a formal flowpath for floodwaters appears to afford some significant benefits in terms of reducing flood depths and flood extents in the north Darlington Point area, however these come with financial costs associated with construction that are not matched by any quantifiable reduction in the flood damages as the areas benefiting from these flood level reductions are of a more rural land use and not residential.

Table 27 Evaluation outcomes on the flowpath along Travelling Stock Reserve in north Darlington Point

Evaluation Criteria	Rating	Comments
Hydraulic Impacts	**+1**	Beneficial reductions in flood levels and extents across the eastern sections of north Darlington Point and to the trafficability of the Kidman Way to Griffith, however some minor increases in flood levels anticipated upstream and adjacent to the Kidman Way.
Inundated Buildings	**0**	No change in buildings inundated above floor level during 1% AEP design flood event
Emergency Response	**+1**	Improvements in the trafficability of flood depths on Whitton Darlington Point Road and The Kidman Way going north. Reduced inundation depths across most of north Darlington Point local roads and properties.

Evaluation Criteria	Rating	Comments
Technical Feasibility	**-1**	Approval from Local Land Services to reshape the Travelling Stock Reserve to construct the channel may be difficult. Would need to be maintained in a condition suitable for use as a Travelling Stock Route.
Environmental Impacts	**0**	Should involve minimal disturbance to vegetation and biodiversity constraints, however area has terrestrial and biodiversity constraints mapped along in on Murrumbidgee LEP 2013. The flowpath would only be active during a larger flood event, so any impacts as a result of floodwater inundation are anticipated to be temporary.
Economic Feasibility	**-2**	BCR = 0 as no changes in quantifiable flood damages.
Community Acceptance	**+1**	Over 70% of the community indicated support to upgrade roads so they are less susceptible to flooding.
SCORE	**0**	

Recommendation: Not recommended for further investigation.

9.4.3 FM5 – Improving flow conveyance under the Kidman Way south of Darlington Point.

9.4.3.1. Concept Design of FM5

The design event modelling for floods greater than the 2% AEP design flood event revealed what appeared to be a high level flowpath that breaks westward out of the Murrumbidgee River floodplain and travels across The Kidman Way south of Darlington Point. In the 1% AEP design event flood, floodwater depths through this flowpath are between 0.25 and 0.5 metres deep. Opportunity to utilise and expand upon this high level flowpath to help alleviate flood impacts at north Darlington Point was assessed.

The potential location of the flowpath channel is shown on **Plate 22**. Design of this option started off by lowering the crest levels of The Kidman Way, effectively forming a causeway, with the option being refined during the modelling process to include culverts under the Kidman Way.

- Option 5A:
  - 700-metre-wide causeway along the southern sections of the Kidman Way, by lowering road crest level.
  - Cost to construct – $1.42 million
  - Cost to maintain – included in Councils existing asset management regime
- Option 5B:
  - Eight (8) concrete culverts with the dimensions of 600mm wide x 450mm high (including earthworks to construct adequate foundation and bedding for the concrete culverts).

- Reconstruction of the road pavement to match existing conditions.
- Cost to construct – $3.08 million
- Cost to maintain – included in Councils existing asset management regime

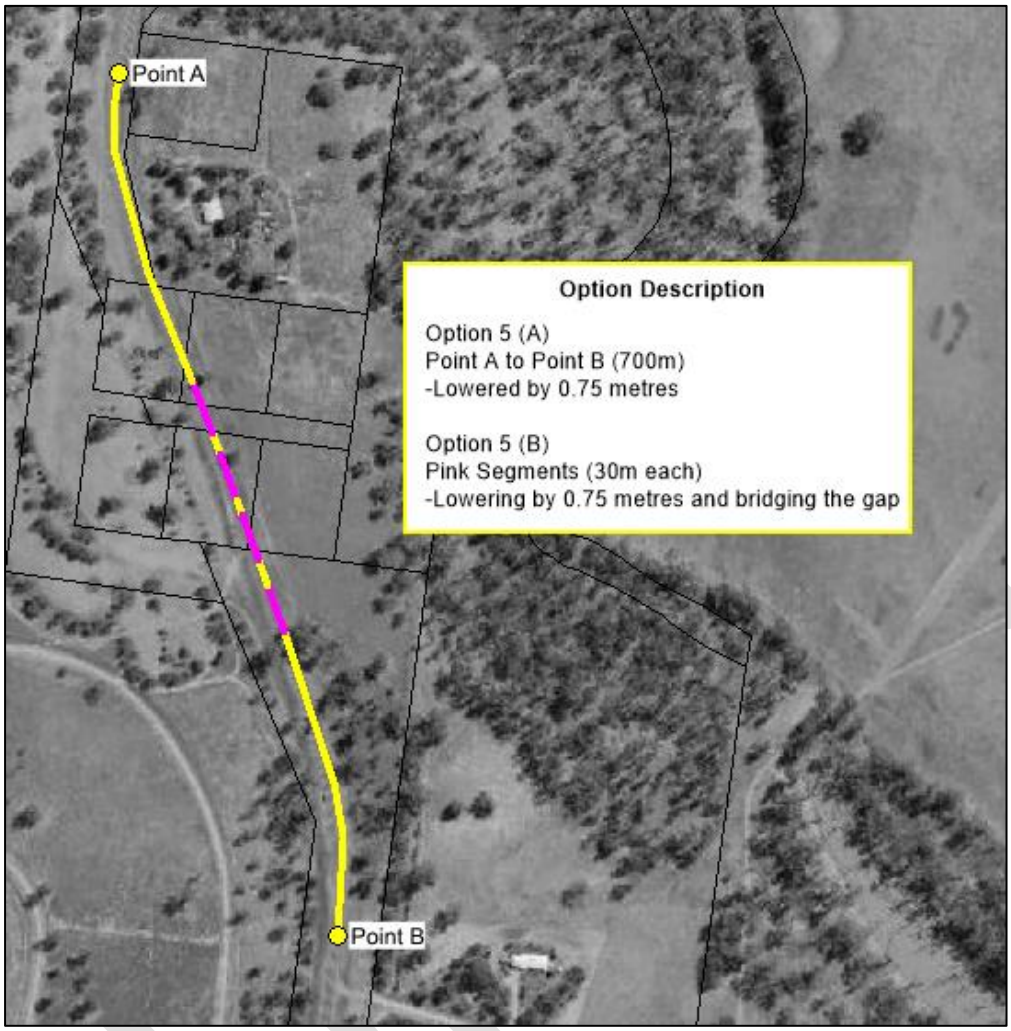


Plate 22 FM5 (A) and FM5 (B) concept designs

9.4.3.2. Hydraulic Impact of FM5

FM 5A

- Areas immediately of the Kidman way that were previously dry during the more frequent flood events are now wet.
- Flood level increases up to 0.37 metres were anticipated immediately downstream of the causeway, reducing to 0.20 metres a further 2 kilometres downstream in the 1% AEP design flood event AEP
- Minor increases in flood levels continued for 10 kilometres or so downstream
- Reduction of 1% AEP design flood level by 0.19 metres around north Darlington Point
- A review of the results of all design flood simulations indicate the number of properties subject to changes in property inundation or above floor inundation are predicted as:

Table 28 Hydraulic Impact of FM Option 5A

Design Flood Event	Change in number of properties impacted by over floor flooding	Change in number of properties impacted by flood waters (in addition to above floor flooding)
5% AEP	+2	+1
2% AEP	-5	+3
1% AEP	-4	0
0.5% AEP	-142	-80
0.2% AEP	-123	-21
Extreme flood event	-40	+9

- Reduce flood damage costs by $1.05 million over the 50-year design life of the construction.
- Reduction in in annual average damages of approximately $75,900.
- Preliminary benefit-cost ratio of less than 0.8

FM 5B

- Flood level increases up to 0.20 to 0.50 metres were anticipated immediately downstream of the Kidman Way in the 1% AEP design flood event AEP.
- Minor decreases of up to 0.02 metres expected in the Murrumbidgee River and around north Darlington Point during the 5% AEP design flood event and 1% AEP design flood event.
- A review of the results of all design flood simulations indicate the number of properties subject to changes in property inundation or above floor inundation are predicted as:

Table 29 Hydraulic Impact of FM Option 5B

Design Flood Event	Change in number of properties impacted by over floor flooding	Change in number of properties impacted by flood waters (in addition to above floor flooding)
5% AEP	+2	+2
2% AEP	-3	+2
1% AEP	0	-2
0.5% AEP	-61	+11
0.2% AEP	-3	-1
Extreme flood event	-5	+4

- Reduce flood damage costs by $221,000 over the 50-year design life of the construction.
- Reduction in in annual average damages of approximately $15,970.
- Preliminary benefit-cost ratio of less than 0.1.

9.4.3.3. Summary of FM5 Assessment

Overall, the introduction of a formalised high level flowpath under the Kidman Way appears to provide a decrease in flood levels within the Murrumbidgee River itself, however only minor reductions around north Darlington Point. Flood levels are expected to increase for all design flood events for the areas downstream of the Kidman Way, for all design flood events.

Table 30 Evaluation of FM5 – improving flow conveyance under the Kidman Way

Evaluation Criteria	Rating	Comments
Hydraulic Impacts	**-1**	Minor decreases in flood level in the Murrumbidgee River and around north Darlington Point. Increases in flood levels downstream of The Kidman Way for all design flood events up to and including the extreme flood event.
Inundated Buildings	**0**	No change to the number of buildings inundated above floor.
Emergency Response	**+1**	Improvements in the trafficability of The Kidman Way during all design events up to and including the 0.5% AEP design flood event if culverts are introduced.
Technical Feasibility	**+2**	Considered reasonably straight forward to construct. Could be constructed by Council.
Environmental Impacts	**0**	Terrestrial biodiversity constraints up and downstream. Changes to the hydrological cycles as a result of these works introducing more frequent floodwaters into the area downstream would have to ensure no adverse impact on these terrestrial biodiversity constraints. Minimal environmental impacts anticipated once construction complete.
Economic Feasibility	**-2**	Low BCR with a significant capital cost.
Community Acceptance	**-2**	Over 70% of the community indicated support to upgrade roads so they are less susceptible to flooding. Introducing a causeway at this location has the opposite effect. Including culverts under the Kidman Way increases flood levels immediately downstream where there is existing development.
SCORE	**-2**	

Recommendation: Not recommended for further investigation.

9.4.4 FM6 – Widening Murrumbidgee River channel

9.4.4.1. Concept design of FM6

As discussed in **Section 4**, there are considerable flood depths anticipated on the overbank areas of the floodplain upstream, downstream, and adjacent to the levee around Darlington Point. Several responses received during the community consultation phase undertaken during stage 1 of this project noted concern over the perceived insufficient capacity of the main Murrumbidgee River channel at the location of the two bridge crossings and the impacts it had on flooding at north Darlington Point. Therefore, the opportunity to increase this

channel capacity, by removing the natural earth embankment between the two bridges, was assessed.

Essentially, this option involved removing the natural earthen embankment that is currently located between the two bridges over the Murrumbidgee River to assess what influence this area has on the flooding characteristics at north Darlington Point. Refer to **Plate 23** for an outline of the location of these works.

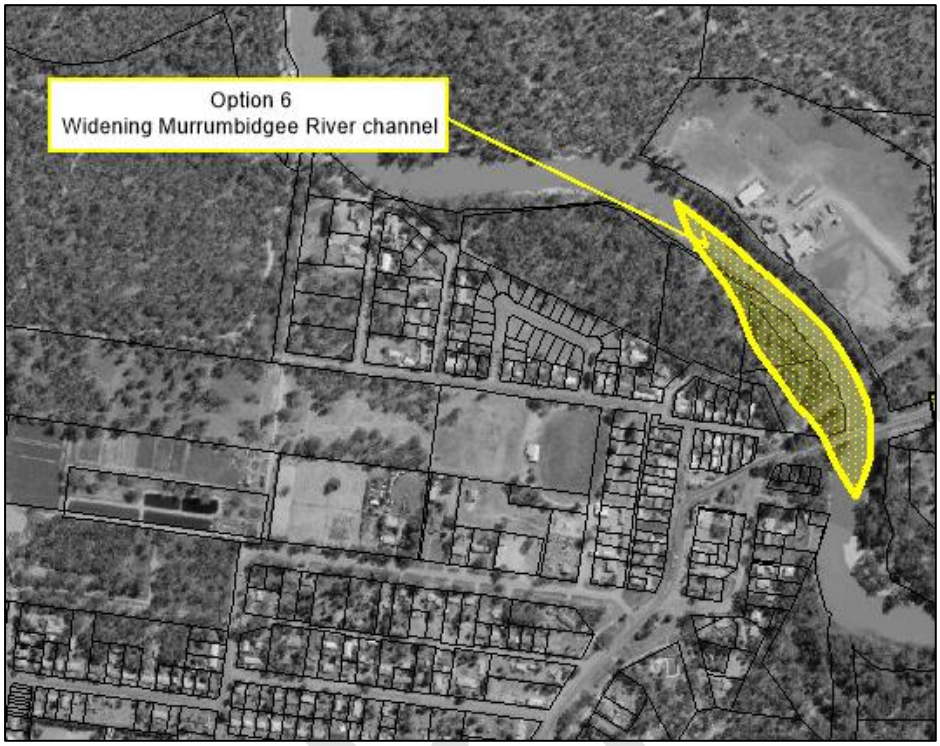


Plate 23 FM6 – Location of works

- Cost to construct - $1.54 million
- Cost to maintain - 2% of the construction cost - approximately $154,000 per year.

9.4.4.2. Hydraulic Impact of FM6

The assessment of the hydraulic impact of this option on reducing the flood risk include:

- Reduction in flood levels upstream for a distance of approximately 7 kilometres by up to 0.02 metres during the 5% AEP design flood event.
- Reductions of between 0.02 metres and 0.06 metres are estimated to occur in the high level flowpath under the Kidman Way south of Darlington Point during the 1% AEP design flood event.
- Reductions up to 0.15 metres around north Darlington Point during the 1% AEP design flood event.
- Increase in flood levels downstream of the bridges in the Murrumbidgee River for over 10 kilometres during the 1% AEP design flood event.
- A reduction in mainstream flood levels of the Murrumbidgee River have the potential to increase the level of protection of the existing levee.
- A review of the results of all design flood simulations indicate the number of properties subject to changes in property inundation or above floor inundation are predicted as:

Table 31 Hydraulic Impact of FM Option 6

Design Flood Event	Change in number of properties impacted by over floor flooding	Change in number of properties impacted by flood waters (in addition to above floor flooding)
5% AEP	0	0
2% AEP	-4	0
1% AEP	0	-1
1% AEP	-3	-2
0.2% AEP	-4	+3
Extreme flood event	-5	+4

- Reduce flood damage costs by $157,000 over the 50-year design life of the levee
- Preliminary benefit-cost ratio of less than 0.1

9.4.4.3. Summary of FM6 assessment

- Overall, despite the extent over which these works would reduce flood levels along the length of the Murrumbidgee River, these impacts are considered minor when the cost and associated environmental impacts during construction are taken into consideration.
- This option was generally supported by the community with comments provided during initial community consultation drop-in sessions and at the floodplain committee meetings.
- There are a number of constraints located in the area of these works, including Terrestrial and biodiversity constraints, wetland constraints, Aboriginal and Cultural Heritage constraints.
- This option would be incredibly difficult to construct, as it requires the embankment sections within the Murrumbidgee channel to be removed. This would require significant in-stream erosion and sediment control measures to be in place during and after construction to ensure sediment is not transported into the Murrumbidgee River.
- The road and bridges across the Murrumbidgee River are Transport for NSW assets, and so approval would have to be sought from Transport for NSW for any works close to or on their assets.

Table 32 Evaluation outcomes of widening the Murrumbidgee River channel at the existing bridge crossings

Evaluation Criteria	Rating	Comments
Hydraulic Impacts	**+1**	Minor decreases in flood level in the Murrumbidgee River and around north Darlington Point and across the Kidman Way south of Darlington Point. Increases in flood levels downstream of The Kidman Way for all design flood events generally within existing floodplain areas.
Inundated Buildings	**+1**	Small reduction in the number of buildings inundated above floor for almost all design flood events.

Evaluation Criteria	Rating	Comments
Emergency Response	**0**	No quantifiable improvements to the inundation of roads around Darlington Point or emergency response outcomes.
Technical Feasibility	**- 2**	Difficult to construct. Would require numerous approvals under different legislation.
Environmental Impacts	**-2**	Terrestrial biodiversity constraints up and downstream. Immediate impacts on water quality due to construction in channel. Minimal environmental impacts anticipated once construction complete.
Economic Feasibility	**- 2**	Low BCR with a significant capital cost.
Community Acceptance	**+1**	General discussions with the community during initial community consultation phase revealed some support for this option.
SCORE	**-3**	

Recommendation: Not recommended for further investigation.

9.4.5 FM7 – Increased flow conveyance under The Kidman Way adjacent to the caravan park

9.4.5.1. Concept design of FM7

As discussed in **Section 4** and **Section 9.4.4**, there are considerable flood depths anticipated on the overbank areas of the floodplain immediately around the Darlington Point levee. Option 6 assessed the feasibility of increasing the conveyance area available in the Murrumbidgee channel by removing some of the embankment between the two existing bridges. Option 7 assesses the feasibility of providing additional conveyance capacity under the Kidman Way immediately adjacent to the Darlington Point Caravan Park.

- Removal of some of the earth embankment of the Kidman Way and replacing it with a series of concrete culverts located on both the eastern and western side of the roadway access to Darlington Point Caravan Park.
- These culverts would include 20 reinforced concrete box culverts of 1800mm high x 1200mm high.
- Additional earthworks would be required on the northern side of the Kidman Way to provide a continuous downward grade from the culverts for approximately 100 metres.
- Cost to construct - $2.39 million

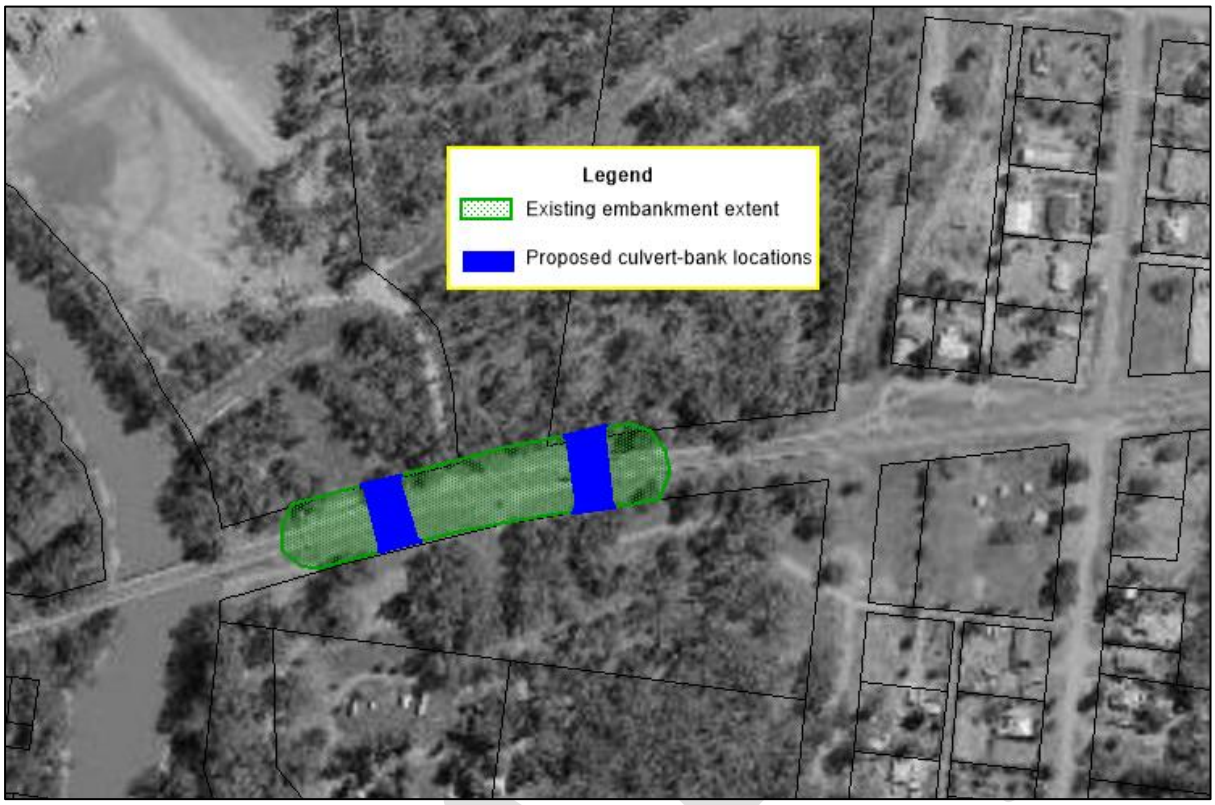


Plate 24 FM7 concept design

9.4.5.2. Hydraulic Impact of FM7

The assessment of the hydraulic impact of this option on reducing the flood risk include:

- As the flood event increases in magnitude, the impacts of these works decrease.
- Flood levels predicted to decrease downstream of the Kidman Way up to 0.10 metres in the 5% AEP design flood event, however these impacts result in flood levels increasing further downstream in the floodplain areas by up to 0.02 metres.
- Flood levels increase by up to 0.02 metres downstream of the Kidman Way in the 1% AEP and 0.2% AEP design flood event
- A review of the results of all design flood simulations indicate the number of properties subject to changes in property inundation or above floor inundation are predicted as:

Table 33 Hydraulic Impact of FM Option 7

Design Flood Event	Change in number of properties impacted by over floor flooding	Change in number of properties impacted by flood waters (in addition to above floor flooding)
5% AEP	0	0
2% AEP	-1	+1
1% AEP	0	0
0.2% AEP	-2	-1
0.5% AEP	-1	+1
Extreme flood event	-1	+1

- Reduce flood damage costs by $53,000 over the 50-year design life of the works
- Preliminary benefit-cost ratio of less than 0.1

9.4.5.3. Summary of FM7

Overall, despite the extent over which flood levels decrease as a result of implementation of this option, they are only minor decreases in flood levels during all design flood events in the Murrumbidgee river and north Darlington Point. In addition, these reductions in flood levels do not reduce the number of properties impacted by over floor flooding in the study area. Option 7 is not considered to be financially viable at this time as part of this floodplain risk management study, however, could be undertaken as part of future asset management works or road upgrades by Transport for NSW and/or Council. A detailed analysis would need to be undertaken at that time to determine flood impacts of the works.

Table 34 Evaluation outcomes of increasing flow conveyance under The Kidman Way adjacent to the caravan park

Evaluation Criteria	Rating	Comments
Hydraulic Impacts	**+1**	Minor decreases in flood level in the Murrumbidgee River and at north Darlington Point primarily in channel and overbank areas. More substantial decreases in flood level are localised and maintained to the area immediately downstream of the works.
Inundated Buildings	**0**	No change to the number of buildings inundated above floor.
Emergency Response	**0**	No changes to the trafficability of roads either side of this section of road for emergency management purposes during flood events.
Technical Feasibility	**-2**	Would be difficult to construct as would require closure of the Kidman Way for a period.
Environmental Impacts	**-1**	Terrestrial biodiversity and wetland constraints in the general area of proposed works.
Economic Feasibility	**-2**	Low BCR with a significant capital cost.
Community Acceptance	**+1**	Minimal community support for this option.
SCORE	**-3**	

Recommendation: Not recommended for further investigation as part of the floodplain risk management program but could be undertaken as part of future asset management works or road upgrades by Transport for NSW and/or Council.

9.4.6 FM8 - Vegetation Removal through National Park flowpaths

Several residents noted that some of the channels through the National Park north of north Darlington Point were littered vegetation and large fallen trees. There was concern from the community members that the vegetation in these areas was restricting the flow of water, thereby elevating water levels elsewhere, particularly north Darlington Point. There was also

concern that parts of the vegetation (e.g., branches) may also be mobilised during floods leading to blockages downstream. Therefore, the potential benefits associated with removing this larger debris from the major channels through the National Park north of north Darlington Point was investigated.

Plate 25 provides an example of fallen tree debris in these channels.

Plate 25 Fallen debris through channels in the National Park

9.4.6.1. Concept design of FM8

The area proposed for clearing is completely covered by Riparian Lands and Watercourses and Terrestrial Biodiversity layers included in the Murrumbidgee LEP 2013 mapping. Therefore, complete clearing of all vegetation along the channel is unlikely to be supported, however was investigated as part of this study to gain an understanding the impact this vegetation and debris has on flood behaviour in the study area.

The concept design for FM8 included:

- The extent of the area where vegetation removal was investigated as part of the study is shown in **Plate 26.**
- Manning's "n" roughness was reduced across the areas identified in **Plate 26** from 0.1 to 0.08.
- It is difficult to determine an accurate costing for this option. The estimates costs of these works assumed that the owners of the land (NSW Government) undertook the works themselves and removed some of the vegetation off site. Estimated costs of these works is $1.07 million.

9.4.6.2. Hydraulic impact of FM 8

- The impact of this option decreases with increasing flood size - flood level reductions decrease as the design flood event increases.

- During the 5% AEP design flood event, flood level reductions up to 0.02 metres almost 6 kilometres upstream of the works, increasing to 0.10 metres in the eastern sections of north Darlington Point.
- During the 1% AEP design flood event, flood level reductions up to 0.02 metres extend approximately 2.5 kilometres upstream of Darlington Point, with reductions of up to 0.20 metres are predicted to occur across the rural areas east of north Darlington Point, with reductions of only 0.02 metres estimated to occur through the north Darlington Point area itself.
- During the 0.2% AEP design flood event, the reduction in flood levels is estimated to occur primarily along the high-level flow path that crosses the Kidman Way south of Darlington Point, with reductions in flood levels estimated between 0.02 metres and 0.10 metres across the rural lands.
- A review of the results of all design flood simulations indicate the number of properties subject to changes in property inundation or above floor inundation are predicted as:

Table 35 Hydraulic Impact of FM Option 8

Design Flood Event	Change in number of properties impacted by over floor flooding	Change in number of properties impacted by flood waters (in addition to above floor flooding)
5% AEP	0	-1
2% AEP	-4	-1
1% AEP	0	-3
0.5% AEP	-31	+12
0.2% AEP	-5	+2
Extreme flood event	-5	+4

  - Reduce by 1 property in the 5% AEP design flood event
  - Reduce by 5 properties in the 2% AEP design flood event
  - Reduce by 3 properties in the 1% AEP design flood event
  - Reduce by 3 properties in the 0.2% AEP design flood event
  - Reduce by 1 property in the extreme flood event
- Reduction in flood damages costs by $260,000 over 50 years.
- Preliminary benefit-cost ratio of less than 0.3

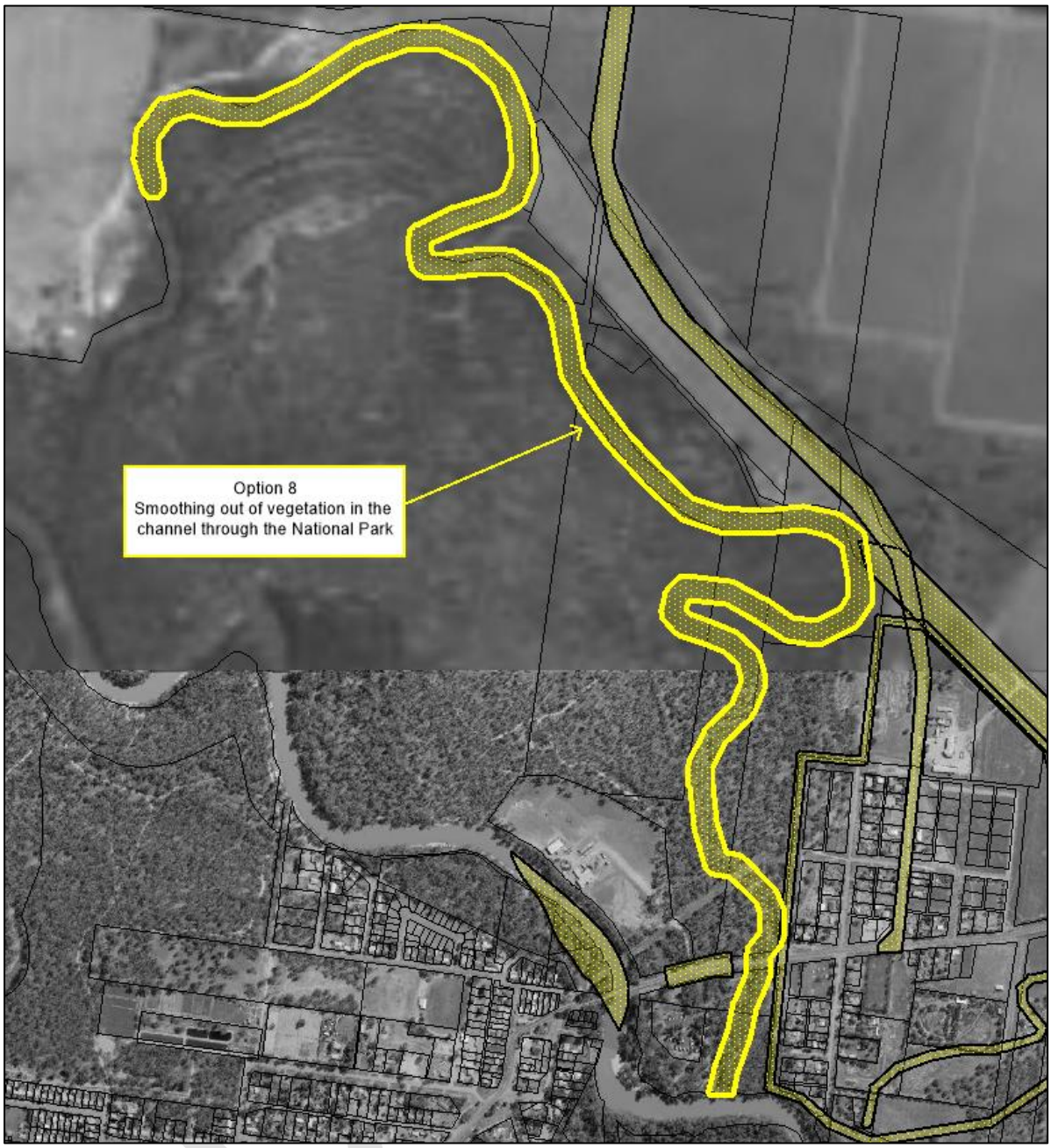


Plate 26 Location of FM8

9.4.6.3. Summary of FM8

The primary disadvantage associated with this option is the proposed location of works within a National Park and within areas mapped as Riparian Lands and Watercourses and Terrestrial Biodiversity layer on Murrumbidgee LEP 2103. It would be extremely difficult to gain approval for these works, particularly as they provide negligible changes to the flood damages expected in the study area. There would also be ongoing costs associated with the continual upkeep of the channel to ensure vegetation or other debris do not remain in the channel.

Overall, the high capital and ongoing costs and comparatively lower financial benefits mean that vegetation clearing is not supported for implementation as part of this floodplain risk management plan.

Table 36 Evaluation outcomes on the vegetation removal through the National Park channels

Evaluation Criteria	Rating	Comments
Hydraulic Impacts	**+1**	Minor decreases in flood level upstream of the works, extending to the outer areas of the floodplain.
Inundated Buildings	**0**	No change to the number of buildings inundated above floor.
Emergency Response	**0**	No changes to the trafficability of roads in the study area for emergency management purposes during flood events or impact on emergency management procedures.
Technical Feasibility	**-1**	Could be difficult to access and move some of the larger debris due to location within the National Park.
Environmental Impacts	**-1**	Terrestrial biodiversity and wetland constraints up and downstream. Would be difficult to determine what vegetation or debris could actually be removed in accordance with legislation without detailed investigation, which may restrict how much and the location of what can be removed.
Economic Feasibility	**-2**	Low BCR with a significant capital cost.
Community Acceptance	**+1**	General minimal community acceptance of this option.
SCORE	**-2**	

Recommendation: Not recommended for further investigation.

9.4.7 FM9 – Causeway along Hay Road

During the upgrade works of the levee around Darlington Point, concerns were raised by members of the community on the potential adverse impacts on properties to the south along Hay Road as a result of the levee works. The potential to offset these impacts with a causeway along Hay Road was suggested by residents.

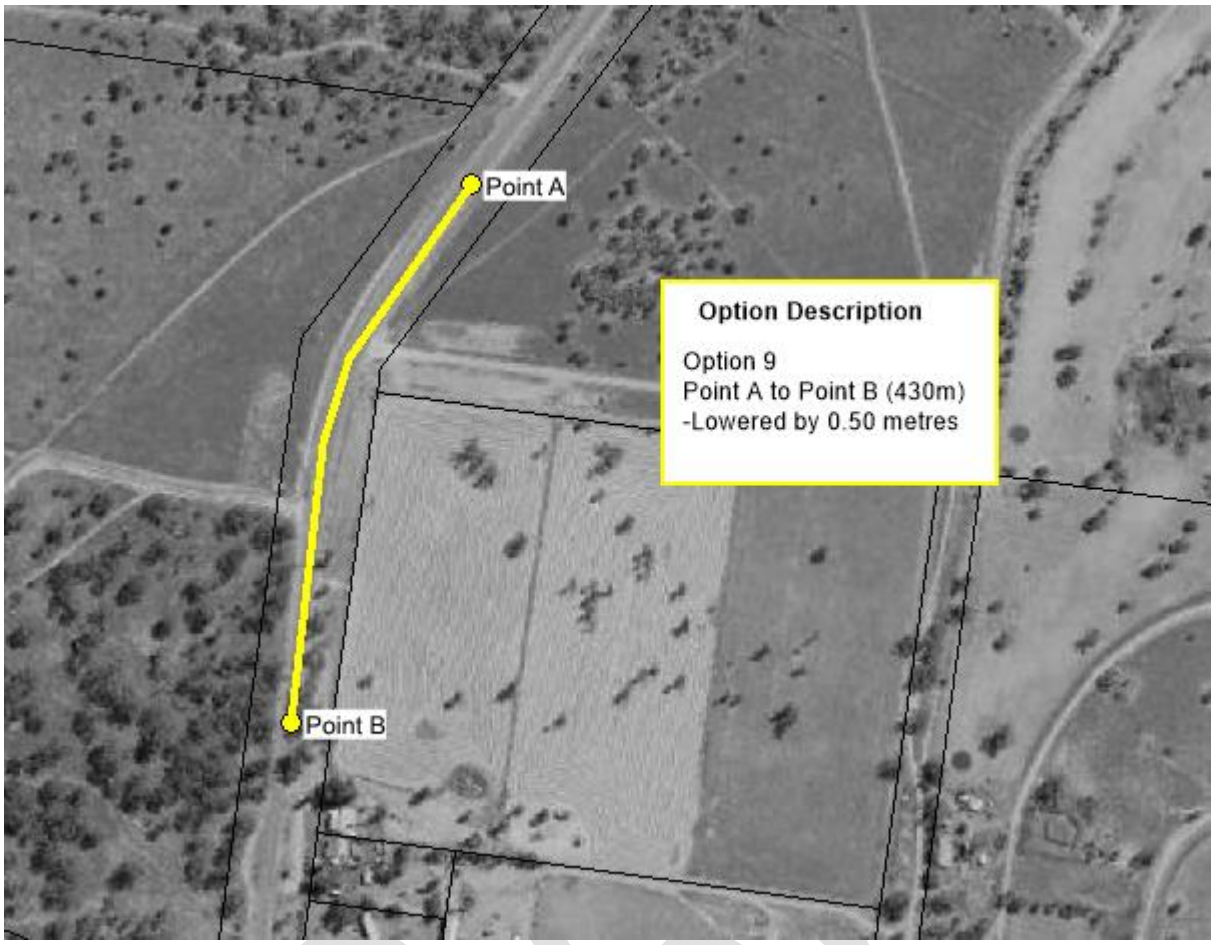


Plate 27 Concept Design of Option FM9

9.4.7.1 Concept design of FM9

The option of reducing the road crest levels of Hay Road near the Sturt Highway was assessed. The location of this causeway was consistent with the general location of the high level flow path assessed as part of FM option 5.

The concept design for FM option 9 includes:

- Reducing the road crest levels by 0.50 metres along an approximate length of 430 metres of Hay Road
- Grading the road levels at the northern and southern extent of these works to tie into existing road levels.
- Cost estimate of this concept design estimated that these works would cost approximately $803, 500 to undertake.

9.4.7.2 Hydraulic impact of FM9

- The impacts of this option only occur during the 1% AEP design flood event and greater.
- During the 1% AEP design flood event, flood level reductions up to 0.02 metres extend approximately upstream to The Kidman way in the south-east (Approximately 900 metres) and to the boundary of the levee 700 metres north.
- In the immediate area upstream of the causeway, flood level reductions between 0.1 and 0.2 meters are estimated to occur during the 1% AEP design flood event, although thee impacts are estimated to occur over a distance less than 150 metres.

- During the 0.2 % AEP design flood event, the reduction in flood levels occur over a very small areas upstream of Hay Road up to 0.02 metres.
- A review of the results of all design flood simulations indicate the number of properties subject to changes in property inundation or above floor inundation are predicted as follows:

Table 37 Hydraulic Impact of FM Option 9

Design Flood Event	Change in number of properties impacted by over floor flooding	Change in number of properties impacted by flood waters (in addition to above floor flooding)
5% AEP	0	0
2% AEP	0	0
1% AEP	0	-2
0.5% AEP	0	0
0.2% AEP	0	0
Extreme flood event	0	0

- Reduction in flood damages costs less than $4,000 over 50 years.
- Preliminary benefit-cost ratio of less than 0.01

9.4.7.3 Summary of FM9

The high capital costs and low financial benefit of this option, whereby only 2 residential properties are positively impacted, means that the construction of a causeway along Hay Road is not supported for implementation as part of this floodplain risk management plan.

Table 38 Evaluation outcomes on the causeway along Hay Road

Evaluation Criteria	Rating	Comments
Hydraulic Impacts	**+1**	Minor decreases in flood level upstream of the works, extending to the north approximately 700 meters and the south-west 900 metres during the 1% AP design flood event.
Inundated Buildings	**+1**	2 buildings no longer inundated by above floor flooding.
Emergency Response	**-2**	Decrease in the trafficability of Hay Road for emergency management purposes during flood events should the Kidman Way become untrafficable.
Technical Feasibility	**+2**	Considered reasonably straight forward to construct. Could be constructed by Council.
Environmental Impacts	**0**	Minimal environmental impacts expected as a result of the construction of the causeway.
Economic Feasibility	**-2**	Low BCR with a significant capital cost.
Community Acceptance	**0**	Unknown community acceptance of this option.
SCORE	**0**	

Recommendation: Not recommended for further investigation.

9.5 Drainage Upgrades

9.5.1 FM10 - General upgrade of culverts throughout the Darlington Point area

There are a number of stormwater drainage pipes and culverts around Darlington Point that were assessed for potential upgrade. These culverts are located outside of the area bounded by the levee and are primarily under local road crossings. These culverts primarily provide connectivity between open channels in the study area.

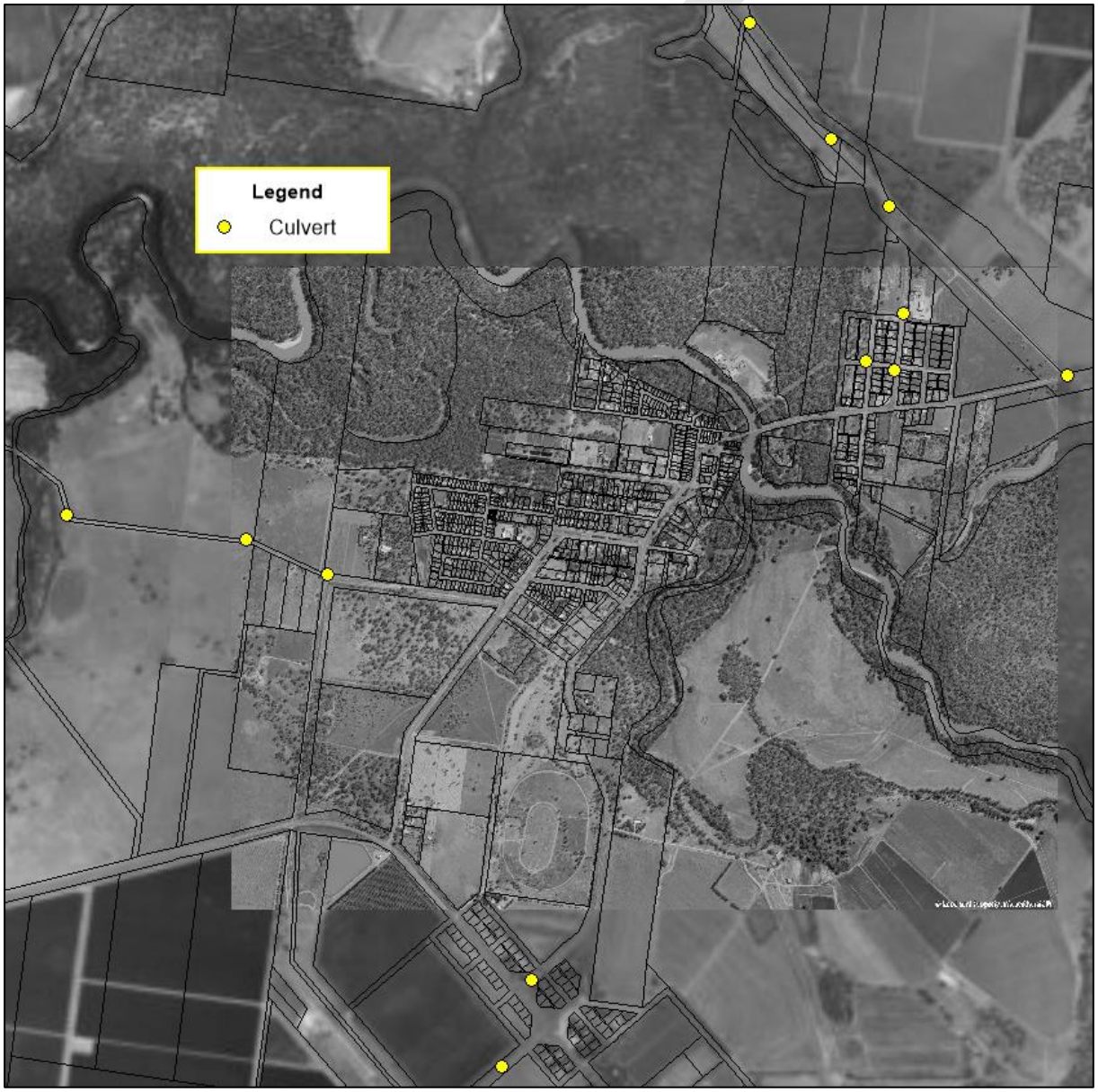


Plate 28 Locations of culverts upgraded as part of FM10

The hydraulic impacts associated with upgrading the culverts to double their current size were quantified by including them in the TUFLOW model. The 20% AEP and 1% AEP design flood event were re-simulated with these changes in place.

In general, the culvert upgrades were found not to provide a significant hydraulic benefit, particularly during larger events. Any reduction in flood levels were very localised and did not extend downstream a significant distance. These upgrades did not have any impact on over floor flooding of properties in the study area. As such, it was difficult to quantify the benefits of upgrading the culverts in regard to flood damage.

Recommendation: Not recommended for implementation.

9.6 Summary and Recommendations

A summary of the evaluation of each flood modification option is provided in **Table 39, Table 40 and Table 41.** As shown in **Table 41**, no flood modification options are recommended for further consideration to assist in managing the existing flood risk across the floodplain at Darlington Point

Table 39 Economic Assessment of Flood Modification Options

Flood Modification Option	Present Value Estimates ($ millions)				BCR
	Cost Estimate	Total Damage for Existing Conditions	Total Damage with Option in Place	Reduction in Damage with Option in Place	
FM1 – North Darlington Point levee	$7.68	2.280	1.811	0.47	0.06
FM2 - North Darlington Point levee – temporary levee	$2.49	2.280	2.254	0.03	0.01
FM3 – Spillway analysis	$0.20	Not determined			
FM4 – Travelling Stock Route flowpath	$6.14	2.280	2.284	0.00	0.00
FM5A - Improving flow conveyance under the Kidman Way south of Darlington Point with a causeway	$1.42	2.280	1.233	1.05	0.74
FM5B - Improving flow conveyance under the Kidman Way south of Darlington Point with low level bridge	$3.08	2.280	2.059		
FM6 - Widening Murrumbidgee River channel	$1.54	2.280	2.123	0.16	0.10
FM7 - Increased flow conveyance under The Kidman Way adjacent to the caravan park	$2.39	2.280	2.227	0.05	0.02
FM8 - Vegetation Removal through National Park flowpaths	$1.07	2.280	2.020	0.26	0.24
FM9 – Causeway along Hay Road	$0.80	2.280	2.276	0.004	0.01

FM10 - General upgrade of culverts throughout the Darlington Point area	N/A	N/A	N/A	N/A	N/A

Table 40 Change in Number of Properties Impacted by Above Floor Flooding due to Flood Modification Options

Flood Modification Option	Change in Number of Properties Impacted by Above Floor Flooding		
	5% AEP Design Flood Event	1% AEP Design Flood Event	Extreme Flood Design Flood Event
FM1 – North Darlington Point levee	-3	-24	-42
FM2 - North Darlington Point levee – temporary levee	-1	-7	1
FM3 – Spillway analysis	Not determined		
FM4 – Travelling Stock Route flowpath	0	0	2
FM5A - Improving flow conveyance under the Kidman Way south of Darlington Point with a causeway	3	-4	-31
FM5B - Improving flow conveyance under the Kidman Way south of Darlington Point with low level bridge	3	-4	-31
FM6 - Widening Murrumbidgee River channel	0	-1	-1
FM7 - Increased flow conveyance under The Kidman Way adjacent to the caravan park	0	0	0
FM8 - Vegetation Removal through National Park flowpaths	-1	-3	-1
FM9 – Causeway along Hay Road	0	-2	0
FM10 - General upgrade of culverts throughout the Darlington Point area	0	0	0

Table 41 Evaluation matrix for Flood Modification Options

Option No	Option Description	Evaluation Criteria / Score#							
		Hydraulic Impacts	Inundated Buildings	Emergency Response	Technical Feasibility	Environmental Impacts	Economic Feasibility	Community Acceptance	Recommended for Further Consideration?
FM1	North Darlington Point levee – permanent levee	+1	+1	0	-1	-1	-2	+1	**No**
FM2	North Darlington Point levee – temporary levee	+1	+1	+1	-1	0	-2	0	**No**
FM3	Construction of spillway in existing levee	0	0	0	-1	0	-1	0	**No**
FM4	Bypass channel along Travelling Stock Route in north Darlington Point	+1	0	+1	-1	0	-2	+1	**No**
FM5	Improving flow conveyance under the Kidman Way south of Darlington Point –causeway / culverts	-1	0	+1	+2	0	-2	-2	**No**
FM6	Widening Murrumbidgee River channel	+1	+1	0	-2	-2	-2	+1	**No**
FM7	Increased flow conveyance under the Kidman Way adjacent to the Caravan park	+1	0	0	-2	-1	-2	+1	**No**
FM8	Smoothing out vegetation through the channel through the National Park adjacent to north Darlington Point	+1	0	0	+1	-1	-2	+1	**No**
FM9	Causeway along Hay Road	+1	+1	-2	+2	0	_2	0	**No**
FM10	General upgrade of culverts throughout the Darlington Point area	Not evaluated as part of current study							**No**

Refer to **Table 20** for evaluation criteria and scoring system

10 Property Modification Options

10.1 Introduction

Property modification options refer to modifications to planning controls and/or modifications to individual properties to reduce the potential for inundation in the first instance or improve the resilience of properties should inundation occur. Modifications to individual properties is typically used to manage existing flood risk while planning measures are employed to manage future flood risk.

Property modification options considered as part of the current study included:

- Voluntary House Purchase
- Voluntary House Raising
- Voluntary Flood Proofing
- Planning Modifications

Further discussion on property modification options that could be potentially implemented to help manage the existing and potential future flood risk is provided below.

10.2 Property Modification Options

10.2.1 PM1 - Voluntary House Purchase

Voluntary house purchase (VHP) refers to the voluntary purchase of an existing property on a high-risk area of the floodplain. The purchased property is typically demolished, and the land is rezoned so that it can be retained as open space or an equivalent land use that is more compatible with the flood risk.

Due to the high capital costs associated with this option, VHP is typically only considered appropriate in floodway / high hazard areas where other flood risk reduction strategies are impractical or uneconomic. Moreover, NSW Government funding is only available for VHP for properties that were approved and constructed prior to 1986 when the original Floodplain Development Manual was gazetted (Office of Environment & Heritage, 2013a).

The computer flood modelling outputs were interrogated with existing building footprints to identify houses that may be eligible for VHP. More specifically, buildings that fell within the following areas at the peak of the 1% AEP flood were considered potentially eligible for VHP:

- High flood hazard areas; and
- Floodway areas.

It is noted that the 'high hazard' definition in the NSW Office of Environment & Heritage guideline refers to the NSW Government's "Floodplain Development Manual" (2005) hazard categories. The more recent national hazard categories have been adopted as part of the current study (refer **Section 4.2.4**). In this regard, it was assumed that the national H1, H2 and

H3 categories would fall under the 'Low' hazard category in the NSW Government's "Floodplain Development Manual (2005)" and the national H4, H5 and H6 categories would fall under the 'high' hazard category in the Manual.

A total of 3 houses were identified as being potentially eligible for voluntary purchase. All identified properties are located within high hazard /floodway /flood storage areas at the peak of the 1% AEP event, with velocities around each dwelling predicted to exceed 1 m/s at the peak of the 1% AEP design flood event.

Revised flood damage estimates were also prepared by removing the damage contribution provided by these houses. That is, it was assumed that the purchased properties would be demolished, and the current occupants relocated to an area outside of the floodplain. The revised damage calculations yielded a reduction in the predicted damages of $47,000 over a 50 year period, providing a preliminary BCR of less than 0.1.

Although there does not appear to be a significant financial incentive to implement VHP, it should be recognised that the primary goal of VHP is to remove high-risk properties from the floodplain in instances where no other flood or property modification options are viable. In this regard, most VHP programs across NSW provide a BCR less than 1. Therefore, it is considered worthwhile for Council to pursue VHP as part of a long-term risk reduction strategy across this study area and across the whole LGA.

It is suggested that Council undertake a feasibility study for voluntary house purchase across the LGA. This would involve collating VHP information for all floodplain risk management plans and use this information to prioritise potential VHP properties for the LGA so the costs associated with implementation of this option are best allocated within available funds. Once this prioritised list is prepared, Council could initiate discussions with homeowners to determine their willingness to participate.

If homeowners do not wish to participate in VHP, Council could discuss alternate options for reducing the existing risk. This could include:

- Voluntary house raising (discussed in **Section 10.2.2**).
- Encourage flood-compatible redevelopment of the existing property.
- One of these properties is on a very large lot. Any redevelopment on that lot should encourage relocating the residential dwelling outside of the high flood risk areas.

Recommendation: Feasibility study undertaken to implement a voluntary house purchase scheme across the LGA as part of a long-term flood risk reduction measures across the study area.

Table 42 Evaluation Outcomes for Voluntary Purchase

Evaluation Criteria	Rating	Comments
Hydraulic Impacts	**+1**	Localised changes in flood behaviour may occur in vicinity of purchased properties but broad-scale changes across study area likely to be minimal
Inundated Buildings	**+2**	3 less buildings inundated above floor level during 1% AEP flood
Emergency Response	**+1**	Removal of high risk properties will reduce the number of residents in the floodplain and reduce burden on emergency services during flood events
Technical Feasibility	**-1**	No significant technical hurdles, however wholly relies upon the home owner to voluntarily sell their property to Council, which can take a number of years, if at all. Homeowner can sell their property to others, if desired.
Environmental Impacts	**0**	Purchased properties could be demolished and returned to open space, increasing visual and environmental amenity of the area.
Economic Feasibility	**-1**	High capital cost and low BCR
Community Acceptance	**-1**	Not very strong community support
SCORE	**2**	

10.2.2 PM2 - Voluntary House Raising

Voluntary house raising (VHR) is a well-established method of reducing the frequency, depth and duration of above floor inundation. VHR can be a suitable measure for reducing the flood damage for individual dwellings or can be used as a compensatory measure where other flood mitigation works are predicted to adversely impact on flood behaviour across individual dwellings. An example of house raising is provided in **Plate 29**.

VHR is best suited to single-storey, timber or clad walled houses with a pier and beam foundation in areas of low flood hazard where structural mitigation works are impractical or uneconomic. It should also be noted that Government funding is only available for VHR for residential properties that were approved and constructed prior to 1986 when the original Floodplain Development Manual was gazetted (Office of Environment & Heritage, 2013b).

The computer flood modelling outputs were interrogated in conjunction with building footprints to identify houses that may be eligible for VHR. Specifically, houses that met the following criteria were pursued:

- Subject to frequent above floor inundation. In this regard, properties that were predicted to be inundated above floor level during a 10% AEP design flood event were selected.
- Single storey, non-brick houses constructed on a pier and beam foundation.
- Low flood hazard area at the peak of the 1% AEP event.

A total of 6 houses were identified as being potentially eligible for voluntary house raising in the study area. This would involve raising these houses above the flood planning area of the 1% AEP plus 300mm freeboard, to be consistent with the flood planning level recommended in this study.

Plate 29 Examples of houses before (top image), during (middle image) and after (bottom image) house raising (photos courtesy of Fairfield City Council)

The cost associated with raising a house will vary depending on the location, size and complexity of the house. However, recent house raising projects completed by Fairfield City Council indicates a typical cost of $82,000 per building. This cost estimate is based on an average floor area of 130 m^2 and raising the house by 2.5 metres. Installation of a car port / garage etc could be accommodated on the lower level, but this is not included in the cost estimate.

Revised flood damage estimates were also prepared by updating the damage contribution provided by these houses due to their elevated floor levels. The revised damage calculations yielded a reduction in the damages of $132,000 over a 50 year period, providing a preliminary BCR of less than 0.3.

It is questionable as to whether each of the existing dwellings are structurally suitable for house raising and if the occupants could still navigate their homes with stairs and elevated floor levels. The amenity of the area also has to be considered, as the resultant elevated properties would be located amongst the existing housing stock, which may be much lower.

It's possible that allocating funds for house raising may be overcapitalising in this study area due to the existing value of the properties and the costs involved with raising the houses. Therefore, the financial viability of this option is considered to be low.

Nevertheless, the identified properties are predicted to be subject to relatively frequent inundation and other opportunities to reduce the potential for frequent inundation of this property are worth pursuing. More specifically, discussions could be held with the property owner to outline the potential high cost of ongoing ownership of the existing property due to flood damages and encourage flood-compatible redevelopment of the existing site.

Recommendation: Voluntary house raising not considered viable as part of this project. However, discussions could be held with property owners to encourage flood-compatible redevelopment.

Table 43 Evaluation Outcomes for Voluntary Raising

Evaluation Criteria	Rating	Comments
Hydraulic Impacts	**0**	Minimal impacts on flood behaviour anticipated as a result of these works
Inundated Buildings	**+2**	6 less buildings inundated above floor level during 1% AEP flood
Emergency Response	**-2**	May increase the potential for isolation and/or need for evacuation or resupply if evacuation is not completed early
Technical Feasibility	**-2**	Raising existing buildings can be quite challenging. Not all occupants will be able to use a raised house.
Environmental Impacts	**0**	Negligible environmental impacts
Economic Feasibility	**-2**	Could be considered as overcapitalisation, rather than redeveloping the property.
Community Acceptance	**-1**	Not very strong general community support
SCORE	**-5**	

10.3 Planning Modification Options

10.3.1 PM3 – Recommended flood planning level

Existing definition of flood planning level in Murrumbidgee Council LEP2013

Murrumbidgee Council has defined the flood planning level as "*the level of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metre freeboard*" through Clause 6.2 of the Murrumbidgee Local Environmental Plan 2013 (LEP). This is consistent with the NSW Governments 'Floodplain Development Manual' (NSW Government, 2005), which suggests that a flood planning level consisting of the 1% AEP flood plus a 0.5 metre freeboard will generally be appropriate for new residential development unless exceptional circumstances exist. This "standard" is also echoed by the 'Guideline on Development Controls on Low Flood Risk Areas – Floodplain Development Manual' (Department of Planning, 2007) which states that "*…unless there are exceptional circumstances, councils should adopt the 100 year flood as the FPL for residential development*". This definition effectively applies a "one size fits all" approach for defining the flood planning level across the LGA.

Freeboard analysis of levee crest

A freeboard analysis was carried out to determine the estimated freeboard provided by the existing levee, and to help provide guidance for an appropriate spillway analysis. This detailed freeboard analysis has been undertaken in accordance with the methodology undertaken by NSW Governments Public Works Advisory as part of the assessment of the Wagga Wagga Levee Upgrade in 2010.

Table 44 Freeboard components

Freeboard	Maximum height of component (metres)	Probability	Joint Probability component (metres)
Wave run-up	0.19	0.5	0.095
Wave set-up	0.01	0.5	0.005
Local Water surge	0.10	1	0.100
Uncertainty in flood level	0.30	1	0.300
Levee Settlement	0.02	0.5	0.01
Defects in levee	0.1	0.5	0.050
Climate change	0.15	1	0.150
TOTAL			0.710
FREEBOARD ALLOWANCE			**0.75**

Appendix D details the freeboard assessment. The freeboard assessment considers a range of factors from the design flood information, including the wind and wave action on the levee, uncertainties in design flood level estimation, levee settlement and defects, and potential climate change impacts. A summary of these freeboard components is presented in **Table 44.**

This detailed freeboard analysis determined a value of 0.71 metres, which has been rounded up to 0.75 metres to be used in this study.

Considerations for Flood Planning Area and Flood Planning Level in study area

Flood planning levels (FPLs) and the flood planning area (FPA) are important tools in the management of flood risk. The Flood Planning Area (FPA) is used to define the area where flood-related development controls apply over development. For those areas contained within the FPA, the Flood Planning Levels are frequently used to establish the elevation of key components of a development, such as minimum floor levels. The flood planning area has been defined for both those properties located within the land protected by the levee and on the wider floodplain.

Flood Planning Levels (FPLs) are typically derived by adding a freeboard to a specific design flood. This specific design flood is frequently referred to as the "planning" flood. The freeboard is intended to account for any uncertainties in the derivation of the planning flood level. Flood planning levels, as well as the freeboard component itself, can be specified for different land uses or types of development (residential, non-residential or rural, based on the vulnerability of the development to flooding) and for different flooding sources (riverine or local overland flooding). The FPLs can be combined with topographic information to establish the Flood Planning Area (FPA). The FPL / FPA can then be used to assist in managing the existing and future flood risk by:

- Setting design levels for mitigation works (e.g., levees); and,
- Identifying land where flood-related development controls apply to ensure that new development is undertaken in such a way as to minimise the potential for flood impacts on people and property.

The NSW Floodplain Development Manual 2005 defines the food planning level as "a combination of flood levels and freeboards selected for floodplain risk management purposes, as determined in management studies and determined in management plans". NSW flood related planning requirements for local councils are set out in Ministerial Direction No. 4.3 Flood Prone Land, issued in 2007 under the then Section 117 (now Section 9.1) of the EP&A Act 1979. The Direction also requires that councils must not impose flood related development controls above the residential flood planning level (FPL, typically the 1% AEP flood plus 0.5m freeboard) for residential development on land, unless a relevant planning authority provides 'adequate justification' for those controls to the satisfaction of the Director-General.

Flooding at Darlington Point can occur as a result of elevated water levels in the Murrumbidgee River, or local overland flow for the areas behind the levee. As such, this study needs to consider both mechanisms of flooding when determining an appropriate flood planning level and the flood planning area.

The assessment for the flood planning level for mainstream flooding and local overland flooding needs to consider a number of additional factors when evaluating the freeboard. These include:

i) Mainstream flooding:

- Differences in levels between the 1% AEP design flood event and floods greater than it i.e. the 0.5% AEP, 0.2% AEP design flood event and the extreme flood event. The difference between the 1% AEP and 0.5 % AEP design flood level in most locations is approximately 0.1 metres and the 1% AEP and extreme flood level generally between 0.2 to 0.5 metres.
- The volume of floodwater in the design extreme event is approximately 3 times those estimated to occur in the 1% AEP design flood, however produces flood levels that are between 0.2 and 0.5 metres higher. Therefore, there is not a significant increase in risk due to increasing flood depth as the design floods become less frequent.
- Rate of rise of floodwaters in the Murrumbidgee River – the design flood information indicates a maximum rate of rise of approximately 1.2 metres per day during the peak of the flood, falling to approximately 0.76 metres per day once bank full flow is reached.
- Effective warning time – there are a number of weeks from the onset of rainfall in the upper parts of the catchment to when peak water depths in Darlington Point are reached during a flood event. The 2012 flood took approximately one (1) week from when it reached its peak in Wagga Wagga upstream to reach Darlington Point and around 3- 4 days from when it reached its peak in in Narrandera to reach peak water levels in Darlington Point. This is adequate time for property owners to take actions to reduce personal and property damage.
- Rising road access out of north Darlington Point and the areas to the south of Darlington Point.
- Consideration of potential property damage with higher or lower freeboards and resultant higher or lower flood planning levels
- Uncertainties in the estimates of flood levels - the detailed freeboard assessment of the upgraded levee was carried out as part of this study and has been included in **Appendix D** and discussed in **Section 0.** It provides an example of some of the uncertainties that could be considered during this freeboard analysis.

ii) Local Overland flooding:

- Duration of flooding – floodwater generally remains in the areas behind the levee between 12 and 24 hours as a result of local flooding.
- Differences in water levels (i.e. the flood grade) across the areas behind the levee of Darlington Point are considered to be negligible.
- Cumulative impact as a result of infill behind the levee is considered to be negligible
- Changes in rainfall patterns and volumes as a result of climate change are considered to be negligible.
- Limited warning time for local flooding - The BoM provide flood warnings for large scale flooding in the Murrumbidgee River, however no warning is currently issued for local flooding as a result of local rainfall only.
- The difference in flood characteristics between the different flood mechanisms of local overland flooding behind the levee and mainstream Murrumbidgee flooding.

The assessment of the flood planning level specified in Murrumbidgee LEP 2013 for managing the flood risk in the study area includes consideration of both the flood planning event and the freeboard. These are discussed individually below.

Planning Flood event

The study area contains land zoned as RU1 Primary Production, RU5 Village and R5 Large Lot Residential where residential development can be located.

As per the NSW Governments Standard LEP Instrument, the 1% AEP design flood is considered as the minimum required planning level for residential development. As such, it is considered appropriate to apply the same development requirements to the areas where residential development could be located in the study area. Alternatively, a more frequent or less frequent design flood event may be selected however adequate justification would have to be provided and exceptional circumstances sought from the NSW Government, as per the Section 9.1 Direction (refer **Section 6.2.1)**.

A more frequent design flood event would expose the residential development to a greater flood risk as they would be vulnerable to flooding in events more frequent than the 1% AEP. The use of a less frequent event would reduce the risk of larger future floods by requiring floor levels to be higher and the flood planning area to be larger than the existing FPA. However, these additional building requirements could introduce social and economic costs associated with the development of the new buildings and introduce discrepancies due to increases in restrictions and development potential across the larger flood planning area. Therefore, it is recommended to use the 1% AEP design flood level as the basis of the flood planning level for all future residential development in the study area.

A review of the detailed sensitivity assessment completed as part of the 2018 flood study "Murrumbidgee River at Darlington Point and Environs Flood Study" (BMT WBM, 2018) indicates that there is little sensitivity in the flood levels of the Murrumbidgee River at Darlington Point. The assessment tested variations in hydraulic roughness, peak flow estimation and climate change, with the results reproduced in
Table 45**.** These results indicate that there was minimal change in the flood levels for the 1% AEP, 0.5 % AEP and 0.2% AEP events when the flood model parameters are varied.

In general, the flood height range between the riverine 1% AEP flood and the 0.5% AEP design flood is approximately 0.20 metres at Darlington Point. Therefore, the risk to life and potential for structural damage during floods greater than the 1% AEP design flood event is not significantly greater than the 1% AEP design flood event plus a freeboard. The adoption of the 1% AEP design flood event for setting the residential flood planning levels is considered appropriate for the study area for riverine flooding.

The levee around Darlington Point has a design crest level based on the 1% AEP design flood level, with a freeboard estimated at 0.75 metres above the 1% AEP design mainstream flood level, as discussed in **Section 0.** As such, it is considered that the levee provides a suitable level of protection to the 1% AEP design flood event of the Murrumbidgee River (riverine) for the existing properties located behind it. However it does not provide any protection for local overland flooding. In addition, for the properties located behind the levee, the local catchment 1% AEP design overland flood level should also be considered for the planning flood event, to

ensure the local flood planning level adequately caters for all flooding mechanisms that may impact a property.

Table 45 Summary of Model Sensitivity Assessment – Table 7-7 of "Murrumbidgee River at Darlington Point and Environs Flood Study" (BMT WBM, 2018)

Location	1% AEP Design flood level (mAHD)					
	Existing 1% AEP design flood level	Hydraulic Roughness		Peak Flow variation		Climate change impacts
		Manning's "n" decreased	Manning's "n" increased	90% lower bound (2% AEP)	90% upper bound (0.2% AEP)	Increased rainfall (0.5% AEP)
Kidman Way / Murrumbidgee River Road	125.6	125.5	125.6	125.5	125.6	125.6
Darlington Street	126.1	126.0	126.2	126.0	126.3	126.2
Bridge Street gauge	125.6	125.5	125.7	125.5	125.8	125.7
Caravan Park	125.8	125.7	125.9	125.6	126.0	125.9
Darlington Point Public Pool	-	-	-	-	125.7	125.4
Kidman Way (south)	126.0	-	126.1	-	126.1	126.1
Hay Road	125.1	-	125.2	-	125.3	125.2

It should be noted that the primary objective of the study is to define the nature and extent of the flooding problem across the study area. Therefore, there is a need to distinguish between areas of significant inundation depths and those areas subject to negligible inundation for the area behind the levee. In this regard, the 1% AEP design overland flood results were filtered using the following criteria before inclusion in the flood mapping.

- Water depths less than 0.10 metres were removed; and,
- Isolated "puddles" were also removed if they were less than 100m^2.

The resultant 1% AEP design overland flood levels were used as the basis for the overland flood planning level for the area behind the levee.

Freeboard

The selection of the freeboard component of the flood planning level requires careful consideration. A freeboard provides a factor of safety when considering:

- The uncertainties in the flood level estimates.
- Local factors in the floodplain influencing different water levels across the floodplain.
- Wind and wave action.
- Changes in rainfall patterns as a result of climate change.

Clause 6.2 of Murrumbidgee LEP 2013 applies a 0.50 metre freeboard to the 1% AEP design flood level. The floodplain of the Murrumbidgee River around Darlington Point is generally

wide and flat. In areas outside of the levee, application of the 0.50 metre freeboard to the existing 1% AEP design flood level would extend the flood planning area beyond the extent of the extreme flood. The extreme flood is recognised as the largest flood that could conceivably occur at a location. Therefore, applying flood related development controls beyond the extent of floodprone land represented by the extreme flood event is not considered feasible.

Although the approach defined in the Murrumbidgee LEP 2013 is easy to apply and understand, it fails to consider the variable flood characteristics that are evident across the LGA (including areas subject to relatively shallow overland flow) and does not follow the merits based approach that is encouraged in the *'Floodplain Development Manual'* (NSW Government, 2005). More specifically, the Manual advocates consideration of a range of factors in determining the most appropriate flood planning level. These include the risk to life across the full range of design flood events, flood behaviour, social issues, land availability/needs, duration of flooding, the value of land, existing level of development and the current FPL for planning purposes .

There may be a case to support adopting a freeboard that is lower than 0.5 metres in this study area. The freeboard is, in essence, a "factor of safety" that is used to cater for uncertainties in the estimation of the planning flood (1% AEP design flood). The assessment for freeboard associated with riverine flooding from the Murrumbidgee River and local overland flooding for the areas behind the levee have been undertaken individually.

(i) Freeboard for overland flooding behind the levee

A freeboard of 0.50 metres was applied to the areas impacted by flooding in the 1% AEP design overland flood event (greater than 0.15 metres depth) to define the flood planning area for the area behind the levee. This resulted is almost the entire Darlington Point area protected by the levee to be located within the flood planning area. Given the shallow depths of flooding as a result of local overland flooding and minimal duration of flooding experienced during local flood events, this freeboard represented an unrealistic "factor of safety" applied to the expected food risk at the 1% AEP design flood level.

Therefore, a freeboard of 0.30 metres was applied to the resultant areas impacted by flooding in the 1% AEP design overland flood event (greater than 0.15 metres depth) to provide the flood planning level for the area behind the levee. This recommended flood planning area is represented on **Figure 35.** This proposed flood planning area is considered a reasonable representation of the area where flood related development controls should be implemented to manage the existing flood hazard.

(ii) Freeboard for riverine flooding

As per the assessment of freeboard behind the levee, a freeboard of 0.50 metres was applied to the areas impacted by flooding in the 1% AEP design Murrumbidgee River flood event to define the riverine flood planning area. This resulted in the flood planning area extending beyond the extent of the extreme food event in many locations. Again, this level of protection from flood damages is considered disproportionate considering the flood risk in many parts of the floodplain.

Plate 30 identifies two (2) areas within the riverine floodplain that currently include land that is zoned R5 Large Lot Residential and RU5 Village that are outside the extent of the levee and

within the extent of the floodplain. As such, a residential flood planning level would need to be applied to these areas. The range in flood height between the 1% AEP design flood event, and larger floods, has been undertaken to understand the range in flood risk at these sites.

Within these two (2) locations, six (6) spot sites have been identified, and a comparison between the existing 1% AEP design riverine flood level, and the 0.2% AEP, 0.5% AEP and extreme flood level has been undertaken. This information has been included in **Table 46**, as well as details of the ground level at each of these sites.

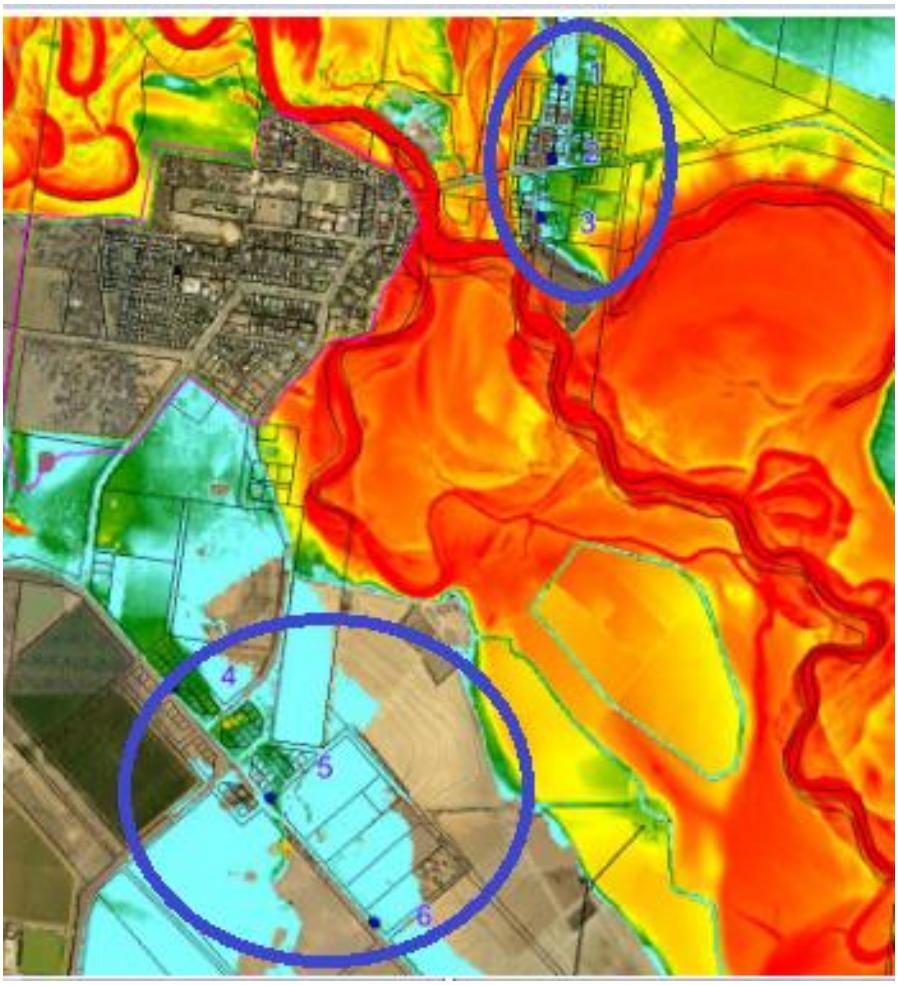


Plate 30 Location of spot checks for sensitivity to flood levels for freeboard analysis during 1% AEP design flood event

Table 46 Spot location sensitivity of design flood levels

Location (refer Plate 30)	Ground level (mAHD)	Design flood level (mAHD)			
		1% AEP	0.5% AEP	0.2% AEP	Extreme flood event
1	125.37	125.51	125.6	125.68	126.06
2	126.62	125.84	125.96	126.05	126.44
3	126.08	126.28	126.36	126.44	126.69
4	125.02	125.2	125.35	125.43	125.63
5	125.31	125.52	125.56	125.59	125.72

Location (refer Plate 30)	Ground level (mAHD)	Design flood level (mAHD)			
		1% AEP	0.5% AEP	0.2% AEP	Extreme flood event
6	125.52	125.72	125.84	125.87	125.94

The difference in flood levels between the 1% AEP design riverine flood event, and the 0.2% AEP, 0.5% AEP and extreme flood listed in **Table 46** varies between 0.2 metres and 0.5 metres, generally with less than 0.20 metres between the 1% AEP design riverine flood event, and the 0.5% AEP design flood event. As such, it is considered that a freeboard of 0.30 metres would provide a level of protection up to the 0.5% AEP design flood level, whist providing adequate allowance for uncertainties that cannot be explicitly represented in the flood modelling.

Recommended flood planning level

The flood planning level recommended for the study area is the 1% AEP design flood event, plus a freeboard of 0.30 metres. This flood planning level is recommended for local overland flooding behind the levee, and for areas impacted by mainstream riverine flooding.

The recommended flood planning area is represented on **Figure 35**. This figure represents the riverine and local overland flood planning areas.

It is to be noted that the Jerilderie Floodplain Risk Management Plan, completed and adopted by Council in 2015, also recommended a flood planning level that was based on the 1% AEP design flood level and a freeboard allowance of 0.30 metres.

It must also be remembered that any works in the floodplain in the rural areas would be subject to approval from WaterNSW under the Water Management Act 2000 as part of a Rural Flood works. Consideration of these works is outside the scope of this study.

Recommendations: Update definition of flood planning level for this study area as recommended in this study, to 1% AEP plus a 0.30 metre freeboard

10.3.2 PM4 - Appropriateness of current Murrumbidgee LEP 2013 zoning

An evaluation was undertaken to establish the compatibility of the Murrumbidgee LEP 2013 land use zones with the flood hazards, with the outcomes described in **Section 6.3.** The current study has defined hazard based upon the contemporary H1 – H6 categories presented in the *Australian Disaster Resilience Guideline 7-3 Flood Hazard"* (AIDR, 2017) that are considered current best practice.

As part of this assessment, the following definitions were used to convert the H1-H6 categories into an equivalent low/high classification:

- Low Hazard: H1 – H3
- High Hazard: H4 – H6

As indicated on **Figures 42 and 43** the Murrumbidgee LEP 2013 land use zones appear to be generally compatible with the flood hazards as the areas considered as high hazard are generally maintained in and immediately adjacent to the main Murrumbidgee River. That is, there is no obvious need for modification to the current LEP zones based on current flood risk.

Nevertheless, intensification of land uses within the floodplain, and particularly below the (proposed) flood planning level should be discouraged. Accordingly, the area around the junction of The Kidman Way and the Sturt Highway, to the south of Darlington Point, is currently zoned as RU5 Village and R5 Large Lot Residential and is located within the proposed flood planning area. There are several existing developments within these areas, however there is potential for more intense residential development with the current zoning. Therefore, it is recommended that Council consider changing the zoning in these areas from RU5 and R5 to a non-residential, or less intense residential land use, to minimise flood risk to future developments.

Recommendations: Consider changing the zoning around the junction of the Sturt Highway and The Kidman Way to a non-residential, or less intense, residential zoning.

10.3.3 PM5 - Update to Murrumbidgee LEP Clause 6.2 Flood Planning

As discussed in **Section 6.3**, Clause 6.2 of Murrumbidgee LEP 2013 states that "This clause applies to land at or below the flood planning level", with the flood planning level defined as 1% AEP design flood level plus a 500mm freeboard. The recommendations for flood planning level made as part of this study are inconsistent with Clause 6.2 of Murrumbidgee LEP 2013 as the freeboard recommended for areas inside the levee is not 500mm.

An example to enable greater flexibility in the definition of where flood related development controls apply, as related to the flood planning level and flood planning area, in the Murrumbidgee LEP 2013, is included in **Plate 31**. The wording included in **Plate 31** adds the "flood planning area" to the land that the clause applies to.

It is recommended that Council make the flood planning area map related to the flood planning clause available publicly. This is discussed further below in **Section 10.3.4**.

Recommendations: Update Clause 6.2 of Murrumbidgee LEP 2013 to adequately describe the flood planning levels recommended in this study.

Clause 6.2 Flood planning
(1) The objectives of this clause are as follows—
(a) to minimise the flood risk to life and property associated with the use of the 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 the following land—
(a) land at or below the flood planning level,
(b) land identified as "Flood planning area" on the flood planning area map,
(3) Development consent is required for any development on land to which this clause applies.
(4) Development consent must not be granted for development on land that is at or below the flood planning level 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, and
(4) A word or expression used in this clause has the same meaning as it has in the NSW Government's *Floodplain Development Manual (*ISBN 0 7347 5476 0*)* published by the NSW Government in April 2005, unless it is otherwise defined in this clause.
(5) In this clause—
flood planning level means the level of a 1:100 ARI (average recurrence interval) flood event plus 0.5 metres freeboard or other freeboard as determined by an adopted floodplain risk management plan by the Council in accordance with the NSW Governments Floodplain Development Manual.
Flood planning area means the land mapped in an adopted floodplain risk management study and plan

Plate 31 - Potential updated LEP wording Option

10.3.4 PM6 - Flood planning area mapping

The current flood planning area or flood planning level map related to Clause 6.2 of Murrumbidgee LEP 2013 is not publicly available. It is recommended that Council make the flood planning area map related to the flood planning clause publicly and freely available. This may be done by referencing the maps in adopted floodplain risk management plans or linking this mapping in the DCP documentation.

It is recommended that these flood planning areas maps are not included in the suite of gazetted maps of the Murrumbidgee LEP 2013 mapping. Excluding the flood planning area map from the formal LEP mapping would enable the flood planning map to be updated as frequently as needed and without the requirement of a Planning Proposal, which can often be lengthy and expensive. If the flood planning area mapping is included in an adopted floodplain risk management plan or development control plan, then there is a legislative process that the maps would have to undertake for their approval and adoption and implementation.

Recommendations: Update the flood planning area map related to Clause 6.2 of Murrumbidgee LEP 2013 and make publicly available in an easy to find location.

10.3.5 PM7 - Introduction of "Floodplain Risk Management Clause" in Murrumbidgee LEP 2013.

As discussed in **Section 6.3**, the only clause related to flooding and floodplain management in the Murrumbidgee LEP is Clause 6.2 – Flood Planning. This clause only relates to development below the flood planning level. Council could consider introducing a clause related to floodplain risk management to help manage the land between the flood planning area and the extent of the extreme flood.

Council could also consider introducing an additional LEP clause related to the floodplain risk management across the full extent of the floodplain, with the objectives to:

- Better manage the land between the flood planning area and the extent of the extreme flood.
- Protect critical and vulnerable developments that may be proposed just outside of the flood planning area.
- Consider evacuation and emergency response requirements across the entire floodplain as part of the development planning and approval processes, making them legally enforceable.

Suggested wording for this clause is included in **Plate 32** below.

As part of the inclusion of this additional LEP clause, there is an opportunity to including a map indicating where this for floodplain risk management clause would apply and include this information on a Section 10.7(5) certificate.

Recommendations: Include an additional clause in Murrumbidgee LEP 2013 'Floodplain Risk Management' that includes consideration of flood risk up to and including the extreme flood event.

Clause XXX Floodplain risk management

(1) The objectives of this clause are as follows—

(a) in relation to development with particular evacuation or emergency response issues, to enable evacuation of land subject to flooding in events in excess of the flood planning level,

(b) to protect the operational capacity of emergency response facilities and critical infrastructure during extreme flood events.

(2) This clause applies to land between the flood planning area and the level of the probable maximum or extreme flood but does not apply to land subject to the discharge of a 1:100 ARI (average recurrent interval) flood event plus 0.3 metre freeboard.

(3) Development consent must not be granted to development for the following purpoNSW SES on land to which this clause applies unless the consent authority is satisfied that the development will not, in flood events exceeding the flood planning level, affect the safe occupation of, and evacuation from, the land—

(a) camping grounds
(b) caravan parks,
(c) childcare centres or facilities
(d) correctional centres,
(e) emergency services facilities,
(f) function centre
(g) group homes,
(g) health service facilities,
(h) residential care facilities,
(i) seniors housing
(j) tourist and visitor accommodation.

(4) In this clause—

Extreme flood has the same meaning as the probable maximum flood

flood planning area means the area of land at or below the flood planning level.

flood planning level means the level of a 1:100 ARI (average recurrent interval) flood event plus 0.3 metre freeboard or as defined in adopted floodplain risk management plan.

probable maximum flood has the same meaning as it has in the *Floodplain Development Manual (*ISBN 0 7347 5476 0*)* published by the NSW Government in 2005.

Plate 32- Potential Floodplain Risk Management Clause

10.3.6 PM8 - Need for "exceptional circumstances" for development on floodprone land.

In 2007, the NSW Government introduced the "Guideline on development controls on low risk areas—Floodplain Development Manual". The guideline states "*that unless there are exceptional circumstances, councils should adopt the 1% AEP design flood as the FPL for residential development. In proposing a case for exceptional circumstances, a council would need to demonstrate that a different FPL was required for the management of residential development due to local flood behaviour, flood history, associated flood hazards or a particular historic flood*."

The extent of the extreme flood event was compared to the flood planning area in the study area. The extreme flood event inundates a much wider floodplain than the 1% AEP design flood event, generally many kilometres wider than the extent of the 1% AEP design flood extent. In some places sampled, the extreme flood extent is more than 8 kilometres wider than the flood planning area based on the 1% AEP design flood event and a 0.30 metre freeboard. However, the increase in depths from the 1% AEP design flood event to the extreme flood event is generally in the range of 0.25 metres to 0.45 metres. There are some areas where this difference in depth exceeds 1.0 metres. Therefore, there is a flood risk above the flood planning level that needs to be considered.

Once flood height differences exceed about 2.5m (i.e., >2.0 metres above the FPL) serious consideration must be given to the need for 'exceptional circumstances' due to the high potential risk to life and the potential for structural damage to buildings.

An assessment was completed to determine if and where 'exceptional circumstances' may be appropriate for flood-related development controls on residential development on land outside of the flood planning area. 'Exceptional circumstances' for such areas may be required where there is an unacceptably high flood risk. This was considered by:

1) comparing the extent of the flood planning area with the extreme flood event,
2) calculating the flood height range between the 1% AEP design flood and the extreme flood event,
3) available warning time.
4) considering whether based on existing housing stock, people could be expected to survive inundation of their houses in an extreme flood event.

The differences in depths of flooding between the 1% AEP design flood event and the extreme flood event is, on average between 0.20 and 0.45 metres, in the study area.

The amount of warning time at Darlington Point of the arrival of floodwaters from Narrandera is over 4 days, and several weeks from the onset of flood producing rains in the upper parts of the catchment. This amount of warning time enables residents and emergency services to prepare thoroughly for the potential of flooding in the study area, maximising the potential to reduce flood losses. The rate of rise of the floodwaters is also slow (less than 1.32 metres per day in channel bank and 0.8 metres per day out of bank) and would also provide adequate warning time to the residents for the onset of flooding.

Therefore, the need for exceptional circumstances for flood related development controls beyond the flood planning level are not considered necessary in the study area.

Recommendations:
The need for 'exceptional circumstances' for flood related development controls above the flood planning level is not recommended.

10.3.7 PM9 - DCP Revision

A detailed review of the flood relate development controls in the "Village" development control plan was prepared in **Section 6.3.2**. It is recommended that Council consider the review as soon as possible due to the age of the existing DCP. There are a number of items that would need consideration in this DCP chapter, and these include:

- Introduction of a chapter in the development control plan associated with flood related development controls;
- Mapping of flood planning area;
- Consider emerging best practice for mapping Flood Planning Constraint Categories and inclusion within council planning documents;
- Update the format of the chapter on flood related development controls to current best practice. Items to consider:
    - Controls to manage flood impacts.
    - Controls to manage risk to life, including emergency management requirements.
    - Flood planning levels and minimum floor level requirements for developments. These minimum floor levels may vary with different land uses and vulnerabilities to flooding.
    - Appropriate building design and materials.
    - Location of development relative to True Flood hazard or flood planning constraints category.
    - Requirements for flood impact assessments.
    - Consideration of cumulative developments in the floodplain.
    - Sustainable development, including consideration of climate change impacts on flooding.
    - Requirements for flood impact assessments.
    - Considerations for variations in development control standards
- Indicate in the prescriptive criteria matrix where development is *suitable / supported* and *unsuitable/ not supported*;
- Include consideration for flood emergency and evacuation planning for properties located within the floodplain but outside the flood planning area.
- Applying flood related development controls for evacuation purposes could help to reduce risk to life as controls could be introduced to evacuate land before the land itself is inundated or before surrounding roads become inundated.
- If an additional LEP clause related to Floodplain Risk Management was introduced associated with land inundated by the extreme flood event, then flood related development controls associated with the evacuation of land subject to flooding in events expected to exceed the 1% AEP design flood event could also be applied. There may also be opportunity to apply flood related development controls to critical and vulnerable developments (such as developments similar in nature to the Altina Wildlife Park) that may be proposed to be located outside of the flood planning area, with the FPA based on the 1% AEP design flood level plus a 0.30 metre freeboard.

Appendix I includes information that could be used as the basis for an updated Flood Policy or Flood DCP.

Recommendations: Information developed in this study can be used as a basis for flood related development control considerations in the updated DCP. Information is included in Appendix I that can be used as part of a flood Policy or updated Flood DCP.

10.3.8 PM10 – Update Section 10.7 Certificates

It is recommended that Council update Section 10.7 certificates to reference the updated design flood information generated as part of the current study. This will help to ensure the most up-to-date information is available and used for properties located within the study area.

This needs to be implemented with the other changes identified in the preceding sections of this report regarding the updating of the LEP and DCP flood mapping information to include all flood constraints up to and including the areas covered by the flood planning level and extreme flood event.

Recommendations: Updated Section 10.7 certificate to reference updated design flood information generated as part of the current study.

10.3.9 PM11 – Strategic rezoning of Candidate sites in study area

A number of Candidate sites were included in a planning report submitted by Habitat Planning (2020) on behalf of Council for potential rezoning in future. A preliminary assessment of the flood risk at these sites has been included **in Appendix E**.

Recommendations: Use the information contained in Appendix E as the preliminary assessment of flood risk at these sites and as a basis for further planning investigations at these sites.

10.4 Summary and Recommendations

A summary of the recommendations regarding which property and planning modification options should be considered further is shown in Table 47**.**

Table 47 Evaluation matrix for Property and Planning Modification Options

Option	Recommended for Further Consideration?
PM1 - Voluntary House Purchase	**Yes**
PM1B - Voluntary House purchase scheme across whole LGA	**Yes**
PM2 - Voluntary House Raising	**No**
PM3 – Recommended flood planning level	**Yes**
PM4 - Appropriateness of current Murrumbidgee LEP 2013 zoning	**Yes**
PM5 - Update to Murrumbidgee LEP Clause 6.2 Flood Planning	**Yes**
PM6 - Flood planning area mapping	**Yes**
PM7- Introduction of "Floodplain Risk Management Clause" in Murrumbidgee LEP 2013	**Yes**
PM8 - Need for "exceptional circumstances" for development on floodprone land	**No**
PM9 - DCP Revision	**Yes**
PM10 - Update Section 10.7 Certificate Information	**Yes**
PM11 - Strategic rezoning of Candidate sites in study area	**Yes**

11 Response Modification Options

11.1 Introduction

It is generally not economically feasible to treat all flood risk up to and including the extreme flood event, through flood modification and property modification measures. Therefore, response modification measures are implemented to manage the residual / continuing flood risk by improving the way in which emergency services and the public respond before, during and after floods. Response modification measures are often the simplest and most cost-effective measures that can be implemented and, therefore, form a critical component of the flood risk management strategy for the catchment.

Response modification options considered as part of the study include:

- Emergency response planning
- Options to improve emergency response during a flood
- Options to aid in post-flood recovery

Further discussion on response modification options that could be potentially implemented is provided below.

11.2 Emergency Response Planning Options

Effective planning for emergency response is a vital way of reducing risks to life and property, particularly for infrequent floods that are not managed through flood or property modification measures. Potential opportunities for improvements to existing emergency response planning are discussed below.

11.2.1 RM1 - Property Level Flood Information

A starting point for improving people's readiness for floods is to help them better understand how they could be directly and indirectly affected by floods. Knowing how their house or business could be directly affected by floods is generally more effective than more generic advice. Understanding how the floods behave around Darlington Point, and how long these floodwaters can inundate the area, would also help improve people's readiness for floods.

Advancements in flood modelling software and associated spatial datasets has significantly enhanced the quantity and quality of information from flood studies and floodplain risk management studies available at the property level. Council currently makes a range of development and planning information available via the NSW Governments Planning Portal and mapping database. The NSW Planning Portal is in a continual state of development, as the NSW Government looks to streamline development and planning processes across NSW. There may be opportunity to include the outputs from this study, such as flood planning area and flood hazards, on the NSW Planning Portal. However, it is not clear how changes to this flood related information (such as development in the floodplain that modify the flood

characteristics, or the construction of flood mitigation works in) could be easily updated on the NSW Governments Planning Portal. Council should seek clarity on this prior to loading flood related information onto the NSW Governments Planning Portal.

Alternatively, Council could consider providing flood mapping and flood related information on its own website or webpage. The flood information could include information such as design flood depths and flood hazards, with the potential to provide information describing when and where access on roads would be expected to be cut. This is quite detailed and complex information and additional resources may be required to explain what this information means to some residents and how it could be used to assist in the preparation of individual or business flood response plans. In addition, to help residents and business owners interpret the potential risk associated with future floods, design and historical flood levels at the Murrumbidgee River gauge, and potentially additional gauges upstream, could be made available.

There could be opportunity to develop a separate flood information portal or website (refer to discussion in the following section) should Council not want to include all the flood related information on their own website. Any flood information portal would need to be clearly linked from the Council website to ensure the community understands where to source flood information.

A flood information portal could also provide real time flood information that can be accessed during floods (e.g., flood warnings, current & projected water levels at gauges).

Software, such as WaterRIDE^{TM}, can also automate the preparation of documentation that summarises key flood parameters at the property scale, including graphics depicting flood inundation extents. An example of property level flood information generated by WaterRIDE^{TM} is shown in **Plate 34** and **Plate 34**.

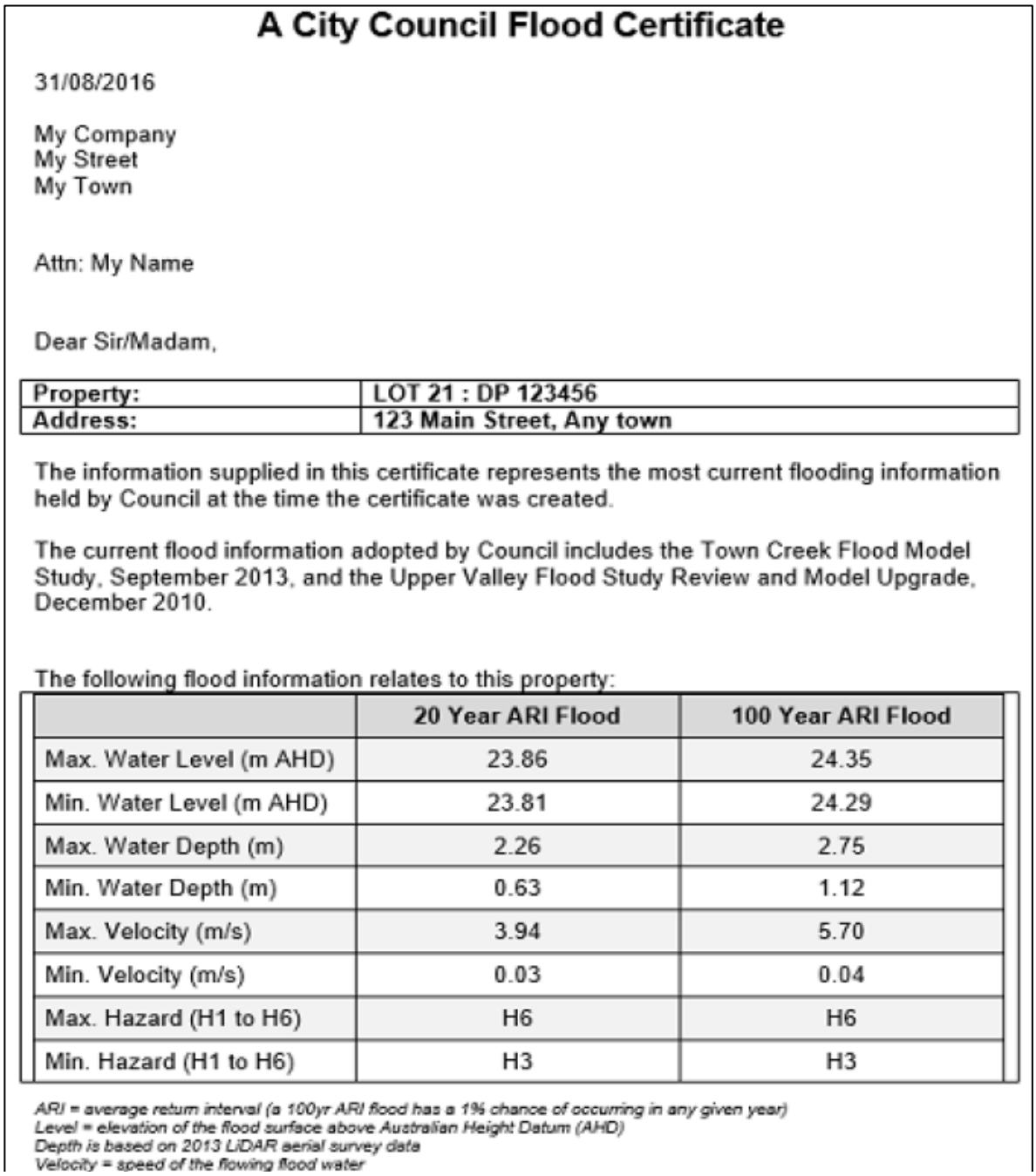
An advantage of websites is their ability to be a living document incorporating current information sources such as flood mapping, BoM flood warnings, live information on nearby river and rain gauges and the latest advice from relevant organisations such as the NSW SES and Transport for NSW. Therefore, assuming the website is maintained, it can serve as a central repository for a range of contemporary flood information.

Some of the potential capabilities of flood portals in order of increasing complexity are:

- 'Pull' style (on demand user requested) distribution of generic and regionalised flood information flyers;
- 'Pull' style re-broadcasting of relevant information such as flood warnings and NSW SES alerts;
- 'Push' (based on prior opt-in or subscription) of information based on email / SMS subscription lists;
- Generation of customised flood information flyers for individual properties;
- Showing 'live' river and rainfall gauge information in the context of past floods and peak rainfall events. This can also include live identification of flooded roads and identification of alternative flood evacuation routes for any point in the catchment; and,

- Integration with rainfall forecasting systems and real time flood modelling to predict the extents and timing of the current flood and generate required warnings.

Recommendations: Make available additional flood information at a property scale, including flood depths, hazards and emergency response classifications, with suitable explanations and guidance as to how this information can be used to inform flood emergency plans (Council; NSW SES)



A City Council Flood Certificate

31/08/2016

My Company
My Street
My Town

Attn: My Name

Dear Sir/Madam,

Property:	**LOT 21 : DP 123456**
Address:	**123 Main Street, Any town**

The information supplied in this certificate represents the most current flooding information held by Council at the time the certificate was created.

The current flood information adopted by Council includes the Town Creek Flood Model Study, September 2013, and the Upper Valley Flood Study Review and Model Upgrade, December 2010.

The following flood information relates to this property:

	20 Year ARI Flood	100 Year ARI Flood
Max. Water Level (m AHD)	23.86	24.35
Min. Water Level (m AHD)	23.81	24.29
Max. Water Depth (m)	2.26	2.75
Min. Water Depth (m)	0.63	1.12
Max. Velocity (m/s)	3.94	5.70
Min. Velocity (m/s)	0.03	0.04
Max. Hazard (H1 to H6)	H6	H6
Min. Hazard (H1 to H6)	H3	H3

ARI = average return interval (a 100yr ARI flood has a 1% chance of occurring in any given year)
Level = elevation of the flood surface above Australian Height Datum (AHD)
Depth is based on 2013 LiDAR aerial survey data
Velocity = speed of the flowing flood water

Plate 33 Example of property level flood information (images provided courtesy of Advisian)

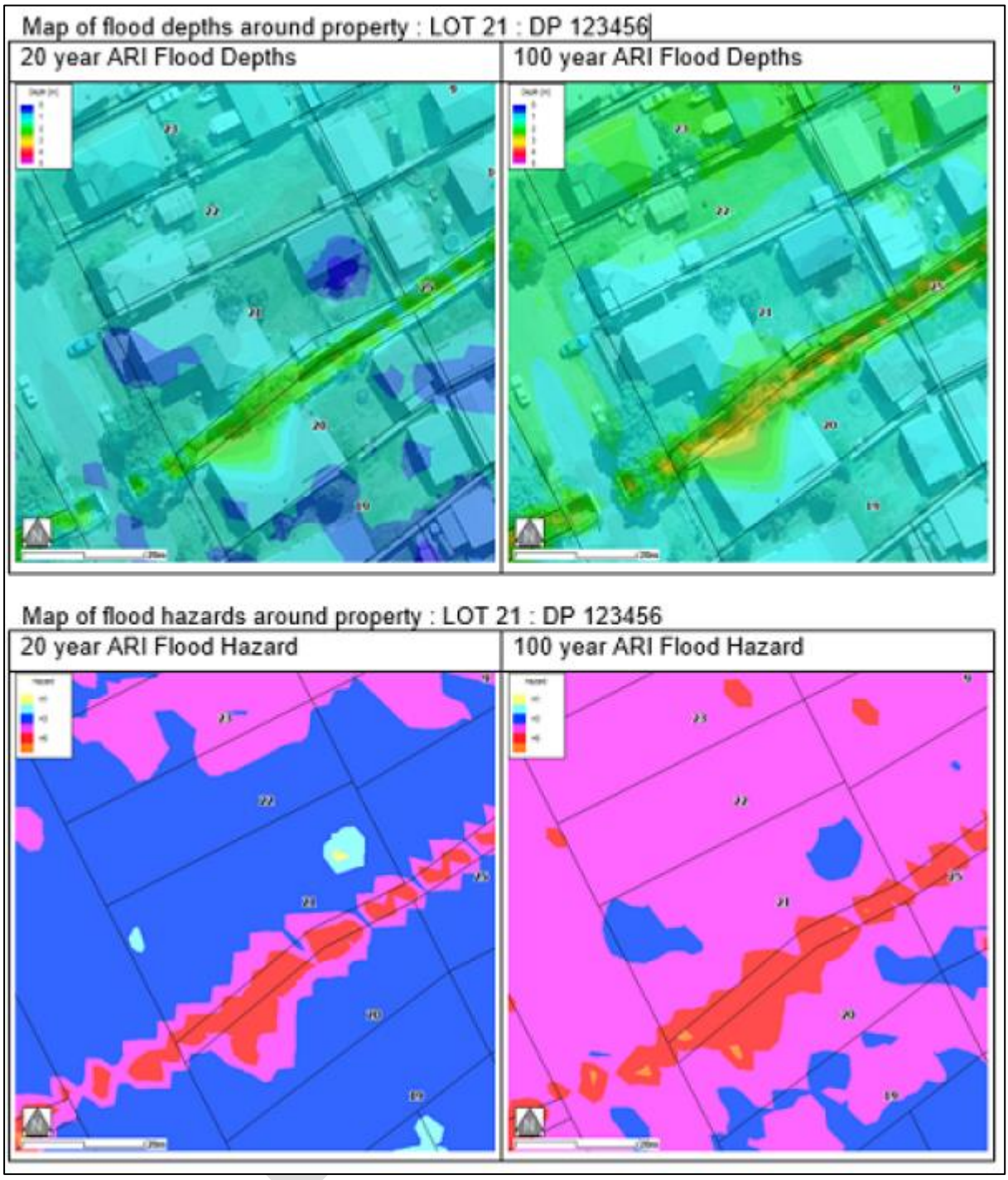


Plate 34 Example of property level flood information mapping (images provided courtesy of Advisian

It is noted that the samples provided above use ARI terminology however templates used in any future property flood level information should be generated using AEP terminology.

11.2.2 RM2 - Community Flood Awareness and Education

Actual flood damages can be reduced, and safety increased, where communities are flood-ready:

> *'People who understand the environmental threats they face and have considered how they will manage them when they arise will cope better than people who lack such comprehension… Many people who live and work in flood liable areas have little idea of what flooding could mean to them – especially in the case of large*

> *floods of severities well beyond their experience or if a long period has elapsed since flooding last occurred. It falls to the combat agency, with assistance from councils and other agencies, to raise the level of flood consciousness and to ensure that people are made ready for flooding. In other words, flood-ready communities must be purposefully created. Once created, their flood-readiness must be purposefully maintained and enhanced'* (Keys, 2002).

Based on learnings from recent disasters, the focus of community disaster education has now turned from concentration on raising awareness and preparedness to building community resilience through learning. Simply disseminating flood information to the community does not necessarily trigger changed attitudes and behaviours. Flood education programs are most effective when they:

- Are developed by members of the NSW SES experienced in Community Education and Flood Awareness Campaigns. The local community should also be included in the development of these flood education materials, heling to ensure the material should is suitably tailored to the residents of Darlington Point and surrounding area;
- Are participatory i.e. not consisting only of top-down provision of information but where the community has input to the development, implementation and evaluation of education activities;
- Involve a range of learning styles including experiential learning (e.g. field trips, flood commemorations), information provision (e.g. via pamphlets, DVDs, the media), collaborative group learning (e.g. scenario role plays with community groups) and community discourse (e.g. forums, post-event de-briefs);
- Are aligned with structural and other non-structural methods used in floodplain risk management and with emergency management measures such as operations and planning; and
- Are ongoing programs rather than one-off, unintegrated 'campaigns', with activities varied for the audience.

It is difficult to accurately assess the benefits of a community flood education program, but the consensus in floodplain management practice is that the benefits far outweigh the costs. Nevertheless, sponsors must appreciate that ongoing and/or annual funding is required to sustain gains that have been made as flooding is generally an infrequent event and flooding impacts or knowledge learned can easily be forgotten by the community over a number of years without a flood.

Darlington Point has been impacted by a number of significant flood events in the past 45 years, with floodwaters from these floods inundating the area around Darlington Point for a number of weeks each time. The responses to the community survey carried out as part of stage 1 of this study indicated there is a high level of flood awareness as a result of this flooding. However, the survey also revealed that those new to the area had minimal knowledge of the vulnerability of the area to flooding. As floodwaters inundate the land for a longer period, people can become complacent about the flood risks and be tempted to enter floodwaters, either with a vehicle or on foot. Therefore, ongoing flood education and promotion of safety messaging is recommended as a floodplain risk management measure to help reduce these potential flood risks in the study area. This information should also be communicated to those who move into the area.

Education Messages

Key messages for community education are developed to achieve a specific objective. Various flood education messages developed over time include 'Never enter floodwaters', 'Have a home or business FloodSafe plan', 'Know your evacuation route' and 'Do not rely on being rescued'. These messages could be tailored to suit the food risks around Darlington Point. From the estimation of flood risks in this study, community survey responses and discussions with stakeholders throughout this study, a number of key messages emerge for people in the study area:

- Education messages need to reiterate that the levee around Darlington Point has been designed and constructed to help mitigate the risk up to and including the 1% AEP design flood event at Darlington Point. Any rainfall event that is predicted to produce flooding that are estimated to exceed the 1% AEP design flood event will require evacuation of Darlington Point. The freeboard levels available on the upgraded levee above the design flood level are apportioned as a factor of safety on the 1% AEP design flood level, not for additional flood level elevations.
- 'Evacuation needs to occur before roads are submerged by floodwaters'. There is an obvious reluctance for people to evacuate from the imminent threat of flooding if they cannot see the floodwater themselves. However, in this study area, several of the roads around Darlington Point become inundated by floodwaters long before floodwaters themselves reach properties. Some of these properties may become isolated and residents may be required to drive through floodwaters if they choose to evacuate only once their property becomes inundated. In addition, numerous members of the community indicated they would not evacuate during future flood events, based on the experiences of past flood events.

  Therefore, the education messages really need to emphasise that early evacuation from these properties, when directed to so by the NSW SES, is the only safe evacuation option. This message should also acknowledge that residents may also have concerns leaving their property or valuables behind. As part of the development and update of the flood education and evacuation strategies from the study area, safety of property needs to be catered for by the authorities (NSW SES/police etc) and conveyed to the residents.
- 'Never drive, ride, walk or play in floodwaters'. The need to continue broadcasting this message is suggested by the knowledge that motorists in NSW continue to lose their lives when attempting to cross floodwaters, and by the number of roads in the study area that can be flooded for long periods of time. Messages could also provide technical information to dissuade drivers from crossing flooded roads, such as the depths at which cars float[1] and emphasise that driving through even shallow water can generate waves that can increase the potential for above floor flooding and flood damage. Messages could also target the motivations for crossing floodwater, pointing out that it's better to arrive home late than not at all. These messages would only work if there are alternate routes that are established should particular roads be closed due to floodwaters inundating the road.

[1] See http://www.abc.net.au/news/2016-06-18/research-shows-cars-deadly-in-floodwaters/7522798

- 'One day a bigger, faster flood will happen than what anyone has ever seen. Council has modelled what these floods might be like. Learn whether your house or business, or access to them, could be flooded in an extreme flood. Identify whether it's safe for you to stay or whether you need to evacuate before you see the flooding at your property. Plan ahead to keep your family/staff safe'. A message such as this is important to disseminate to the residents and businesses in the study area, as a high proportion of responses to the community survey undertaken earlier in this study indicated they would remain at home rather than evacuate during future flood events **(Section 3.1**). While staying in place might have worked for the historical floods people may have experienced at Darlington Point, it could lead to disaster in an extreme flood when the levee around Darlington Point is overwhelmed and the connecting roads are inundated by hazardous floodwaters (**Section 7.3.2**).

Recommendations: Develop local flood educational messages to be used as part of local flood education and awareness initiatives. (NSW SES)

11.2.3 RM3 - Flood Emergency Response Plans

Home and Business Flood Plan Preparation / Updates

Despite the somewhat frequency of flooding in this area, it is unlikely that many private dwellings or business owners within the study area have formal flood emergency response plans. The plans set out protocols to follow by the resident or business before, during and after a flood to help mitigate damages and the potential for risk to life at the property level. This requires innovative approaches to persuade residents to plan ahead for floods. For the Darlington Point area, one of the main hazards associated with flooding is the duration that the floodwaters inundate the roads and properties.

It is considered that the most effective method, albeit a labour-intensive method, will be via direct outreach from the NSW SES, starting with those in north Darlington Point. It is estimated that there are only 13 properties in north Darlington Point that are currently impacted by flooding above floor level in the 1% AEP design flood event, increasing to approximately 30 in the extreme flood event.

The residents and business owners located in the area behind the levee should also be included in the flood planning preparation opportunities. These residents and business owners need to be aware of the potential for the levee to be overtopped in future flood events, and evacuation of the area behind the levee would occur before this.

The NSW SES could, with Council's assistance, host a flood planning morning or evening. Council could staff the meetings with laptops enabling the inspection of flood risks at property scales and NSW SES personnel could then help homeowners translate that information into effective home emergency plans. Including a sausage sizzle or family friendly activities will assist in promoting the event to the community.

Evacuation planning for the areas around Darlington Point needs to consider other issues that may impact on a person's ability or willingness to evacuate, such as animals and valuables, and include them in the evacuation plan. Past practices during flood events indicate residents are often hesitant to leave pets behind, or are scared of potential looting should they

evacuate, and so choose to stay rather than evacuate when requested to do so. Feedback received from the community during stage 1 of this study highlighted the number of residents who were responsible for animals or other people in their household and would stay at their home to look after them during a flood rather than evacuate. Inclusion of these considerations in a home flood plan prior to a flood is a good way to ease the concern a resident may have when they are forced to make decisions in difficult circumstances in future. It would also make the resident aware that particular authorities have documented roles to cater for these concerns during such an event, such as pets and companion animals being accepted at flood evacuation centres.

The NSW SES has developed a Home Emergency Plan and an Emergency Business Continuity Plan Toolkit to assist with the preparation of private and business flood emergency management plans. These can be completed either online or as a hardcopy (see http://www.NSW SESemergencyplan.com.au/).

Recommendations: Host meetings in to promote the preparation of Home and/or Business Emergency Flood Management Plans (NSW SES; Council). Including a sausage sizzle or family friendly activities will assist in promoting the event to the community.

Flood Plans for Larger and More Vulnerable Facilities

It would be beneficial if the NSW SES and Council encouraged and/or assisted the businesses owners, where vulnerability to flooding impacts would severely impact their ability to operate, to prepare or update their own flood emergency response plans. This would enable these business owners to take advantage of the superior flood behaviour information generated from the current study. Among the higher priorities for flood plans are:

- Altina Wildlife Park
- Darlington Point Caravan Park
- The owners or managers of the Grain silos located on the Kidman Way

In addition, it is recommended that Council notify major infrastructure providers, such as Energy Australia and Transport for NSW, advising them of the outcomes of the revised flood study and the potential to provide updated flood information for their assets. This will ideally assist in providing each asset owner with an improved understanding of the flood exposure of their assets and explore opportunities for improving the level of service afforded by these important facilities during times of flood.

Recommendations: Assist the following facilities to prepare or update their own flood emergency response plans incorporating new flood intelligence (NSW SES, Council):

1) Altina Wildlife Park
2) Darlington Point Caravan Park
3) Grain silo operators on the Kidman Way, north Darlington Point

Council should also approach key infrastructure providers with revised flood intelligence information (Council)

11.2.4 RM4 - Establishment of Local NSW SES Unit or a Community Action Team (CAT) in Darlington Point.

Currently, Darlington Point is serviced by the NSW SES Units stationed in Coleambally and Griffith. This floodplain risk management study has highlighted the vulnerability of Darlington Point to flood risks, particularly in larger flood events. Therefore, it is strongly recommended that a local NSW SES Unit or a Community Action Team (CAT) be established at Darlington Point. This NSW SES Unit will need to recruit members who are residents and/or business owners in the local community. The establishment of a local NSW SES Unit or CAT will also need the support of Council, through the supply of information and use of resources, such as facilities and vehicles.

The responses to the community survey distributed during stage 1 of this study indicates a general distrust of the NSW SES after the 2012 flood event in the Murrumbidgee River at Darlington Point that resulted in evacuation of parts of the community. Therefore, one of the first tasks of this local NSW SES unit should be the re-establishment of working relationships with the local community building up the communities' trust in the NSW SES. This can be done by targeting influential members of the local community or members who currently lead local community groups, to participate in and help lead the local NSW SES Unit.

A local NSW SES Unit relies on the resources of the local Council, both through the provision of information and the use of resources during a flood event. Therefore, the establishment of a local NSW SES Unit or CAT would have to be done in conjunction with Murrumbidgee Council, as the operation and success of the local NSW SES unit will rely on the resources the council can assist the NSW SES with. Council resources may include the use of council vehicles and staff to help close inundated roads or manage traffic, and an area where NSW SES vehicles can be stored during non-flood times. Council buildings may also be used as a local headquarters during a flood event. Council resources may also be required to assist with the post flood clean up.

The arrangements between the NSW SES and Council for the use of resources would need to be included in the NSW SES Local Flood Plan and Councils Local Emergency Management Planning documentation. Both of these plans should be reviewed on a regular basis.

NSW SES crews are generally made up of volunteers. Therefore, the establishment of a local Darlington Point NSW SES Unit or CAT will rely on local residents and business owners to

become members. Discussions with the community have highlighted a general distrust of the NSW SES after the 2012 flood event and the problems the forced evacuation caused. Therefore, it may be beneficial for the NSW SES to undertake community education and awareness with the local community to gauge the interest in the formation of a local NSW SES Unit or CAT prior to committing to the establishment of an actual NSW SES unit at Darlington Point.

Recommendations: Establish a local NSW SES Unit or Community Action Team at Darlington Point, with the assistance of Council resources to support the operation of this local Unit.

11.2.5 RM5 - Local Flood Plan Updates

The current Murrumbidgee Local Flood Plan (the Plan) was reviewed in **Section 7.1**. The review determined that the Plan needs to be updated to so that the structure and contents align with the most recent NSW SES Local Flood Plan template, and to incorporate flood intelligence from recent flood studies, floodplain risk management studies, and recent flood events. As part of this work, the Flood Intelligence Card Darlington Point (410 Murrumbidgee River) needs to be updated to incorporate outputs from the latest design flood modelling as well as the changes to hydraulic behaviour as a result of the upgrades to the Darlington Point levee that have recently been completed.

Flood intelligence available from the current study includes:

- Design flood extents, depths, velocities and flood hazards.
- Predicted building inundation in design floods up to the extreme flood event.
- Predicted road inundation in design floods up to the extreme flood event;
- Evacuation constraints in design floods up to the extreme flood event.
- Updated design information of the Darlington Point upgraded levee.

Recommendations: Update Murrumbidgee Local Flood Plan to align with the most recent NSW SES Local Flood Plan template and to incorporate new flood intelligence (NSW SES) developed in this study, including upgraded levee information.

11.3 Options to Improve Emergency Response During a Flood

11.3.1 RM6 - Flood Warning System

The purpose of a flood warning is to provide advice on impending flooding so people can take action to minimise the impacts of flooding on themselves and their property.

The Australian Warning System is a new national approach to information and warnings for hazards like bushfire, flood, storm, cyclone, extreme heat and severe weather. The Australian Institute for Disaster Resilience states that the Australian Warning aims to deliver a more consistent approach to emergency warnings, no matter where you are. It uses

a nationally consistent set of icons to show incidents on websites and apps, supported by calls to action.

There are three warning levels:

Advice: An incident has started. There is no immediate danger. Stay up to date in case the situation changes.

Watch and Act: There is a heightened level of threat. Conditions are changing and you need to start taking action now to protect you and your family.

Emergency Warning: An Emergency Warning is the highest level of warning. You may be in danger and need to take action immediately. Any delay now puts your life at risk.

Each warning level has a set of action statements to give the community clearer advice about what to do. Calls to action can be used flexibility across all three warning levels.

Further and more detailed information on the Australian Warning System can be found here: https://knowledge.aidr.org.au/resources/australian-warning-system/

Where effective flood warnings are provided, risk to life and property can be significantly reduced. Studies have shown that flood warning systems generally have high benefit-cost ratios if sufficient warning time is provided and if the population at risk is aware of the threat and prepared to respond appropriately.

The Bureau of Meteorology issues a number of products that provide warning of floods, including Severe Weather Warnings for torrential rain and/or flash flooding, and Flood Watches that typically provide 24 to 48 hours' notice that flooding is possible based upon current catchment conditions and forecast rainfall.

The NSW SES uses information from flood warning products to develop Flood Bulletins, Evacuation Warnings, Evacuation Orders and an All Clear. These are distributed to the community via conventional and social media, Councils, other emergency services and government agencies before, during and after flood events.

11.3.1.1 Update to current flood warning system to Darlington Point

The Murrumbidgee River is serviced by a quantitative flood warning system provided by the Bureau of Meteorology and the NSW SES. As indicated in the NSW State Flood Sub Plan, the Bureau of Meteorology issues height-time predictions for the Murrumbidgee River at a number of locations. Those locations of interest to Darlington Point are included in **Table 48**. The aim of this system is to provide 7 days warning for minor flooding at the Darlington Point gauge and 3 days warning for major flooding. The NSW SES issues Flood Bulletins, Evacuation Warnings and Orders for these locations before, during and after flood events.

This flood warning system has been in operation for a long period of time and has been used on numerous occasions for a range of real flood events, with magnitudes varying from minor to major. The flood warning system has been found to be effective and efficient at

disseminating the warning information to the public and the other government authorities. As such, the opportunity to enhance the flood warning system was not considered necessary for Darlington Point for major flooding, however the addition of a telemetered pluviograph in the more local area may be beneficial to provide more local data.

Access to real time local rainfall data to the community and the NSW SES will assist with situational awareness for the local area, both before and during a flood event. It may also provide intelligence for any local flooding that have impacts locally but does not provide much flow contribution to the main Murrumbidgee River. The Bureau of Meteorology (pers coms) have indicated that an audit undertaken as part of ANZEMC National Flood Warning Infrastructure Plan several years ago, there was a lack of rainfall gauges in the lower Murrumbidgee River downstream of Wagga Wagga. This is an opportunity to provide an additional gauge into the Murrumbidgee River system to improve this situation as well as help provide flood intelligence for local flooding.

There may be opportunity to obtain funding from the state government to assist with the implementation of this telemetered pluviograph, discussions would need to be held with council, the state government and BOM to determine the ongoing maintenance requirements of an additional rainfall gauge.

Recommendations: Investigate opportunity to introduce a telemetered pluviograph at Darlington Point for access to real time local data and for greater situational

11.3.1.2 Provide outcomes of this floodplain risk management study to BOM for upgrade of their flood warning system (if warranted)

This floodplain risk management study and plan has updated flood information related to the flood characteristics for the Murrumbidgee River at Darlington Point that includes information from the levee upgrade works. It would be of benefit to pass this information on to the BOM to assist with provision of the flood warning service for the Murrumbidgee River.

Recommendations: Provide a copy of this floodplain risk management study and plan to the BOM to assist with provision of the flood warning service for the Murrumbidgee River.

Table 48 Flood Warning Gauges

Bureau number	AWRC number	Forecast location	Station owner	Gauge type	Flood classification (mAHD)			Prediction type	Target warning lead time		70% of peak forecasts within	Local Flood Bulletin provided by NSW SES
					Minor	Moderate	Major		Time (hrs)	Trigger height (m)		
573000s	410001	Wagga Wagga	WaterNSW	Automatic	7.3	9.0	9.6	Quantitative	12 hrs 24 hrs 30 hrs	7.3m 9.0 m >9.6m	+/- 0.3m	Yes
574020	410005	Narrandera	WaterNSW	Automatic	6.7	7.3	8.2	Quantitative	5 days	>6.7m	+/- 0.3m	Yes
575011	410021	Darlington Point	WaterNSW	Automatic	5.5	7.0	7.3	Quantitative	7 days	5.5m	+/- 0.3m	Yes
75170	410078	Carrathool	WaterNSW	Automatic	7.0	7.5	8.5	Quantitative	10 days	7.0m	+/- 0.3m	Yes

Sources: Provision and Requirements for Flood Warning in NSW – Supplementary Document to the State Flood Plan, NSW SES November 2019, Volume 2.

11.3.2 RM7 - Upgrade of Existing Evacuation Routes

Since the year 2000, 178 people have lost their lives in Australia as a result of flooding. The majority of these deaths are associated with motorists attempting to drive across flooded bridges, culverts, causeways or roads in their local area. Although flood deaths have been steadily declining since the 1960s, motor vehicle related deaths in floodwaters are rising (Haynes et al, 2016).

The road access to Darlington Point from the north and south and west become inundated during the larger flood events. Upgrading of evacuation routes would reduce the frequency of roadway inundation and reduce or prevent vehicles driving through floodwaters.

11.3.2.1 Installation of Flood Depth Indicators

Flood depth indicators could be installed at known roadway overtopping points. The depth indicators show the depth of water across the roadway, thereby helping to inform the community about whether the roadway may be safe to cross in a vehicle. However, without any accompanying information to describe the potential dangers associated with crossing flooded roads, the potential success of flood depth indicators can be limited. Furthermore, emergency services advocate not driving through any floodwater regardless of depth as the integrity of the road surface beneath the water cannot be guaranteed. Therefore, there is potential for installation of depth indicators to increase the number of vehicles driving through water which may increase the flood risk. However, with the Sturt Highway and the Kidman Way vulnerable to inundation from floodwaters, and the duration the floodwaters inundating from days to weeks, these signs may be of benefit.

Therefore, if this option is pursued it should be supplemented with appropriate signage not to drive through floodwaters and/or other education material. In recent flood events in NSW, the NSW SES has been increasingly creative and persistent in broadcasting this message through its social media platforms, even including video interviews with drivers who have turned around when confronted by flooded roads – demonstrating good behaviours.

Although the installation of flood depth indicators is recommended with caution due to the issues associated with driving through floodwaters, they are a relatively 'cheap' option (the cost of a typical indicator is about $400 including installation). Therefore, they may be considered in areas subject to frequent inundation along the Sturt Highway and the Kidman Way to assist with thoroughfare during flood events.

Recommendation: Could be considered at locations that do not have an existing flood depth indicator and where flood gates are not feasible. However, should be supplemented with appropriate education material about driving on flooded roads.

11.3.2.2 Road Raising to the north of Darlington Point towards Griffith (Response Modification Option 7)

The Kidman Way north of Darlington Point is currently estimated to be inundated at flood levels that just exceed the 1% AEP design flood event. This road is the only road north out of Darlington Point, and is a very important thoroughfare for traffic travelling to Griffith. Opportunities to raise this section of the road were examined so that the road would provide a substantiated flood immunity to the 1% AEP design flood level with a freeboard. This would also afford additional evacuation time during larger floods, should a flood greater than the 1% AEP design flood event be predicted.

The potential location of the upgrades to the road levels are shown in **Plate 35.** Road raising was assessed by including a raised length of 4,100 metres of the Kidman Way in the hydraulic model, with two sets of cross drainage structures to facilitate the flow of overland flows from east to west. As shown in **Plate 35.** the concept design for the road raising incorporates:

- Increase in road crest levels to the 1% AEP design flood level plus 200mm along a length of 4.1 kilometres. This results in a maximum depth of fill of approximately one (1) metre.
- Low level bridge of 80m length to cater for the cross flows under various sections of this roadway.
- Cost estimate of $8.35 million to construct

The hydraulic benefits of the upgraded road were quantified by including the works in the TUFLOW model and re-simulating each of the design floods. Results of these simulations are included in **Appendix H**.

Table 49 outlines the economic assessment of this option, including a cost of approximately $8.35 million to construct. This high construction cost includes low level bridges to replace the current culverts that are under the road, to facilitate the flow of floodwaters from the east to the west in a more efficient manner. **Table 50** outlines the number of properties impacted by the implementation of this option, with only three (3) properties expected to have a reduction in flood impacts during the 1% AEP design flood event, and only one (1) of those with a reduction in over floor flooding. Therefore, there is only a very small reduction in flood damages as a result of the implementation of this option.

It must be noted that this option was assessed for its impact on improving emergency management in the study area, and so the results in changes in flood damages should also be assessed with the improvements to the trafficability of The Kidman way during larger flood events. The upgraded levee around Darlington Point provides a level of protection to the 1% AEP design flood event with a freeboard of 0.750 metres. Therefore, it is anticipated should a flood greater than the 1% AEP design flood event be predicted, evacuation of Darlington Point would be undertaken. As such, it would be anticipated that this section of the Kidman Way

adjacent to north Darlington Point would only be traversed by emergency management vehicles during floods equal to or greater than the 1% AEP design flood event.

Overall, the upgrade to The Kidman Way appears to afford some benefits, during the less frequent flood events, however these come at a significant financial cost. This option is not recommended for further investigation as part of the Floodplain Risk Management Plan but could be undertaken as part of future asset management works or road upgrades by Transport for NSW and/or Council.

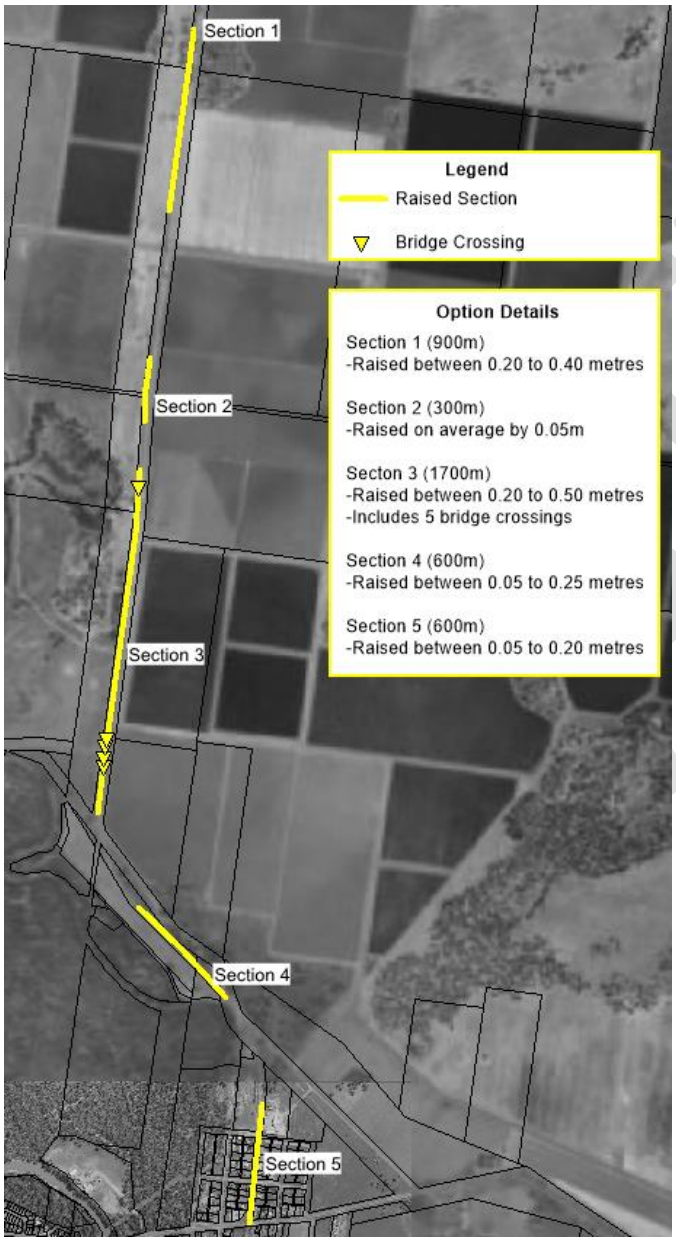


Plate 35 Option RM7 concept design

Table 49 Economic Assessment of Response Modification Option 7

Response Modification Option	Present Value Estimates ($ millions)				BCR
	Cost	Total Damage for Existing Conditions	Total Damage with Option in Place	Reduction in Damage with Option in Place	
RM7 - Road Raising to the north of Darlington Point towards Griffith	$8.35	2.280	2.268	0.01	0.00

Table 50 Hydraulic Impact of Response Modification Option 7

Design Flood Event	Change in number of properties impacted by over floor flooding	Change in number of properties impacted by flood waters (in addition to above floor flooding)
5% AEP	0	-2
1% AEP	-1	2
Extreme flood event	0	0

Table 51 Evaluation outcomes on the raising of the Kidman Way north of Darlington Point

Evaluation Criteria	Rating	Comments
Hydraulic Impacts	**-1**	Minor decreases in flood level in the Murrumbidgee River and at north Darlington Point. Increases in flood levels downstream of The Kidman Way for all design flood events.
Inundated Buildings	**0**	No change to the number of buildings inundated above floor.
Emergency Response	**+2**	Improvements in the trafficability of The Kidman Way during all design events up to and including the 0.5% AEP design flood event.
Technical Feasibility	**+2**	Considered straight forward to construct. Could be constructed by Council
Environmental Impacts	**-1**	Terrestrial biodiversity constraints up and downstream. Changes to the hydrological cycles as a result of these works would have to ensure not adverse impact on these Terrestrial biodiversity constraints. Minimal environmental impacts anticipated as a result of construction.
Economic Feasibility	**-2**	Low BCR with a significant capital cost.
Community Acceptance	**+1**	Over 70% of the community indicated support to upgrade roads so they are less susceptible to flooding.
SCORE	**1**	

Recommendation: Not recommended for further investigation as part of the floodplain risk management study but could be undertaken as part of future asset management works or road upgrades by Transport for NSW and/or Council.

11.4 Options to Aid in Post-Flood Recovery

11.4.1 RM8 - Recovery Planning

The Murrumbidgee Local Flood Plan (LFP) sets out the responsibilities of various agencies in post-flood recovery. Recovery, as outlined in the LFP, largely rests with the NSW SES with assistance from the Local Emergency Operations Controller (LEOCON) and the Local Emergency Management Committee (LEMC).

It is suggested that additional, specific items could be included in the LFP to further assist emergency services and the community to expedite post-flood recovery, including:

- Council to ensure vital facilities such as water and sewer are restored/operational
- Council to aid in removing waste and debris as part of clean-up activities
- Appropriate agencies to ensure vital utilities such as power and gas are restored/operational
- Appropriate agencies to offer welfare assistance and counselling services
- Various agencies to record post-flood information to assist in future updates/calibration of flood models and flood studies.

Recommendation: NSW SES update Local Flood Plan to reflect flood recovery responsibilities for various agencies are up to date and correct.

11.4.2 RM9 - Flood Insurance

Flood insurance is available for residential, commercial and industrial buildings as part of most home and contents insurance policies. Flood insurance can also be taken out on public infrastructure and buildings.

Although flood insurance does not reduce the potential for flood damage nor reduce the residual flood risk, it can help in post-flood recovery by providing financial assistance to offset flood damage costs.

The cost of flood insurance varies significantly, based on a range of factors, including:

- The likelihood of flooding
- Expected depth of flooding across insured building (refer **Plate 36**)
- The size and the floor level of the house
- The material used to build the house

Therefore, buildings with a high likelihood of flooding and/or high flood damage potential will face higher insurance premiums. The cost of insurance must be borne by the building owners. Therefore, those properties that are at higher risk of flooding and would arguably benefit the most from flood insurance will face the highest premiums. In such instances, property owners may not be able to afford such premiums.

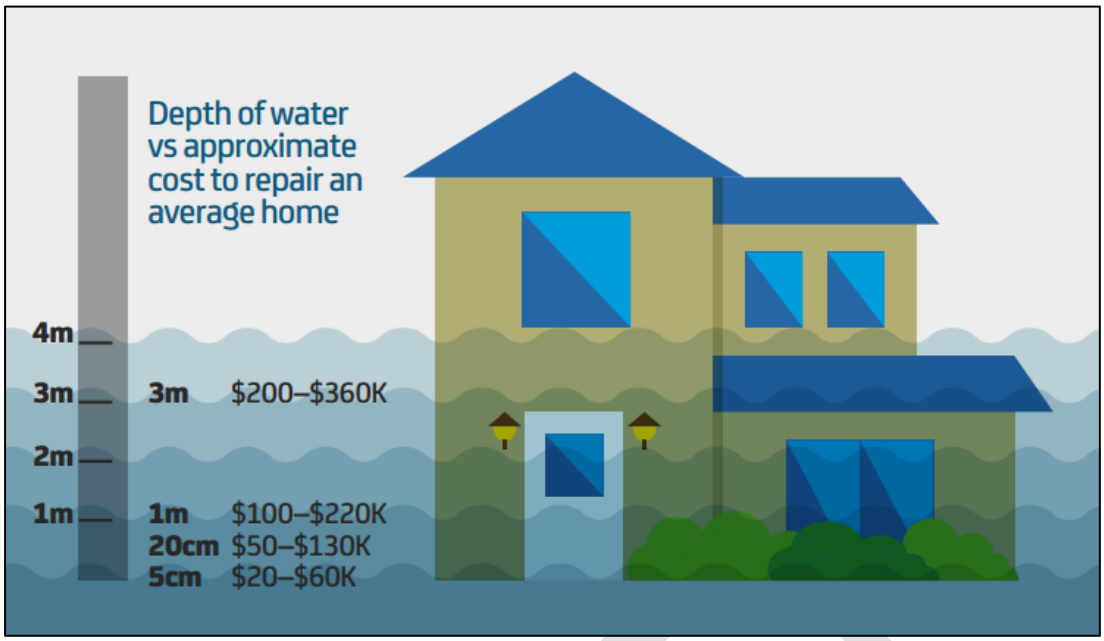


Plate 36 Examples of repair costs versus depth of above floor inundation used by insurance companies to estimate premiums (NRMA, 2015)

Nevertheless, flood insurance should be considered by property owners in high risk areas, where a single large flood may result in an unaffordable loss (through damage to contents or the loss of the building itself - refer **Plate 36**). Council could assist property owners as part of this process by providing property level flood information so property owners can understand their flood risk and the potential financial implications of a significant flood. Based on this, the property owners can make an informed decision on the need to acquire flood insurance. Assuming flood insurance is desired by the property owners, the property level flood information can also be used to assist in negotiating premiums with insurance companies.

Recommendations:
1) Individual property owners should consider flood insurance.
2) Council to assist property owners by providing property specific flood information.

11.5 Summary and Recommendations

A summary of the recommendation for further consideration for each response modification option is provided in **Table 52.** As shown in **Table 52**, a number of response modification options are recommended for further consideration to assist in managing the existing flood risk across the floodplain at Darlington Point.

Table 52 Evaluation matrix for Response Modification Options

Option	Recommended for Further Consideration?
RM1 - Property Level Flood Information	**Yes**
RM2 - Community Flood Awareness and Education	**Yes**
RM3 - Flood Emergency Response Plans	**Yes**
RM4 - Establishment of Local NSW SES Unit or Community Action Team (CAT) in Darlington Point.	**Yes**
RM5 - Local Flood Plan Updates	**Yes**
RM6 - Flood Warning System	**Yes**
RM7 - Upgrade of Existing Evacuation Routes	**No***
RM8 - Recovery Planning	**Yes**
RM9 - Flood Insurance	**Yes**

*could be undertaken as part of future asset management works or road upgrades by Transport for NSW and/or Council

12 Draft Floodplain Risk Management Plan

A floodplain risk management plan is the formalisation of an effective floodplain risk management process (NSW Floodplain Development Manual, 2005). A floodplain risk management study is intrinsically linked to the floodplain risk management plan as it provides the basis and assessment of the actions to manage the flood risk that are sustainable socially, environmentally, culturally and economically in the study area.

A floodplain risk management plan provides a program for the implementation of the management options that includes consideration of priorities, funding, staging, responsibilities, constraints and monitoring. The community should be involved in the formulation and implementation of the floodplain risk management plan. The community's involvement in the assessment, review and selection of floodplain risk management options as presented in this study is an important process in establishing what options should be progressed into the plan.

A floodplain risk management plan represents the most appropriate flood risk management options for the study area at the time it was complete, whilst also considering potential future scenarios. The Plan should be adopted by Council and reviewed regularly, or after a major flood. Financial support for the implementation of the plan is provided by the NSW and Federal Government, with a range of criteria used to assess the works, including:

- Community involvement in the preparation of the Floodplain Risk Management Plan.
- Community support for the options.
- Effectiveness of reducing flood damage to private property and reducing flood risk to the community.
- Benefit / cost ratio of the option.
- Ability of Council to match the financial funding requirements of the option.
- Impacts of the option on the environment.
- Consistency of the option with Council and government planning and development objectives and regulations.
- Effectiveness of the option in floods greater than the planning flood.

12.1 Plan Implementation

12.1.1 Prioritisation / Timing

Each of the recommended options has been assigned a preliminary implementation priority based upon an initial consideration of the above factors (i.e., costs, benefits, technical feasibility etc). The implementation priorities are summarised in **Table 53.**

A timeframe has also been estimated that reflects the likely time to implement each option. However, the implementation time estimates will most likely need to be refined moving forward based upon available resources (i.e., financial and human resources) as well as the need to undertake additional investigations and/or consultation.

Table 51 also summarises the agency that will be responsible for implementation of each option.

12.1.2 Costs and Funding

The components included in the Plan are not expected to have a significant capital cost and should be able to be undertaken as part of Council and NSW SES' ongoing procedures. Notwithstanding, they will require time resources from the staff of these organisations. The possible exception is Voluntary House Purchase which could have a cost of $750,000 depending on the wiliness of all parties to participate.

It should be noted that the costs included in **Table 53** are estimates only. There is potential that some of these tasks could be carried out by consultants engaged by Council or the NSW SES which would have associated costs.

Funding for implementation of the plan may be available from the following sources:

- NSW State Government's Floodplain Management Grants (through Department of Planning, Industry and Environment).
- Murrumbidgee Council's capital and operating budgets.
- NSW SES annual budgets.

12.1.3 Review of Plan

It is important that the Floodplain Risk Management Plan is continually monitored, reviewed and updated over time to ensure that it evolves with the catchment and new flood knowledge. Some events that may prompt a review of the Plan could include:

- If significant impediments are identified for any of the recommended options.
- A significant flood occurs which provides updated data of flood behaviour.
- A new flood study is prepared.
- New knowledge becomes available (e.g., climate change).
- New issues come to light that were not considered or not know at the time the Plan was prepared.
- Development in the catchment increases or varies considerably from what is considered as part of the assessments in this study and plan.

Based on the scoring criteria specified in **Table 20,** the floodplain risk management options assessed as part of this study are presented in **Table 53**.

As noted in **Table 53** most options are scheduled for implementation within a 5-year time frame. This is considered a reasonable estimate considering the resources that are currently available to undertake this work. Council should consider reviewing the Plan after 5-10 years if a review has not already been triggered by any of the above events.

Table 53 Draft Darlington Point Floodplain Risk Management Plan

#	Option	Report Section	Implementation Responsibility	Funding Source	Total Cost	BCR	Priority	Timing	Recommendation/Comments
	Property Modification Options								
PM1	Voluntary House Purchase	10.2.1	State Government and Council	NSW FM program	Up to $750k	<0.1	High	1-3 years	It is recommended that Council undertake a Voluntary Purchase feasibility study including a Voluntary Purchase scheme to be followed by implementation if appropriate.
PM3	Recommended Flood Planning Level	10.3.1	Council	N/A	Council Time	n/a	Hight	1-3 years	Update definition of flood planning level for this study area as recommended in this study, to 1% AEP plus a 0.30 metre freeboard.
PM4-8	LEP Amendments	10.3.2 10.3.3 10.3.4 10.3.5	Council	N/A	Council Time	n/a	High	1-3 years	Amend Murrumbidgee LEP 2013 considering the detailed review presented in this study. This includes updating LEP zoning, LEP clause 6.2, flood planning area mapping and introducing a floodplain risk management clause.
PM9	DCP Amendments	10.3.7	Council	N/A	Council Time	n/a	High	1-2 years	Amend Murrumbidgee Council Development Controls considering the detailed review presented in Section 6.3.2 of this study. This includes updating the flood DCP or introducing a flood

#	Option	Report Section	Implementation Responsibility	Funding Source	Total Cost	BCR	Priority	Timing	Recommendation/Comments
									policy and introducing a flood planning area map.
PM10	Update Section 10.7 Certificates	10.3.8	Council	N/A	Council Time	n/a	High	<1 year	Update Section 10.7 certificates to reference updated flood information produced as part of this study.
PM11	Flood Risk Assessment of Future Development Sites	10.3.9 **Appendix E**	Council	N/A	Council Time	n/a	High	1-3 years	Use the information discussed in **Appendix E** as the preliminary assessment of flood risk at these sites and as a basis for further planning investigations at these sites.
	Response Modification Options								
RM1	Update availability of property level flood information	11.2.1	NSW SES / Individual Business Owners	N/A	Council & NSW SES Time	n/a	Medium	2 years	Make available additional flood information at a property scale, such as flood depths, hazards and emergency response classifications, with suitable explanations and guidance as to how this information can be used to inform individual flood emergency plans.
RM2	Community flood awareness and education	11.2.2	NSW SES / Individual Residents	N/A	Council & NSW SES Time	n/a	Medium	2 years	Develop local FloodSafe documents and educational messages targeting dangerous behaviours such as not evacuating when directed to do so and driving through floodwaters.

#	Option	Report Section	Implementation Responsibility	Funding Source	Total Cost	BCR	Priority	Timing	Recommendation/Comments
RM3	Flood Emergency Response Plans	11.2.3	NSW SES / Residents / Organisations	N/A	Council & NSW SES Time	n/a	Medium	2 years	Host meetings to promote the preparation of Home and/or Business Emergency Flood Management Plans (NSW SES; Council). Including a sausage sizzle or family friendly activities will assist in promoting the event to the community. Furthermore, assist owners of vulnerable or critical developments to develop their flood emergency response plans incorporating new flood intelligence, including Altina Wildlife Park, Darlington Point Caravan Park, Grain silo operators on the Kidman Way in north Darlington Point.
RM4	Establishment of Local NSW SES Unit or Community Action Team (CAT) at Darlington Point	11.2.4	NSW SES / Business owners	N/A	NSW SES time	n/a	High	2 years	Establish a local NSW SES Unit at Darlington Point, with the assistance of Council resources to support the operation of this local unit.
RM5	Local flood plan and flood intelligence card updates	11.2.5	Council & NSW SES	N/A	Council & NSW SES Time	n/a	High	1-2 years	Update Murrumbidgee Local Flood Plan to align with the most recent NSW SES Local Flood Plan template and to incorporate new flood intelligence (NSW

#	Option	Report Section	Implementation Responsibility	Funding Source	Total Cost	BCR	Priority	Timing	Recommendation/Comments
									SES) developed in this study, including upgraded levee information
RM6	Flood warning system	11.3.1	Council	NSW FM program	$20,000	n/a	Medium	3 years	Flood warning system - Investigate the opportunity to install a telemetered pluviograph in vicinity of Darlington Point for access to real time local data and to provide greater situational awareness in the local area during rainfall events. Council may also consider providing this study to the BOM to improve their flood warning system for the region.
RM7	Upgrade existing evacuation routes	11.3.2	Council	N/A	Council time	n/a	Low	3 years	Depth indicators could be considered at locations on roads that get inundated that do not have an existing indicators. However, this should be supplemented with appropriate education material about driving on flooded roads.
RM9	Flood Insurance	11.4.2	Property owner	N/A	variable	n/a	Low	1-3 years	Recommend those properties located within the floodplain consider reviewing the flood insurance component of their house or business insurance with regard to the updated flood information provided in this report.

13 OTHER LEVEES IN THE STUDY AREA INFLUENCING FLOOD BEHAVIOUR AT DARLINGTON POINT

A desk top study was undertaken to identify and locate any other levees in the study area that may be influencing the flood behaviour at Darlington Point. Two private levees were identified as being located to the south of Darlington Point, adjacent to the intersection of the Kidman Way and the Sturt Highway. These are outlined on **Plate 37** below.

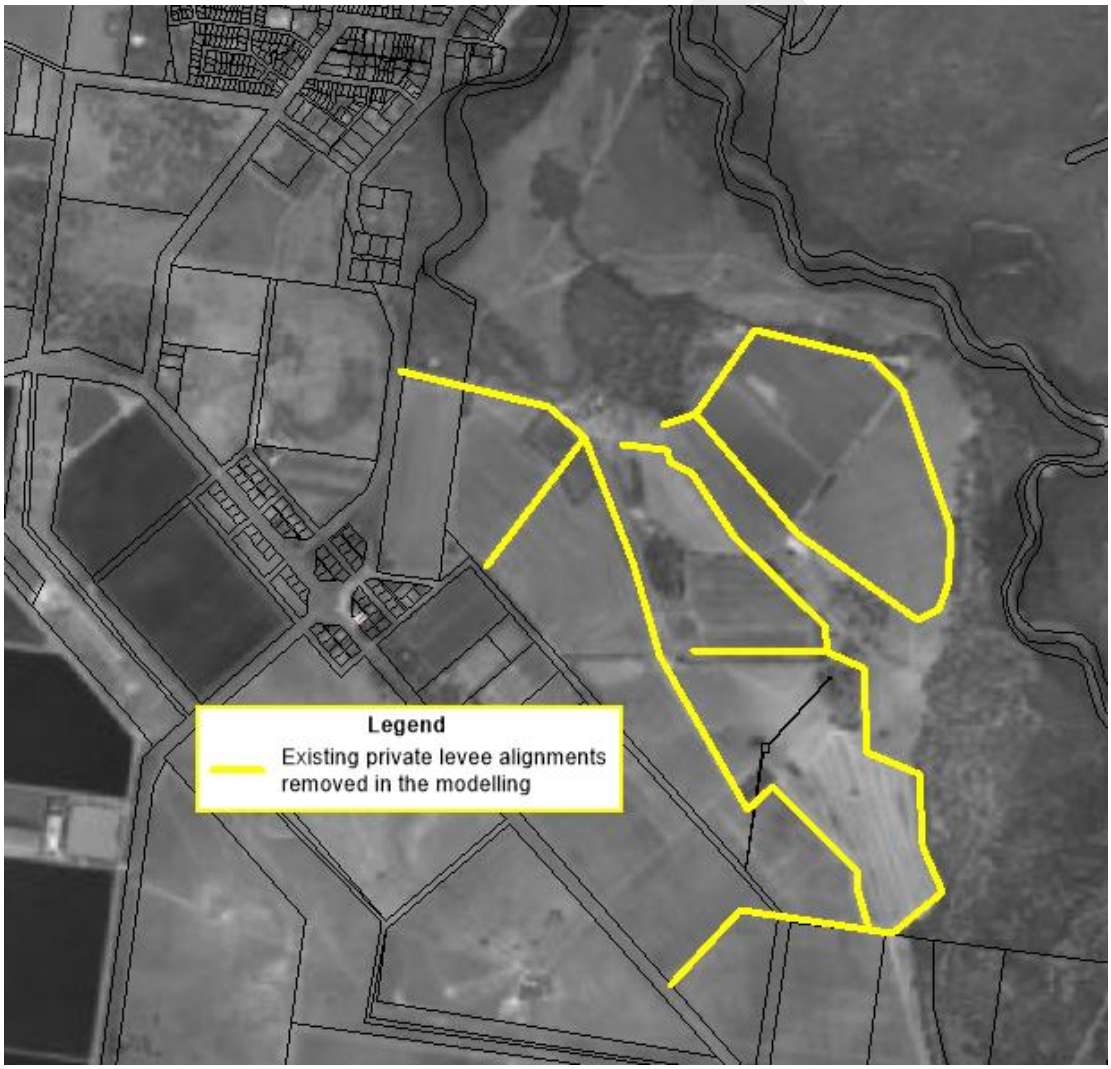


Plate 37 Private levee banks to the south of Darlington Point

These private levee banks were removed from the DEM of the hydraulic model to determine what impact they were having on the flood behaviour at Darlington Point. The hydraulic model was then re-run for the full range of design flood events, with the difference mapping presented below.

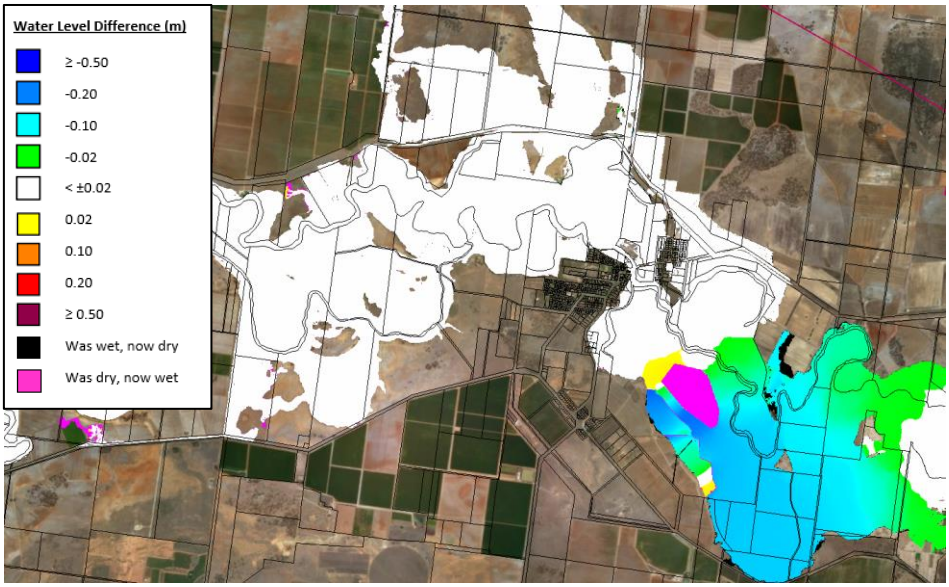


Plate 38 Private levee banks - floodwater level differences for the 5% AEP

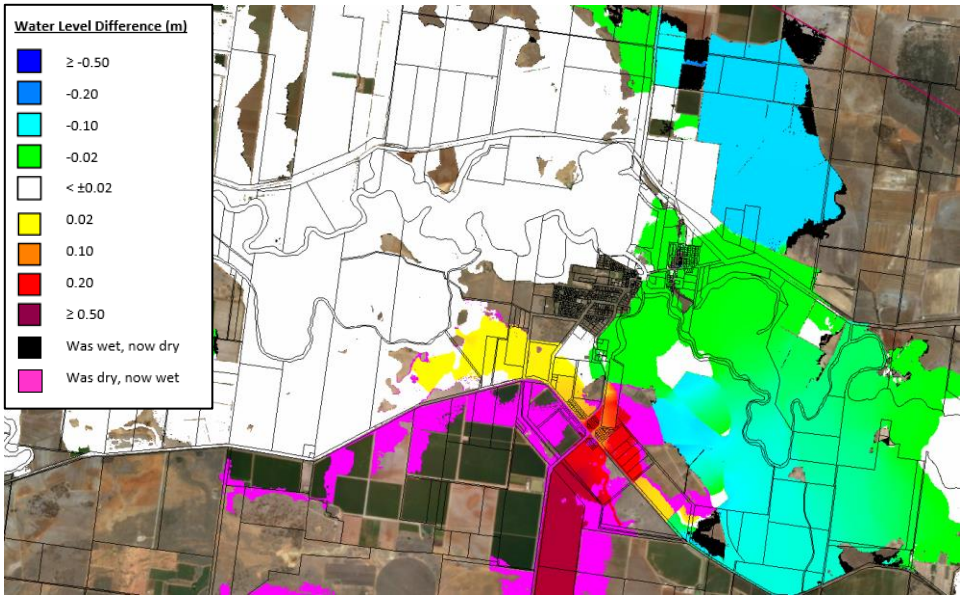


Plate 39 Private levee banks- Option 11 floodwater level differences for the 1% AEP

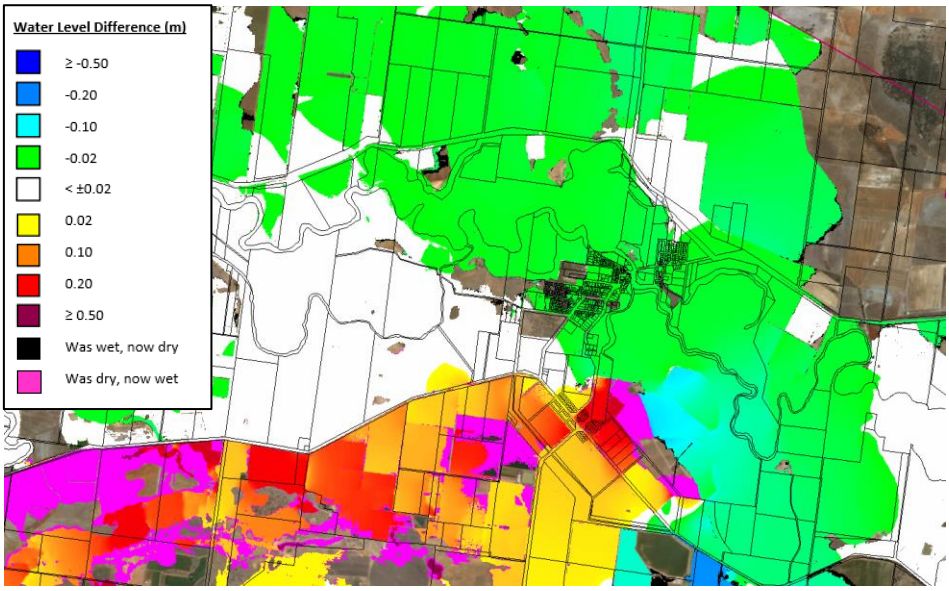


Plate 40 Private levee banks - floodwater level differences for the 0.2% AEP

These results indicate that these levee banks do influence flood behaviour in the Murrumbidgee River at Darlington Point, particularly on private properties south of the Sturt Highway.

Murrumbidgee Council needs to determine the approval authority for these levees. If these levees have been built without the correct approval process, then Council needs to resolve this with the land owners.

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