WARRINGAH COUNCIL

Dee Why South Catchment Floodplain Risk Management Plan

Prepared by Warringah Council
June 2015

Foreword

The NSW Government *Flood Prone Land Policy* is directed towards providing solutions to existing flood 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.

Under the policy, the management of flood prone land is the responsibility of Local Government. The State Government subsidises flood management measures to alleviate existing flooding problems, and provides specialist technical advice to assist Councils in the discharge of their floodplain management responsibilities. The Commonwealth Government also assists with the subsidy of floodplain management measures.

The Policy identifies the following floodplain management 'process' for the identification and management of flood risks:

1. Formation of a Committee	Established by a Local Government Body (Local Council) and includes community group representatives and State agency specialists.
2. Data Collection	The collection of data such as historical flood levels, rainfall records, land use, soil types etc.
3. Flood Study	Determines the nature and extent of the flooding problem.
4. Floodplain Risk Management Study	Evaluates floodplain management measures for the floodplain in respect of both existing and proposed development. This is the stage Council is currently undertaking for the Dee Why South Catchment.
5. Floodplain Risk Management Plan	Involves formal adoption by Council of a management plan for the floodplain.
6. Implementation of the Plan	Implementation of actions to manage flood risks for existing and new development.

This report forms the fifth stage of the floodplain management process for the Dee Why South Catchment floodplain. The Dee Why South Catchment Flood Study, 2013 (Stage 2 and 3 of the floodplain management process) and Floodplain Risk Management Study, 2014 (Stage 4 of the floodplain management process) were both prepared by Cardno (NSW/ACT) Pty Ltd.

This plan has been prepared by Warringah Council to outline flood risk management actions to be undertaken to reduce the flood hazard and risk to people and property in the Dee Why South Catchment.

Executive Summary

The Dee Why South Catchment is bordered by McIntosh Road to the north, Waratah Parade to the west and May Road to the south. The catchment area is approximately 268 hectares and is characterised by a steep escarpment grading down to a low floodplain area, discharging to Dee Why Lagoon. This catchment includes parts of the suburbs of Dee Why and Narraweena. While the majority of the catchment contains residential development, there is a major commercial sector, the Dee Why Town Centre, located in its lower reaches.

Flooding has previously caused property damage and inundated areas of the Dee Why Town Centre. Council's records indicate that the catchment has experienced major flood events in 1947, 1953 and 1954.

Flooding in the Dee Why South Catchment can pose a high flood risk to residents, businesses and members of the public living and working within the catchment.

Warringah Council through the Dee Why South Catchment Flood Study Working Group has prepared a Floodplain Risk Management Plan that fulfils Council's responsibilities under the NSW Government Flood Prone Land Policy. The Plan has been prepared in accordance with the guidelines provided in the 2005 NSW Floodplain Development Manual (The Manual).

The Plan is based on the outcomes of the investigations undertaken in the Dee Why South Catchment Flood Study adopted in 2013 and Dee Why South Catchment Floodplain Risk Management Study (FRMS) prepared in 2014.

The 2014 Dee Why South Catchment Floodplain Risk Management Study identified floodplain management options and evaluated these options based upon a range of economic, social and environmental criteria. These management options were developed in consultation with the community, Council and state agency stakeholders. The study built upon previous work, including the 2013 Dee Why South Catchment Flood Study which defined the nature and extent of flooding in the catchment.

The Plan outlines how Council in conjunction with other Government agencies and residents will implement a coordinated mix of measures that address the existing, future and continuing flood risks in the Dee Why South Catchment.

The objectives of this Plan are to:

- reduce the flood hazard and risk to people and property in the community in the present day, and to ensure future development is controlled in a manner consistent with the flood hazard and risk;
- reduce private and public losses due to flooding;
- where possible, protect and enhance waterways and the floodplain environment;
- be consistent with the objectives of relevant state policies, in particular, the Government's Flood Prone Land and State Rivers and Estuaries Policies and satisfy the objectives and requirements of the Environmental Planning and Assessment Act 1979;
- ensure that the draft floodplain risk management plan is fully integrated with Council's existing corporate, business and strategic plans, existing and proposed planning proposals, meets Council's obligations under the Local Government Act, 1993 and has the support of the local community;

- ensure actions recommended for incorporation in this plan are sustainable in social, environmental, ecological and economic terms; and
- establish a program for implementation and suggest a mechanism for the funding of the plan which should include priorities, staging, funding, responsibilities, constraints, and monitoring.

Measures available for the management of flood risk can be categorised according to the way in which the risk is managed. Various options for flood risk management have been identified and assessed. These options can be broadly defined into three categories of management:

- **Flood modification measures** – Flood modification measures are measures aimed at preventing / avoiding or reducing the likelihood of flood risks. These measures reduce the risk through modification of the flood behaviour in the catchment.
- **Property modification measures** – Property modification measures are focused on preventing / avoiding and reducing consequences of flood risks. Rather than necessarily modify the flood behaviour, these measures aim to modify properties (both existing and future) so that there is a reduction in flood risk.
- **Emergency response modification measures** – Emergency response modification measures aim to reduce the consequences of flood risks. These measures generally aim to modify the behaviour of people during a flood event.

This Plan has taken the prioritised measures from the 2014 Dee Why South Catchment FRMS, and developed an implementation plan for Council. An implementation plan is described in Section 9 and recommended measures and actions include:

FM2	Increase drainage capacity in Oaks Avenue
FM8b	Underground storage tanks at Redman Road
PM5	Planning instrument amendments
EM3	Public awareness and education
EM2	Flood Warning System
EM1	Information transfer to the SES
PM4	Flood proofing guidelines
EM5	Event Data Collection

Each option is classified in one of four categories:

- High priority
- Medium priority
- Low priority
- Ongoing action

The classification of the options will affect the staging of their implementation, with high priority actions likely to be investigated further as an immediate priority, whereas medium and low priority actions will be implemented depending upon budgetary and resource constraints.

The Plan represents the considered opinion of the local community on how to best manage its flood risk and its flood prone land. It also provides a long-term path for the future development of the community.

The management plan will be publicly exhibited and subject to revision in light of any comments received.

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Glossary and Abbreviations

Australian Height Datum (AHD)	A standard national surface level datum approximately corresponding to mean sea level.
Average Recurrence Interval (ARI)	The average or expected value of the periods between exceedances of a given rainfall total accumulated over a given duration. It is implicit in this definition that periods between exceedances are generally random. That is, an event of a certain magnitude may occur several times within its estimated return period.
Cadastre, cadastral base	Information in map or digital form showing the extent and usage of land, including streets, lot boundaries, water courses etc.
Catchment	The area draining to a site. It always relates to a particular location and may include the catchments of tributary streams as well as the main stream.
Design flood	A significant event to be considered in the design process; various works within the floodplain may have different design events. E.g. some roads may be designed to be overtopped in the 1 in 1 year ARI flood event.
Development	The erection of a building or the carrying out of work; or the use of land or of a building or work; or the subdivision of land.
Discharge	The rate of flow of water measured in terms of volume over time. It is to be distinguished from the speed or velocity of flow, which is a measure of how fast the water is moving rather than how much is moving.
Flash flooding	Flooding which is sudden and often unexpected because it is caused by sudden local heavy rainfall or rainfall in another area. Often defined as flooding which occurs within 6 hours of the rain which causes it.
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or overland runoff before entering a watercourse and/or coastal inundation resulting from super elevated sea levels and/or waves overtopping coastline defences.
Flood fringe	The remaining area of flood prone land after floodway and flood storage areas have been defined.
Flood hazard	Potential risk to life and limb caused by flooding.
Flood prone land	Land susceptible to inundation by the probable maximum flood (PMF) event, i.e. the maximum extent of flood liable land. Floodplain Risk Management Plans encompass all flood prone land, rather than being restricted to land subject to designated flood events.
Floodplain	Area of land which is subject to inundation by floods up to the probable maximum flood event, i.e. flood prone land.
Floodplain management measures	The full range of techniques available to floodplain managers.
Floodplain management options	The measures which might be feasible for the management of a particular area.
Flood planning area	The area of land below the flood planning level and thus subject to flood related development controls.
Flood planning levels	Flood levels selected for planning purposes, as determined in floodplain

(FPLs)	management studies and incorporated in floodplain management plans. Selection should be based on an understanding of the full range of flood behaviour and the associated flood risk. It should also take into account the social, economic and ecological consequences associated with floods of different severities. Different FPLs may be appropriate for different categories of land use and for different flood plains. The concept of FPLs supersedes the "Standard flood event" of the first edition of the Manual. As FPLs do not necessarily extend to the limits of flood prone land (as defined by the probable maximum flood), floodplain management plans may apply to flood prone land beyond the defined FPLs.
Flood storages	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood.
Floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often, but not always, aligned with naturally defined channels. Floodways are areas which, even if only partially blocked, would cause a significant redistribution of flood flow, or significant increase in flood levels. Floodways are often, but not necessarily, areas of deeper flow or areas where higher velocities occur. As for flood storage areas, the extent and behaviour of floodways may change with flood severity. Areas that are benign for small floods may cater for much greater and more hazardous flows during larger floods. Hence, it is necessary to investigate a range of flood sizes before adopting a design flood event to define floodway areas.
Geographical Information Systems (GIS)	A system of software and procedures designed to support the management, manipulation, analysis and display of spatially referenced data.
High hazard	Flood conditions that pose a possible danger to personal safety; evacuation by trucks difficult; able-bodied adults would have difficulty wading to safety; potential for significant structural damage to buildings.
Hydraulics	The term given to the study of water flow in a river, channel or pipe, in particular, the evaluation of flow parameters such as stage and velocity.
Hydrograph	A graph that shows how the discharge changes with time at any particular location.
Hydrology	The term given to the study of the rainfall and runoff process as it relates to the derivation of hydrographs for given floods.
Low hazard	Flood conditions such that should it be necessary, people and their possessions could be evacuated by trucks; able-bodied adults would have little difficulty wading to safety.
Mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of the principal watercourses in a catchment. Mainstream flooding generally excludes watercourses constructed with pipes or artificial channels considered as stormwater channels.
Management plan	A document including, as appropriate, both written and diagrammatic information describing how a particular area of land is to be used and managed to achieve defined objectives. It may also include description and discussion of various issues, special features and values of the area, the specific management measures which are to apply and the means and timing by which the plan will be implemented.
Mathematical/computer	The mathematical representation of the physical processes involved in runoff and stream flow. These models are often run on computers due to the

models	complexity of the mathematical relationships. In this report, the models referred to are mainly involved with rainfall, runoff, pipe and overland stream flow.
NPER	National Professional Engineers Register. Maintained by Engineers Australia.
NSW	New South Wales
Overland Flow	Inundation by runoff flowing across the land surface before it enters a principal watercourse. This includes areas where runoff exceeds the capacity of a piped drainage system or flows overland along alternative flow paths which do not follow the drainage lines
Peak discharge	The maximum discharge occurring during a flood event.
Probable maximum flood (PMF)	The flood calculated to be the maximum that is likely to occur.
Probability	A statistical measure of the expected frequency or occurrence of flooding. For a more detailed explanation see Average Recurrence Interval.

1. Introduction

Warringah Council through the Dee Why South Catchment Flood Study Working Group has prepared a Floodplain Risk Management Plan that fulfils Council's responsibilities under the NSW Government Flood Prone Land Policy. The Plan has been prepared in accordance with the guidelines provided in the 2005 NSW Floodplain Development Manual (The Manual).

The Plan outlines how Council in conjunction with other Government agencies and residents will implement a coordinated mix of measures that address the existing, future and continuing flood risks in the Dee Why South Catchment. The Plan covers the areas outlined in Figure 1. The Plan is based on the outcomes of the investigations undertaken in the Dee Why South Catchment Flood Study adopted in 2013 and Dee Why South Catchment Floodplain Risk Management Study adopted in 2014.

Following the implementation of the management options adopted in this plan, there will continue to be a residual flood risk. A fundamental principle of this Plan is to ensure that the options are not considered individually or in isolation. Options have been considered collectively so that their interactions, cumulative impact, economic suitability and effectiveness will ensure that a holistic approach to floodplain management is achieved.

1.1. Purpose of the Plan

The purpose of the Dee Why South Catchment Lagoon Floodplain Risk Management Plan (FRMP) is to formalise the outcomes of an effective floodplain risk management process. It is based on a comprehensive and detailed evaluation of all factors that affect and are affected by the use of flood prone land in the catchment. It represents the considered opinion of the local community on how to best manage its flood risk and its flood prone land. It also provides a long-term path for the future development of the community.

The management plan will be publicly exhibited and subject to revision in light of these responses.

1.2. Objectives of the Plan

Past investigations of flood mitigation options in the Dee Why South Catchment have suggested that reducing the 100 year ARI peak flood level to below kerb height will require strategies which are beyond Council's financial resources. As a result the principal objective of this Plan is to implement a range of suitable measures to reduce the final flood hazard to an appropriate safe level for a commercial centre such as the Dee Why Central Business District (CBD).

The objectives of this Plan are to:

- reduce the flood hazard and risk to people and property in the community in the present day, and to ensure future development is controlled in a manner consistent with the flood hazard and risk;
- reduce private and public losses due to flooding;
- where possible, protect and enhance waterways and the floodplain environment;
- be consistent with the objectives of relevant state policies, in particular, the Government's Flood Prone Land and State Rivers and Estuaries Policies and satisfy the objectives and requirements of the Environmental Planning and Assessment Act 1979;
- ensure that the draft floodplain risk management plan is fully integrated with Council's existing corporate, business and strategic plans, existing and proposed planning proposals, meets Council's obligations under the Local Government Act, 1993 and has the support of the local community;
- ensure actions recommended for incorporation in this plan are sustainable in social, environmental, ecological and economic terms; and
- establish a program for implementation and suggest a mechanism for the funding of the plan which should include priorities, staging, funding, responsibilities, constraints, and monitoring.

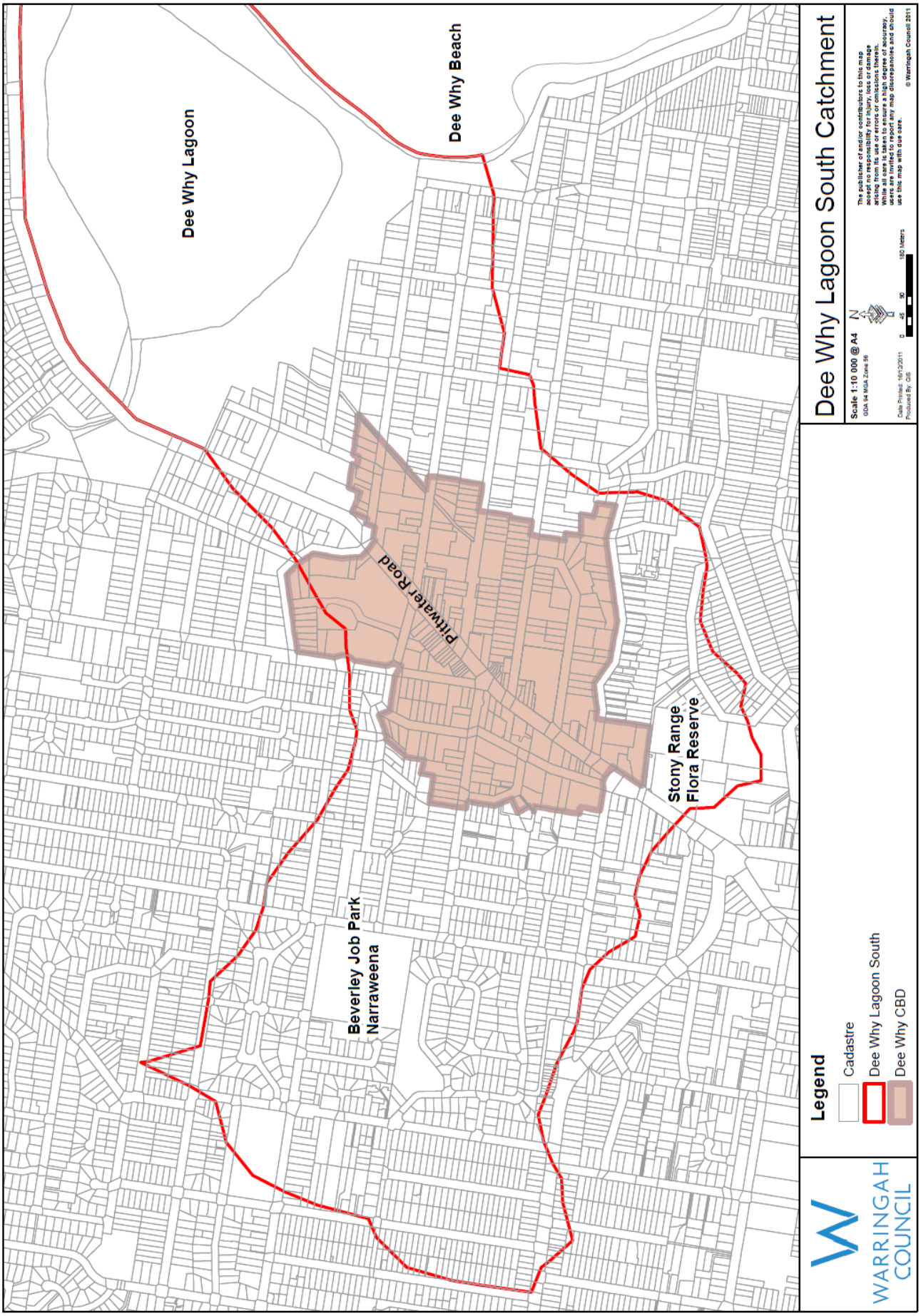

Figure 1 – The extents of the Dee Why South Catchment and Dee Why CBD

2. Catchment Characteristics

The Dee Why South Catchment includes parts of the suburbs of Dee Why and Narraweena which drain to the Dee Why CBD. The Catchment is bordered by McIntosh Road to the north, Waratah Parade to the west, and May Road to the south, and Dee Why Lagoon in the east. The catchment area is approximately 268 ha and is characterised by a steep escarpment which grades down to a low floodplain area, before discharging to the ocean via Dee Why Lagoon (refer Figure 1). The majority of the catchment is developed for residential purposes, with the CBD located in its lower reaches.

Key features and roads are identified in Figure 2.

The catchment has developed from low density residential development in the 1940s to largely medium density residential dwellings in the present day. Most of the original creek lines have been piped with only three sections of open channel remaining:

- A largely open concrete channel running between Victor Road and Redman Road;
- East of Pittwater Road running parallel with both Oaks Avenue and Pacific Parade; and
- Downstream of Dee Why Parade to Dee Why Lagoon

Because the catchment is now mostly paved rainfall does not seep into the ground and instead runs off in even small storms. Consequently flooding in the catchment is predominantly from runoff from streets, roads and properties and/or flows which exceed the capacity of the existing underground drainage system which flow overland to the low points in the catchment which typically follow the original creek lines. High traffic pedestrian and vehicular areas in the Dee Why Town Centre also experience inundation from overland flows, particularly along Redman Road, Pittwater Road, Oaks Avenue and Howard Avenue.

Figure 2 – Key Features and Roads within the Dee Why South Catchment

3. Existing Flood Risk

A comprehensive investigation of the historical and existing flood behaviour in the catchment under a range of design floods, and how this was determined can be found in the 2013 Dee Why South Catchment Flood Study.

3.1. Historical Flooding

Records held by Warringah Council disclose that extreme flooding has been experienced in the Dee Why CBD in the past. Historical photographs record the catchment flooding which occurred in 1947, 1953 and 1954 including severe overland flows which flooded Redman Road, Pittwater Road and potentially Oaks and Howard Avenues. There are no official rainfall records for these floods and therefore it was not possible to assess the severity of the storms which led to the flooding.

The flooding of Pittwater Road which was experienced in 1953 is displayed in Figures 3 and 4.

Figure 3 – Flooding on Pittwater Road, 1953 (Source: Warringah Council)

Figure 4 – Flooding on Pittwater Road, 1953 (Source: Warringah Council)

3.2. Flood Behaviour

A coupled 1D/2D XPSWMM hydraulic model was established and calibrated as a basis for the assessment of existing and future flood behaviour in the Dee Why South Catchment. This flood model was used to undertake assessments for:

- Flood design event simulation for 1 yr ARI, 5 yr ARI, 10 yr ARI, 20 yr ARI, 100 yr ARI, 200 yr ARI, 1,000 yr ARI and PMF storms.
- A range of sensitivity analyses
- Hydraulic categorisation
- Provisional hazard classification
- Future flood risk through climate change assessment

The Dee Why South Catchment is relatively small, falling from a plateau of around 96m AHD, down a steep escarpment to the Dee Why CBD located on a low floodplain. Due to these geographical features and the nature of development in the catchment, the critical duration rainfall event in the catchment is short. These short duration rainfall events lead to flash flooding with little to no warning time.

The main overland flow path originates on the escarpment in Narraweena with the convergence of two overland flow paths in Beverley Job Park. Flood waters increase in depth and velocity as they are transported in an open channel through properties in Lewis Street, Dela Close and Redman Road. Flood waters then exceed the capacity of the underground stormwater infrastructure and surcharge down Redman Road. At the intersection of Pittwater Road and Redman Road the main overland flow path converges with a number of minor overland flow paths from the southern portion of the catchment. From this point overland flows are split with flood waters conveyed down either Oaks Avenue or Howard Avenue.

The flood modelling identified a number of locations within the catchment which would experience depths of flooding of >0.5m in a 100 yr ARI event, particularly in the lower catchment including Redman Road, Pittwater Road and Oaks Avenue. This can be attributed to undersized drainage systems and in some cases to an absence of underground drainage and of dedicated overland flow paths.

Flooding due to overland flows in a 100 yr ARI storm are presented in Figure 5 while 100 yr ARI mainstream flooding is presented in Figure 6.

Particularly hazardous to pedestrians and others, is the rate of rise of flood waters and time it takes to reach the peak flood depth. Most major access roads such as, Pittwater Road, Oaks Avenue, Howard Avenue and Redman Road experience peak flood depths in a 100 yr ARI flood event in as little as 30 minutes - 35 minutes.

3.3. Property Flooding

The majority of development in the Dee Why South Catchment is medium density multi-unit residential dwellings. A significant number of properties are impacted by flooding in the Dee Why South Catchment. This is due to the widespread extent of flooding in a Probable Maximum Flood event as well as counting each individual unit as a property.

The number of properties affected by flooding for a range of flood events is outlined in Table 1.

Figure 5 – 100 yr ARI Overland Flow Flood Extents

Figure 6 – 100 yr ARI Mainstream Flood Extents

Table 1 – Estimated Number of Flood Affected Properties in the Dee Why South Catchment

Flood	Number Flood Affected Properties*
5 yr ARI	1,219
10 yr ARI	1,471
20 yr ARI	1,626
100 yr ARI	2,089
PMF	4,538

**Based on 0.15m filtered extents from the Flood Study. Note that if a property is subdivided each individual title will be considered within the above counts.*

3.4. True Flood Hazard

Flood hazard can be defined as the risk to life caused by a flood, and is categorised in accordance with Appendix L of the Manual as follows:

- Provisional flood hazard is based on the hydraulic characteristics of the floodwaters, namely the relationship between the depth and velocity of floodwaters (provisional hazard = depth x velocity); and
- True flood hazard is a refinement of the provisional flood hazard which considers a range of additional factors that contribute to flood risk.

An assessment of the true flood hazard of the floodplain was undertaken in the 2014 Dee Why South Catchment Floodplain Risk Management Study. This involves undertaking an initial assessment of provisional flood hazards and then refining the assessment based on the consideration of a range of other factors including:

- Size of the flood
- Effective warning time
- Flood readiness
- Rate of rise of floodwaters
- Duration of flooding
- Ease of evacuation
- Effective flood access; and
- Type of development in the floodplain

Due to the rapid rise and onset of flooding in the catchment with limited associated flood warning time there is little possibility for evacuation.

Flood readiness is considered to be low in the catchment due to a range issues, primarily the significant time since a major flood event and the absence of a Local Flood Plan from the NSW SES.

In a 100 yr ARI event the main overland flow paths are categorised as high hazard with a number of the lots abutting these flow paths hazardous due to a lack of flood free access. Particularly isolated are the properties fronting Lewis Street and Dela Close which require access across the open channel. The areas of flooding that are subject to shallower flood depths or lower velocities are categorised as low hazard. In a PMF event most roads are subject to high hazard flooding, restricting access to a significant number of flood affected properties in the lower catchment.

The assessed true flood hazards in the 100 yr ARI flood and the Probable Maximum Flood are presented in Figures 7 and 8 respectively.

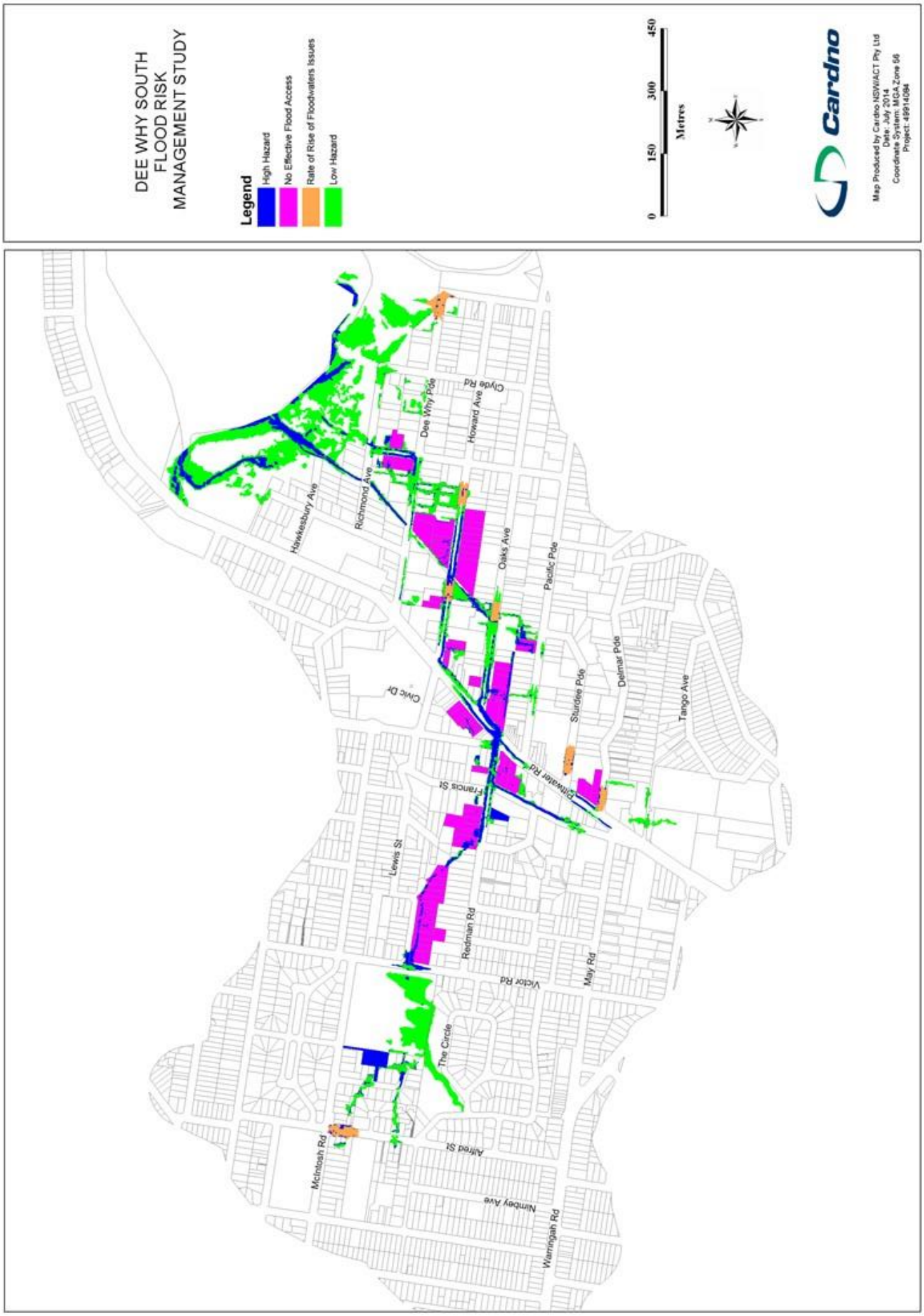

Figure 7 – 100 yr ARI True Flood Hazards

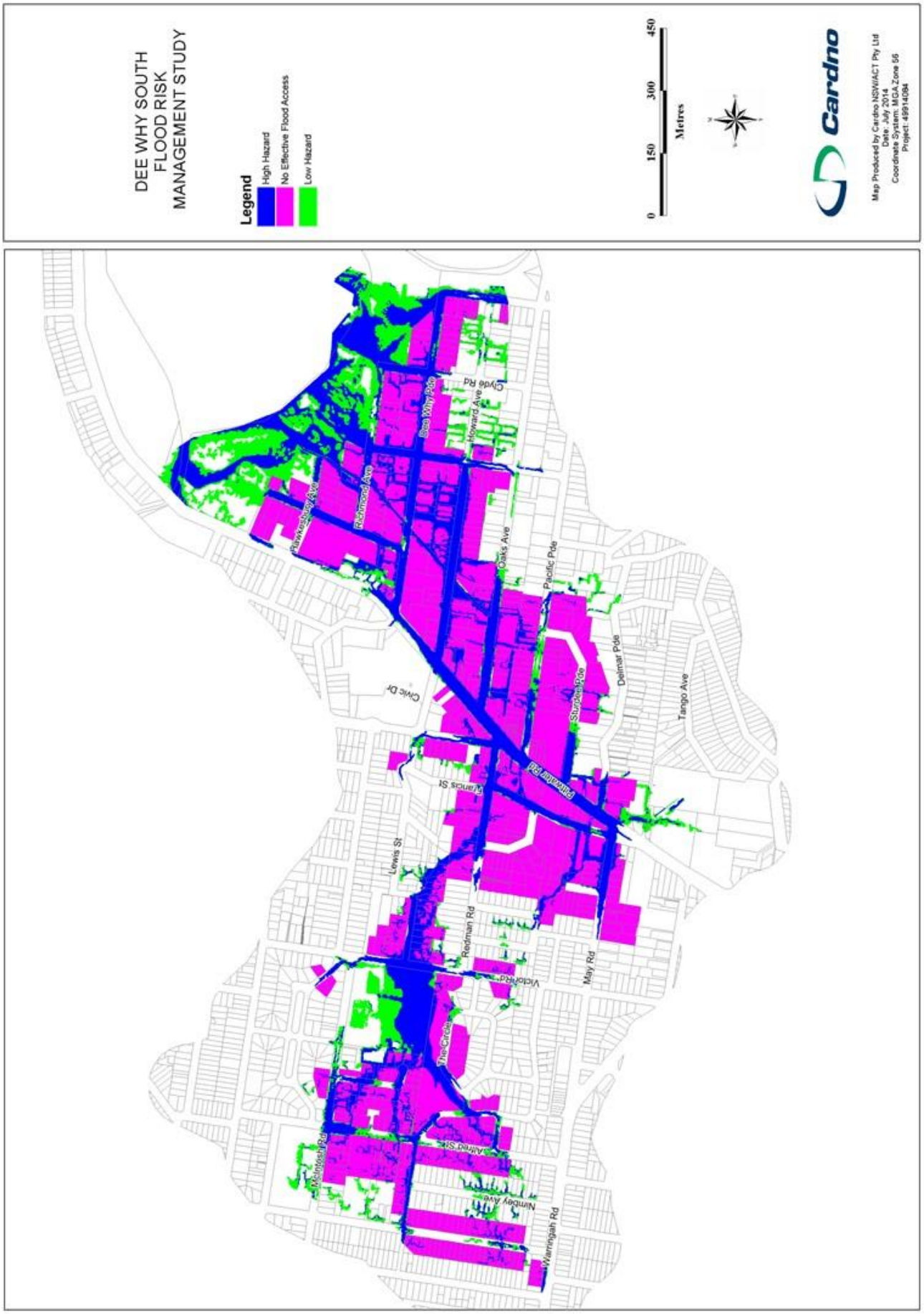

Figure 8 – PMF True Flood Hazards

3.5. Economic Impact of Flooding

A flood can have wide ranging effects on members of the community. There are the financial impacts of flooding as well as social impacts which can be more difficult to quantify. Broadly, the economic impacts of flooding, or flood damages, can be classified into three categories: direct, indirect and intangible.

Direct damages are the most immediate impact of flooding and consist of damage to building structures, contents or external damage. This can include damage to buildings, foundations, walls, carpets, furniture and ancillary structures or motor vehicles. The cost of direct damages is dependent on a number of factors including flood readiness, effective warning time, structure material resilience, flood depths, flood velocities and the duration of inundation.

Indirect damages are the additional financial costs associated with flooding. They are usually incurred following a flood event and can include clean-up costs, costs of temporary accommodation, loss of wages, sales or production and the loss of public opportunities.

Intangible damages cannot easily be quantified in financial terms. They include the emotional, mental and physical damage that a flood can inflict on a community. Although physical loss of life due to flooding is comparatively rare, the emotional cost of a flood can be significant and long-lived.

Flood damages were estimated for those properties whose ground floor level have been previously surveyed. These properties are primarily located in the greater Dee Why CBD area. The flood damages were estimated using flood damages curves prepared by the NSW Government's Office of Environment & Heritage (OEH) that provide a relationship between flood depth and corresponding financial cost for a range of land uses. Inputs include the floor area for individual properties, warning time, contents value and the level of the base of the property.

The Dee Why South Catchment includes the commercial centre of the Dee Why CBD. Within the CBD there are a number of on-grade car parks and extensive on street parking which can experience flooding. To consider the potential impact of flooding on vehicles, a flood damages assessment of parked vehicles was included. Details of how this was undertaken can be found in the 2014 Dee Why South Catchment Floodplain Risk Management Study.

A summary of the direct flood damages for the Dee Why South Catchment can be found in Table 2.

Table 2 – Flood Damages summary for the Dee Why South Catchment

						Proportion of Total Damages			
Flood	No. of Properties with Overfloor Flooding	Average Overfloor Flooding Depth (m)	Maximum Overfloor Flooding Depth (m)	No. of Properties with Overground Flooding	Rounded Total Damages (excl GST)	Residential	Commercial	Public	Cars
PMF	264	1.27 / 1.48	2.73 / 2.86	305	$55,034,000	11%	47%	0%	42%
100 yr ARI	117	0.94 / 0.95	2.56 / 2.53	174	$12,400,000	19%	76%	1%	4%
20 yr ARI	80	0.98 / 0.73	2.55 / 1.70	143	$7,798,000	21%	76%	2%	1%
10 yr ARI	70	1.01 / 0.65	2.54 / 1.67	123	$6,500,000	20%	77%	2%	0%
5 yr ARI	57	1.09 / 0.65	2.52 / 1.37	104	$5,397,000	23%	76%	1%	0%

Note: Overfloor Flood Depths are for Residential / Commercial Properties

The properties included in Table 2 are only those for which floor level survey exists, this is limited to the Dee Why CBD and results in a lower number when compared to the entire catchment (Table 1).

4. Consultation

4.1. Floodplain Committee and Stakeholder Consultation

The Dee Why South Catchment Flood Study Working Group has played an important role in assisting Council in the preparation and implementation of Floodplain Risk Management Plans. The Working Group has been consulted during the preparation of the Floodplain Risk Management Plan and reviewed the Plan prior to the Public Exhibition period.

4.2. Public Exhibition

The draft Dee Why South Catchment Floodplain Risk Management Plan was placed on Public Exhibition between 1 May and 29 May 2015. The purpose of the Public Exhibition is to seek community feedback on the options selected for implementation. As part of this process the following opportunities for the community to participate in the review of the document were provided:

- A letter was sent to approximately 4700 home owners within the extent of the Probable Maximum Flood, inviting them to provide feedback on the Plan.
- Posting of the draft Plan on the project web site, with a link from Council's web site
- Community Engagement email to interested residents and groups
- Displays in the Customer Service foyer of the Civic Centre, and all Council libraries
- Advertisements in the Council Notices section of The Manly Daily
- Two drop-in information sessions
- Hand delivery of letters to 200 business owners and operators in the vicinity of the proposed new stormwater pipes.

Over the public exhibition period of the project the webpage received 131 site visits by 115 individual visitors, and there were 299 page views with 60 document downloads in total. A total of 3 submissions were received during the public exhibition period.

The submissions ranged from concern at the level of flood risk in Dee Why, support for the FRMP to questions on expenditure in floodplain management.

5. Floodplain Risk Management Options

Flood Risk can be categorised as existing, future or residual risk:

- **Existing Flood Risk** – existing buildings and developments on flood prone land. Such buildings and developments by virtue of their presence and location are exposed to an 'existing' risk of flooding.
- **Future Flood Risk** – buildings and developments that may be built on flood prone land. Such buildings and developments would be exposed to a flood risk when they are built.
- **Residual Flood Risk** – buildings and development that would be at risk if a flood were to exceed management measures already in place. Unless a floodplain management measure is designed to withstand the PMF, it may be exceeded by a sufficiently large event at some time in the future.

The alternate approaches to managing risk are outlined in **Table 3**.

Table 3 - Flood Risk Management Alternatives (SCARM, 2000)

Alternative	Examples
Preventing / Avoiding risk	Appropriate development within the flood extent, setting suitable planning levels.
Reducing likelihood of risk	Structural measures to reduce flooding risk such as drainage augmentation, levees, and detention.
Reducing consequences of risk	Development controls to ensure structures are built to withstand flooding.
Transferring risk	Via insurance – may be applicable in some areas depending on insurer.
Financing risk	Natural disaster funding.
Accepting risk	Accepting the risk of flooding as a consequence of having the structure where it is.

Measures available for the management of flood risk can be categorised according to the way in which the risk is managed. There are three broad categories of management:

- **Flood modification options** – Flood modification options are measures aimed at preventing / avoiding or reducing the likelihood of flood risks. These measures reduce the risk through modification of the flood behaviour in the catchment.
- **Property modification options** – Property modification options are focused on preventing / avoiding and reducing consequences of flood risks. Rather than necessarily modify the flood behaviour, these measures aim to modify properties (both existing and future) so that there is a reduction in flood risk.
- **Emergency response modification options** – Emergency response modification options aim to reduce the consequences of flood risks. These measures generally aim to modify the behaviour of people during a flood event.

Several measures relating to each of these categories were assessed as part of the 2014 Floodplain Risk Management Study.

6. Flood Modification Options

Flood modification options modify the behaviour of a flood itself by altering the flow regime; this may be through reducing flood levels or velocities. A number of flood modification options were investigated in the 2014 Dee Why South Catchment Floodplain Risk Management Study.

The Dee Why South Catchment is highly urbanised with much of the original watercourse now piped. As a result there is limited scope for many flood modification options and those investigated primarily comprised pipe upgrades, detention basins or other localised works.

A list of the flood modification options investigated in the Study is found in Table 4. Only those works which were deemed to be effective at reducing flooding, non-cost prohibitive and did not result in adverse flooding or environment impacts are included in this Plan.

Table 4 - Flood Modification Options assessed in the 2014 Dee Why South Catchment FRMS

Option No.	Description
FM1	Pipe upgrade between Pacific Parade and Oaks Avenue
FM2	Increase drainage capacity along Oaks Avenue
FM3	Drainage upgrades between Oaks and Howard Avenues plus Option FM2
FM4	Daylighting of box culvert between Howard Avenue and Dee Why Parade
FM5	Walter Gors Park detention basin plus Option FM2
FM6	Replace open channel between Oaks Avenue and Pacific Parade with new pipe under Pittwater Road plus Options FM1 and FM2
FM7	Raise level of Oaks Avenue and Howard Avenue plus Option FM2
FM8	Storage basins at Mooramba Road car park and Redman Road
FM9	Upgrade of Open Channel between Victor Road and Redman Road plus Option FM8
FM10	Combination of Option FM2 and Option FM8

Of the flood modification options that were investigated in the Floodplain Risk Management Study (Table 4), only Options FM2 and FM8 were included in the Plan. Both of these options offer significant reductions in flood damages compared to their capital cost.

6.1. Increase drainage capacity along Oaks Avenue (Option FM2)

Oaks Avenue is one of the main overland flow paths in the Dee Why South Catchment and is therefore subject to significant flood depths and velocities in a 100 yr ARI flood. Currently there is no underground drainage in the western half of Oaks Avenue.

Oaks Avenue is a major commercial street within the Dee Why CBD, with retail premises fronting the street at the western end. A number of properties on Oaks Avenue would likely suffer overfloor flooding in a 100 yr ARI flood resulting in significant flood damages.

To attempt to convey a portion of the overland flow underground, the Floodplain Risk Management Study investigated the benefits of installing a large diameter pipe from the intersection of Pittwater Road and Oaks Avenue connecting into the existing box culvert opposite 33 Oaks Avenue.

The pipe consisted of an 825 mm diameter concrete pipe running the length of Oaks Avenue with 600 mm diameter pipes connecting additional stormwater pits to the main pipe. The new large diameter pipe will connect into an existing twin box culvert which crosses Oaks Avenue outside 33 Oaks Avenue. There is sufficient capacity in the box culvert to accommodate the additional flows under this option.

This option would be constructed entirely within the Council road reserve and would not need to be constructed under or within private property. This negates the requirement for easements, compensation or compulsory purchase.

The flood modelling undertaken in the 2014 Dee Why South Catchment FRMS indicated this option would reduce flood depths by up to 0.22 m in Oaks Avenue, and would result in further reductions downstream of the option. The principal objective of the 2014 Dee Why South Catchment FRMS was to reduce the flood hazard in key areas of where it is currently high. This option reduces the current high hazard to low hazard for much of Oaks Avenue roadway.

This option is extremely effective at reducing the overall hazard along Oaks Avenue and results in significant benefits to areas along the main flow path downstream of the option. This will result in lower property damage in a 100 yr ARI flood.

To assess the cost effectiveness of the option the flood damages were calculated under existing conditions and following implementation of the option. The present value of the savings in average annual flood damage that the option will afford throughout its design life (the benefit) is divided by the cost to construct and maintain the option to give its cost-benefit ratio.

The assessment of the costs and benefits of Option FM2 are summarised in Table 5.

Table 5 – Economic Assessment of Option FM2

Option	Present Value of Reduction in Flood Damages	Capital Cost	Annual Cost	Total Cost of Option	Benefit/Cost Ratio
FM2	$6,577,000	$1,158,473	$1,900	$1,186,500	5.54

The total lifetime cost of the option is significantly less than the present value of the reduction in flood damages. The resultant cost-benefit ratio is 5.54. This is the highest cost benefit ratio of all flood modification options that were investigated and is due to the large reduction in damages compared to the comparatively modest cost of implementation.

The additional capacity in the twin box culvert that traverses Oaks Avenue may allow for an even larger pipe to be installed in Oaks Avenue, producing further reductions in flood depth and hazard. The feasibility of further increasing the size of the stormwater pipe will be investigated in the detailed design phase of implementation.

The construction cost of the proposed option can be sourced from Council's Stormwater Renewal budget with grant funding a possibility if the timing of the works coincides with the award of Floodplain Management Program grants by the NSW Office of Environment and Heritage.

The costs for the floodplain management options are preliminary estimates based upon a concept design and include the physical estimate of the works. The estimates do not include costs of design, approvals, project management and contingency. Following detailed design it is likely that the project cost will differ from that outlined above.

Even if the resultant costs of implementation for this option are double what is predicted in this Plan, the cost/benefit ratio would still be greater than 3 and significant enough to warrant the construction of the option.

6.2. Underground storage tanks at Redman Road (Option FM8)

The aim of this option is to capture and detain floodwater upstream of Pittwater Road and thereby reduce peak flood levels throughout much of the Dee Why CBD. The eastern end of Redman Road has been identified in the Dee Why Town Centre Masterplan as a potential redevelopment site.

The 2014 Dee Why South Catchment FRMS investigated the construction of two storage tanks with a 600mm connecting pipe to ensure free transfer of flows between the tanks. These tanks would be located under the Mooramba Road Car Park and the eastern end of Redman Road.

Subsequent investigations identified that the while the Mooramba Road Car Park individually has little flood benefit in the 100 yr ARI flood an underground flood storage tank located in Redman Road is a feasible flood modification option. The subsequent modelling assessed a 2,500 m^3 tank to capture overland flows that are conveyed down Redman Road (Option FM8b).

The storage tank results in significant reductions in flood depths downstream of Redman Road. Flood depths on Redman Road, Pittwater Road, Oaks Avenue and Howard Avenue are reduced by up to 0.3 m with the flood hazard in areas of the roadways reducing from high to low hazard.

The assessment of the costs and benefits of Option FM8b are summarised in Table 6.

Table 6 – Economic Assessment of Option FM8b

Option	Present Value of Reduction in Flood Damages	Capital Cost	Annual Cost	Total Cost of Option	Benefit/Cost Ratio
FM8b	$16,861,534	$3,014,900	$21,000	$3,324,672	5.07

The estimated capital cost of the option is around $3 million, this is significantly less than the expected savings that the option would provide through reduced flood damages. The resultant cost-benefit ratio is 5.07, which is comparatively high and further consideration will be given to the implementation of this option.

Option FM2 is effective at reducing flooding on Oaks Avenue and downstream in flood events more frequent than the 100 yr ARI flood event. Once option FM2 has been constructed and is operational, FM8 will only offer additional flood damage reductions to Pittwater Road and more broadly in the 100 yr ARI flood event. Considering the design life of the option would likely be less than 100 years, there is a risk that this option would not demonstrate significant benefits during its operation.

Although the potential reduction in damages that this option affords far outweighs the estimated capital cost, there are major assumptions in the modelling to produce the reported reduction in flood damages. The option captures overland flows from the roadway in Redman Road and detains them in an underground tank. Further consideration needs to be given to the specific design to capture such a large volume of water. To capture sufficient flows for the system to be effective, a number of stormwater inlets would need to be constructed in the roadway. This design could result in a significant roadway redesign and construction and may impact on existing services such as water and sewer mains. These design and construction challenges could increase the estimated capital cost and the resultant economic feasibility of the option.

The Redman Road flood storage tank alone produces major flooding benefits on Pittwater Road, which is a State Government asset. Council does not have the budget available to implement this option independently. Representations have been made to the Roads and Maritime Services (RMS) and State Transit Authority (STA) to further discuss funding the feasibility investigations for Option 8.

7. Property Modification Options

Property modification options are measures which modify existing development or impose controls on future development to increase the flood resilience of properties. Examples of property modification options are:

- Voluntary house raising schemes;
- Voluntary purchase of highly flood affected properties;
- Flood proofing of existing development; and
- Land use planning and development controls

A number of property modification measures were investigated in the 2014 Dee Why South Catchment FRMS. Development in the Dee Why South Catchment has been long established and particularly in the lower catchment is characterised by unit development. This limits the ability of schemes such as voluntary house raising to be effective or widely implemented.

The region is characterised by higher than average property prices. In the catchment, the median house price is $924,000, and the apartment price is $538,000 (APM, 2014). In NSW, the median house price is $500,000 and apartment price is $511,000 (APM, 2014). This poses financial challenges in the implementation of any voluntary purchase of flood affected properties. Funding for voluntary purchase is limited with the NSW annual budget with funding assistance capped at $1 million across NSW. Further, to satisfy the grant funding requirements, any property considered for voluntary purchase must have no opportunity for evacuation or shelter in place.

7.1. Flood Proofing Guidelines

A number of the major roads in the Dee Why CBD are highly flood affected, such as Redman Road, Pittwater Road, Oaks Avenue and Howard Avenue. These roads include sections of retail development fronting the road. The ground floor level of this retail development is often at same level as the top of kerb and would be subject to significant overfloor flooding in a 100 yr ARI event. Further there are a number of existing basement car park entries with ramps set below the 100 yr ARI flood level which are vulnerable to flooding in a 100 yr ARI flood.

Flood proofing is able to reduce either the flooding experienced or damages incurred by existing development which would otherwise be subject to overfloor flooding. The 2014 Dee Why South Catchment FRMS investigated the benefits of preparing and disseminating flood proofing guidelines and noted that it could minimise structural and contents damage.

There is no current statutory requirement to encourage residents or businesses to flood proof their properties. The guidelines could be an attachment to Part E11 of the Warringah Development Control Plan –Flood Prone Land which will be reviewed in 2014/15 and 2015/16.

7.2. Planning Instrument Amendments

At present, flood mapping and the application of development controls in the Warringah LGA does not differentiate between flooding from mainstream or overland flow sources. As such, a standard 500 mm freeboard is applied throughout the Warringah LGA to define the Flood Planning Level (FPL) and to identify properties subject to the provisions of Clause 6.3 Flood Planning in the Warringah Local Environment Plan (WLEP) 2011.

As the drainage system throughout Dee Why is predominantly piped, it could be considered that the primary cause of the flooding is overland flows as opposed to overflows from creeks and watercourses (mainstream flooding).

In areas of the catchment where the PMF level is less than 500 mm higher than the 100 yr ARI flood level the application of a 500 mm freeboard, without consideration of local topography or buildings

can inappropriately identify properties as potentially flood affected without the presence of an actual flood risk.

The NSW Floodplain Development Manual (the Manual) Section C6 provides Councils with discretion in determining whether flooding is due to overland flow. The Manual subcategorises local overland flow into major and minor drainage, with major drainage typically involving water depths greater than 0.3 m (in the storm event used to derive Flood Planning Levels, typically the 100 yr ARI event). Herein major drainage is referred to as overland flow while local drainage is referred to as local runoff. The flood categories proposed for the Warringah LGA are described in Table 7.

Table 7 - Proposed Flood Categories

Flood	Streamflow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or flooding associated with overland flow before it enters a principal watercourse.	
	Mainstream flooding:	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a principal watercourse (which excludes those in a modified condition by being piped, channelised or diverted).
	Overland flow:	Inundation by runoff flowing across the land surface before it enters a principal watercourse. This includes areas where runoff exceeds the capacity of a piped drainage system or flows overland along alternative flow paths which do not follow the drainage lines. Land is considered to be flood affected if the flow depth is greater than 0.3 m or experiences high hazard* when the flow depth is greater than 0.15 m. (Equivalent to 'Major Drainage' in the Manual).
Local Runoff	Local runoff in urban areas generally poses little danger to personal safety. The depth of flow is generally less than 0.3 m and is low hazard. Land subject to local runoff is not considered to be flood affected. (Equivalent to 'Local Drainage' in the Manual).	

**as defined in the Manual*

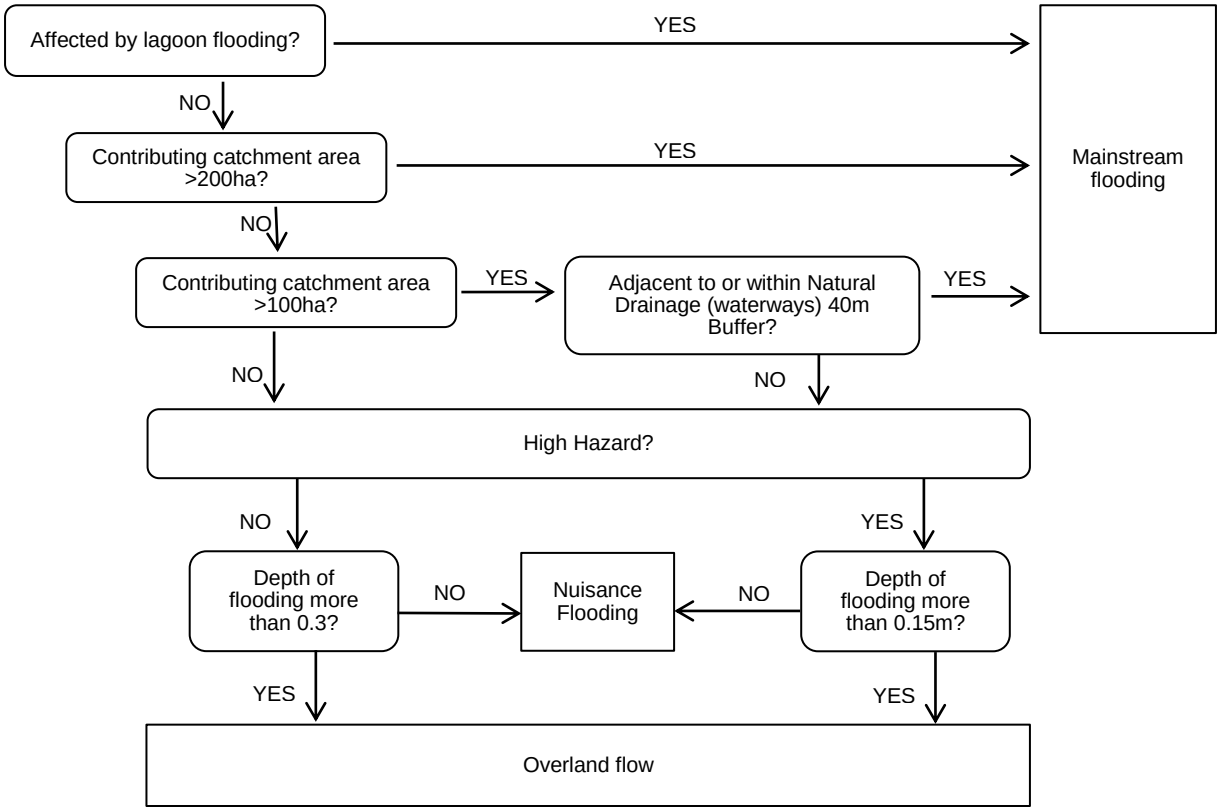

Figure 9 – Proposed flood categorisation process

In establishing flood categories for properties affected by flooding in the 100 yr ARI flood event, the decision-making process outlined in Figure 9 is proposed.

The entire Dee Why South Catchment, excluding the downstream lagoon waterbody, is less than 200 hectares. The only reach of the original open channel is between Victor Road and the western end of Redman Road; however the size of the upstream catchment from this channel is less than 100 hectares. When the above proposed flood categorisation process is applied all flood affected properties in the Dee Why South Catchment, excluding those adjacent to the lagoon, are categorised as subject to overland flows.

A number of recently completed Flood Studies have highlighted areas where the current flood risk planning precincts and related development controls are not appropriately defining and managing the flood risk. In 2014 Council staff investigated alternative approaches to define and manage flood risk, receiving input from the NSW Office of Environment and Heritage and external consultants. The State Government has confirmed that the proposed approach complies with the NSW Floodplain Development Manual, 2005.

The areas impacted by overland flow and mainstream flooding are outlined in Figures 5 and 6 respectively.

It is further recommended that Section E11 Flood Prone Land of *Warringah Development Control Plan* (WDCP) 2011 be amended as outlined in Table 8.

Table 8 – Proposed flood categories and required DCP amendments

Flooding Category	Definition	DCP Changes
Mainstream	• Upstream catchment more than 200ha or • Upstream catchment more than 100ha and within the Natural Drainage (waterways) 40m buffer layer	Medium Risk and High Risk Flood Planning Precincts will be amended to remove areas now classified as 'Overland Flow' and 'Nuisance Flooding'.
Overland Flow	• Upstream catchment less than 200ha and not within the Natural Drainage (waterways) 40m buffer layer • If high hazard depth of flooding more than 0.15m • If low hazard depth of flooding more than 0.3m	A new DCP flood risk planning precinct will be created for 'Overland Flow'. The flood related development controls outlined in Part E11 of the Warringah DCP
Nuisance	• If low hazard flooding with a depth less than 0.3m or • If high hazard flooding with a depth less than 0.15m	No flood related development controls will be applied to this category. Special provisions may be required for basement carpark development

8. Emergency Response Modification Options

Emergency response modification options aim to lower the consequences of flooding by modifying people's behaviour prior to and during a flood. Examples include a more flood resilient community, flood warning systems and improved emergency response arrangements.

8.1. Flood Warning Systems

The Northern Beaches Flood Warning System is a joint partnership between Pittwater, Warringah and Manly Councils in collaboration with the NSW OEH and the Bureau of Meteorology. As described in Millener et. al. (2013), the five-year objective is to develop a basic flash flood warning system for the region's community by the strategic installation of rainfall, water level and flow gauges. A publicly accessible webpage hosted by Manly Hydraulics Laboratory (MHL) (http://new.mhl.nsw.gov.au/users/NBFloodWarning/) is available to inform the public via real-time water level gauge data, provision of advice on flood trigger levels, and provision of advice on where flooding may be occurring. When trigger levels on selected gauges are exceeded the system sends an SMS to relevant personnel in the NSW SES, the Councils and/or the Roads and Maritime Services. The gauges are envisaged to provide data for many years and the effectiveness of the overall system is dependent on the community receipt of and their response to warning messages.

The current warning system and the associated webpage could be enhanced as discussed below.

The NSW SES together with Manly, Warringah and Pittwater Councils, developed the Northern Beaches Flood and Coastal Storms Education Strategy in 2012. A survey of residents undertaken during the preparation of this strategy identified that residents would prefer that specific warning messages be disseminated directly to them via SMS messages and/or by door knocks by the NSW SES. SMS messages are used by other agencies as it is considered effective to warn at risk residents of potential danger. Appropriate trigger levels (such as rainfall depths and Lagoon levels) for issuing of alerts will need to be formulated to provide warnings to at risk residents in flood affected locations. MHL have advised that while their warning system is able to provide such warnings the current trigger levels are based on initiating decisions on the management of the Dee Why Lagoon entrance not for issuing flood warnings.

A second potential improvement is that although there IP telemetry is supported by most of the gauges and older gauges are in the process of being upgraded, the data is still received by MHL's servers where it is uploaded onto the webpage. This often creates around a 30 minute delay between the time when rainfall is recorded and its availability on the webpage. In a flash flood environment such as the Northern Beaches, this is too long to provide any timely flood warning.

Regular maintenance and monitoring of the gauges and system is also required to ensure it is functioning correctly and that any breakdown in the gauges or failure of the telemetry is quickly corrected.

The existing gauge readings could be combined with live vision from webcams mounted in key locations, such as the Dee Why Lagoon entrance. This will enable remote monitoring and thus more regular checking of the conditions prior to the initiation of specific management actions such as opening the lagoon entrance. These potential improvements will be examined at the end of the current contract period in 2017.

8.2. Public Awareness and Flood Education

A community that is aware of the risk and consequences of flooding can prepare for and respond to a flood event more effectively. The single largest factor determining whether a community is flood aware is the frequency of flood events in the recent history of the area. Due to the absence of major flooding in Dee Why within the last 50 - 60 years, flood education must be a purposeful activity to help build a more resilient community.

As identified in the 2008 NSW State Flood Plan the NSW SES has responsibility to:

> "Prepare, coordinate and deliver awareness and educational materials and programs regarding flooding."

This highlights that flood education and building a more flood resilient community is not the sole responsibility of one agency or organisation. A collaborative approach is needed to ensure that during times of little or no flooding that new community members as well as the existing community are aware of the flood risk and the mitigation activities that will help reduce the consequences of flooding.

In the spirit of a collaborative approach, the NSW SES, Manly, Warringah and Pittwater Councils developed the Northern Beaches Flood and Coastal Storms Education Strategy in 2012. The strategy has been developed to outline a plan for the agencies to raise awareness of the mechanism and potential impacts of natural hazards and encourage appropriate emergency response behaviours. It lists a series of actions to be undertaken by the organisations within the 2012-2016 period.

The actions identified in the Strategy have been implemented individually or in isolation which encourages an ad-hoc approach to community education. A more effective approach would be to develop a holistic education campaign that is rigorously planned and which identifies the resources (both staff and financial) required to implement the campaign. It also needs to identify the objectives and how the education campaign will be evaluated against those objectives. The Micromex survey which was undertaken prior to the development of the 2012 Strategy identified hazard 'appetite' through awareness of various parameters. Future surveys need to be designed to include questions which assess baseline scenarios relating to an objective, follow up surveys can then attempt to assess the effectiveness of the education campaign.

8.3. Information transfer to the NSW SES

The Local Flood Plan for the Northern Beaches which covers the Manly, Warringah and Pittwater LGAs has not been finalised. Information from this Plan and the preceding 2014 Floodplain Risk Management Study and 2013 Flood Study needs to be transferred to the NSW SES to assist in finalising the Local Flood Plan.

The Northern Beaches Councils will continue to meet quarterly with the NSW SES – Sydney Northern Region to provide technical data determined through the Floodplain Risk Management Process.

9. Implementation Program

The implementation program essentially forms the action list for this Plan.

The benefit of following this sequence is that gradual improvement of the floodplain occurs, as the funds become available for implementation of these measures.

Further steps in the floodplain management process from this point forward are:

1. Floodplain Management Committee to consider and adopt recommendations of this Plan;
2. Council to consider the Floodplain Management Committee's recommendations;
3. Council to adopt the Plan and submit an application for funding assistance to NSW OEH and other agencies as appropriate; and
4. As funds become available from NSW OEH, other state government agencies and / or Council's own resources, implement the measures in accordance with the established priorities.

This plan should be regarded as a dynamic instrument requiring review and modification over time. The catalysts for change could include new flood events and experiences, legislative change, alterations in the availability of funding and reviews of Council planning policies. In any event, a review every five years is warranted to ensure the ongoing relevance of the Plan.

The Plan is outlined in Table 9, with a priority ranking for all selected options.

Each option is classified in one of four categories:

- High priority
- Medium priority
- Low priority
- Ongoing action

This classification of the options will affect the staging of their implementation, with high priority actions likely to be investigated further as an immediate priority, whereas medium and low priority actions will be implemented depending upon budgetary and resource constraints.

Ongoing actions are actions which will start/continue on a regular recurring schedule.

Table 9 – Implementation program for actions identified in the Plan

Option	Description	Estimated cost		Priority
		Capital	Annual	
Increase drainage capacity in Oaks Avenue	A large diameter pipe is proposed to run the length of Oaks Avenue, connecting into the main box culvert opposite 33 Oaks Avenue.	$1,158,473*	$1,900	High
Underground storage tank/s at Redman Road	Tank/s would be located along the main overland flow path in Redman Rd and would require large underground pits to intercept flow upstream of the tank. Design and construction challenges could significantly increase the estimated capital cost.	$3,014,900*	$21,000	High
Planning instrument amendments	Amend Part E11 of the Warringah Development Control Plan to include separate classifications and development controls for mainstream flooding and overland flow	N/A	N/A	High
Public awareness and education	Review Northern Beaches Flood and Coastal Storms Education Strategy at the end of the current Strategy period (2012-2017)	$0	$5,000	High
Flood Warning System	At the end of the current contract (2017) review potential actions: - Live webcam streaming of lagoon entrances for entrance management - Potential for public opt-in to lagoon water level text messages - Improve speed of data publication on webpage and review reliability of system and potential improvements	$30,000	$7,000	High
Information transfer to the SES	Quarterly meetings to be held between Northern Beaches Councils and NSW SES Sydney Northern region to transfer data obtained through the floodplain risk management process.	N/A	N/A	Ongoing
Flood proofing guidelines	Seek funding assistance from the NSW Office of Environment and Heritage to prepare flood proofing guidelines. Amend the DCP to create a statutory requirement for existing premises undergoing interior development.	$15,000	$1,500	Low
Event Data Collection	Routine data collection following a flood event	$5,000	$5,000	Ongoing

*The costs for the floodplain management options are preliminary estimates based upon a concept design and include the physical estimate of the works. The estimates do not include costs of design, approvals, project management and contingency. Following detailed design it is likely that the project cost will differ from that outlined above.

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