ATTACHMENT C

WOOLLOOMOOLOO CATCHMENT
FLOODPLAIN RISK MANAGEMENT STUDY
(DRAFT REPORT)

WOOLLOOMOOLOO CATCHMENT FLOODPLAIN RISK MANAGEMENT STUDY

DRAFT

DECEMBER 2015

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Project Woolloomooloo Catchment Floodplain Risk Management Study	**Project Number** 114014
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WOOLLOOMOOLOO CATCHMENT FLOODPLAIN RISK MANAGEMENT STUDY

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FOREWORD

The NSW State Government's Flood Policy provides a framework to ensure the sustainable use of floodplain environments. The Policy is specifically structured to provide solutions to existing flooding problems in rural and urban areas. In addition, the Policy provides a means of ensuring that any new development is compatible with the flood hazard and does not create additional flooding problems in other areas.

Under the Policy, the management of flood liable land remains the responsibility of local government. The State Government subsidises flood mitigation works to alleviate existing problems and provides specialist technical advice to assist Councils in the discharge of their floodplain management responsibilities.

The Policy provides for technical and financial support by the Government through four sequential stages:

1. ***Flood Study***
   - Determine the nature and extent of the flood problem.
2. ***Floodplain Risk Management***
   - Evaluates management options for the floodplain in respect of both existing and proposed development.
3. ***Floodplain Risk Management Plan***
   - Involves formal adoption by Council of a plan of management for the floodplain.
4. ***Implementation of the Plan***
   - Construction of flood mitigation works to protect existing development, use of Local Environmental Plans to ensure new development is compatible with the flood hazard.

The Draft Woolloomooloo Catchment Floodplain Risk Management Study and Draft Plan constitute the second and third stages of this management process. This study has been prepared by WMAwater for City of Sydney (Council) under the guidance of Council's floodplain management committee (Committee). This study provides the basis for the future management of those parts of the Woolloomooloo catchment which are flood liable and within the City of Sydney Local Government Area.

1. INTRODUCTION

1.1. Study Area

The Woolloomooloo catchment is located in Sydney's inner city suburbs of Potts Point, Darlinghurst, Sydney, Surry Hills and Woolloomooloo, and is shown on Figure 1. The catchment lies within the City of Sydney Local Government Area (LGA) and has been extensively developed for urban usage. It covers an area of approximately 160 hectares and drains to several points in Woolloomooloo Bay, with a pit and pipe network draining the area, complemented by overland flowpaths, mostly along roads, when the pipe drainage is at capacity. A number of locations in the area are flood liable, mainly as a result of the area's topography which includes several unrelieved depressions and buildings located on overland flowpaths. This creates a significant drainage/flooding problem in many areas in the catchment. Detailed description of the study area is given in Section 2.1.

1.2. The Floodplain Risk Management Process

As described in the Floodplain Development Manual (Reference 1), the floodplain risk management process is formed of sequential stages:

- Data Collection;
- Flood Study;
- Floodplain Risk Management Study;
- Draft Floodplain Risk Management Plan; and
- Plan Implementation.

The first two key stages of the process have been undertaken with the completion of the Draft Woolloomooloo Flood Study (Reference 2). Following this, the Floodplain Risk Management Study and Plan (FRMS&P) are undertaken for the catchment in two phases:

Phase I – Floodplain Risk Management Study in which the floodplain management issues confronting the study areas are assessed, management options investigated and recommendations made. The objectives for this phase include:

- Review the Woolloomooloo Flood Study (2013) and update hydraulic model;
- Identify additional floor level survey requirements;
- Review Council's existing environmental planning policies and instruments, identify modifications required to current policies;
- Identify residential flood planning levels;
- Identify and assess works, measures and controls aimed at reducing the impacts and losses caused by flooding and consider their impacts if implemented, taking into account the potential impacts of climate change; and
- Review the local flood plan, examine the present flood warning system, community flood awareness and emergency response measures (involvement with the NSW State

Emergency Service).

Council has provided specific objectives for the investigation of flood mitigation options for flood affected streets and areas as identified in the current Flood Study.

Phase II – Draft Floodplain Risk Management Plan which is developed from the floodplain risk management study and details how flood prone land within the study areas is to be managed moving forward. The primary aim of the Plan is to reduce the flood hazard and risk to people and property in the existing community and to ensure future development is controlled in a manner consistent with the flood hazard and risk at this time and as a result of climate change. The Plan consists of prioritised and costed measures for implementation.

1.3. Relevant Studies

Limited studies have been undertaken regarding flooding and stormwater in the Woolloomooloo catchment. An assessment of the stormwater capacity was carried out in 1996 and is summarised here, as well as the recent flood study.

1.3.1. City Area SWC 30 Capacity Assessment July 1996

This report (Reference 3) was prepared by SWC and investigated the performance of City Area SWC 30, which includes the Woolloomooloo Bay Subgroup, and gives an estimate of the impact of potential urban consolidation on that performance.

The study included detailed land investigations of both the hydraulic capacity of SWC's trunk drainage system as well as future land use potential.

The drainage data used for the study included the SWC trunk drainage system only and the analysis was undertaken using a spreadsheet based on:

- Urban rational method for inflows (ARR, 1987);
- Approximate capacities of pipes based on grade and area;
- Approximation of channel capacities using Manning's "n" formula and methods for composite roughness and compound sections; and the
- Hydraulic Grade Line Method

The hydraulic capacity of the Woolloomooloo Bay catchment is summarised in Table 1. Little hydraulic and hydrologic detail was available for the Domain as relevant analysis was not included in the report. The study is useful for determination of system capacity and locations for trunk drainage upgrades; however, as it does not define the overland flood hazard in the catchment, the impact of any trunk drainage improvement is unable to be assessed.

Table 1: Drainage Capacity, SWC Capacity Assessment

Sub system	System (km)	Percent Rated	Percent Satisfying, ARI of				
			2 yr	5 yr	10 yr	20 yr	100 yr
Domain	0.03	0%					
Sir John Young Crescent	0.94	60%	100%	18%	0%	0%	0%
Hospital Road	0.84	100%	100%	100%	100%	100%	36%
Woolloomooloo East	3.99	63%	73%	66%	51%	50%	14%
Woolloomooloo West	8.22	49%	57%	43%	39%	31%	15%
McElhone Street	0.26	69%	46%	62%	62%	62%	9%
Victoria Street	1.95	55%	40%	40%	40%	21%	1%
WOOLLOOMOOLOO BAY	16.23	57%	66%	53%	46%	40%	14%

Catchment performance results indicate that Sir John Young Crescent and Victoria Street catchments were the most under serviced (re: drainage capacity) and potentially the most at risk of flooding with 0% and 21% of the piped system with a 20 year ARI capacity respectively.

1.3.2. Draft Woolloomooloo Flood Study, WMAwater, July 2013

This flood study was carried out as part of the Floodplain Risk Management Programme to define existing flood behaviour for the Woolloomooloo catchment in terms of flood levels, depths, velocities, flows and extents. The mechanisms of flooding examined in this study include local overland flow as well as backwater flooding from receiving waters. A 1D/2D TUFLOW hydraulic model was used in conjunction with a DRAINS hydrologic model. The model was calibrated to one event (February 2010) and verified against historical flooding at eight locations across the catchment. The study defined flood behaviour for the 2, 5, 10, 20, 50 and 100 year ARI flood events as well as the PMF. Preliminary hazard and hydraulic categories were determined for the 10, 20 and 100 year ARI flood events and the PMF. Several flooding hotspots were also identified in the study. A floor level survey and damages assessment were carried out, of which the latter identified 160 properties (106 residential, 54 commercial) that would be flooded above floor level in a 100 year ARI event.

The study found that the widespread flood liability in the study area is a result of extensive development (filling of the floodplain and blocking of flow paths) in conjunction with pervious surfaces converted to impervious surfaces. Localised depressions in roads were found to collect excess overland flow and to not be able to effectively be drained by either subsurface drainage or above ground flow paths.

The study identified a number of hotspots and made a preliminary assessment of their flood affectation, including a breakdown of overland and pipe flow in each hotspot across a range of events. The hotspots are shown on Figure 2 and were as follows:

1. Stream Street in Darlinghurst
2. Busby Lane in Woolloomooloo
3. Crown Street near Bossley Terrace in Woolloomooloo
4. Palmer Street at its north end in Woolloomooloo
5. Bourke Street at its south end in Woolloomooloo
6. Victoria Street near Orwell Street in Potts Point

The study also considered the potential effects of climate change by modelling rainfall increases of 10, 20 and 30% on the 1% AEP flood event. Generally speaking, each incremental 10% increase in flow results in a 0.02 m to 0.05 m increase in peak flood levels at most of the locations analysed. A 30% increase in rainfalls would therefore not exceed the typical freeboard for most residential properties.

The key outcomes of the Flood Study which are to be discussed, considered or managed in this Study and Plan are:

- The areas identified as being flooding hot spots;
- Establish the "true" hydraulic category and hazard definitions;
- Identify mitigation measures to address the adverse impacts of new developments; and
- Identify risk management measures to reduce flood costs to properties within the catchment by either structural or non-structural measures.

1.3.3. Woolloomooloo Flood Study Review and Update

The draft Woolloomooloo Flood Study (Reference 2) was reviewed as part of this Management Study, to incorporate any recent changes to the catchment which had occurred. Three minor updates were made. Firstly, the recently developed apartment complex at 62 Sir John Young Crescent was added to the model. This development replaces a previously vacant lot, and has a minor effect on design flood levels on Sir John Young Crescent in the vicinity of the building.

Secondly, the inverts of several nodes along the trunk drainage line were re-estimated using updated interpolation techniques (no invert data was available). The amendment caused minor localised impacts of between ±0.05 m in the 1% AEP event at various locations in the catchments.

Thirdly, the topographical representation of Victoria Street in the hydraulic model was updated based on recently acquired survey data. This survey data included cross-sections of the street, including the footpaths, the kerb/gutter height and the road elevation. The survey points were tinned and replaced the ALS data previously used in the area, which had been flagged in the flood study as having quality issues, due to the trees and buildings distorting the ground representation. It was found that previously undertaken quality control measures on the ALS data had produced a generally accurate representation and that the survey data only made minor refinements to this.

Finally, a small change to building outlines was made. This was on Earl Street where community questionnaire responses indicated flow passed through properties, where previously the houses were schematised as completely obstructing the flow. The impacts of flood levels around the change were minimal.

2. CATCHMENT CHARACTERISTICS

2.1. Study Area

The Woolloomooloo catchment is located in the City of Sydney LGA and includes the suburbs of Potts Point, Darlinghurst, Sydney, Surry Hills and Woolloomooloo. The catchment is fully developed and consists of medium to high-density housing and commercial development with some large open spaces that include Hyde Park, Sandringham Gardens, Fragrance Garden, The Domain Park, the Royal Botanic Gardens, Daffodil Park and a number of other smaller parks.

The catchment covers an area of approximately 160 hectares, all of it draining to SWC's major trunk drainage systems (known as SWC 30) taking flows from the upper regions of the catchment to Sydney Harbour at Woolloomooloo Bay. Drainage of the catchment occurs via pits, pipes and overland flowpaths (predominantly roads). Ownership of the pipe system is mixed with larger pipes in the catchment (also known as the trunk drainage system) owned by SWC. The trunk drainage system is linked to Council's local drainage system consisting of covered channels, in-ground pipes, culverts and kerb inlet pits. When these systems reach capacity, flow cannot enter the subsurface network and passes overland along streets and any other open space. The drainage system is shown on Figure 3.

The topography of the catchment is steep with the greatest relief occurring at the top of the catchment which begins at Oxford Street at elevations of around 55 mAHD. At several locations in the catchment there are sharp drops including adjacent to Victoria Street where the elevation can drop by up to 20 metres towards Brougham Street. Generally the upper catchment areas have grades of approximately 2% to 4%. Grades reduce to approximately 1% north of William Street and closer to Woolloomooloo Bay, north of Harmer and Best Streets, the ground surface slope is closer to 0.5%.

A number of locations within the catchment are flood liable. This flood liability mainly relates to the nature of the topography within the study area as well as the capacity of service provided by drainage assets. Urbanisation throughout the catchment occurred prior to the installation of road drainage systems in the 1900s and many buildings have been constructed on overland flow paths or in unrelieved sags. Due to these drainage restrictions, topographic depressions can cause localised flooding as excess flows have no opportunity to escape via overland flow paths. This creates a significant drainage/flooding problem in many areas throughout the catchment.

Any future development in the area is likely to be in the form of urban consolidation, with aggregation of individual lots creating high density residential developments. An example of this is the recently completed apartment complex at 68 Sir John Young Crescent.

2.1.1. Land Use

The land use zones as identified in the Sydney LEP 2012 are shown in Figure 4. The land usage within the study area is predominately urban residential and mixed residential/commercial, with some parkland on the western boundary of the catchment. Residential land in the area is predominately two-storey terrace houses, interspersed with apartment buildings. A number of parks used as recreational space are scattered throughout the area, with many less than 1 hectare in size. Commercial land use in concentrated along William Street, which has a number of high rise buildings, and Victoria Street and Darlinghurst Road in Kings Cross. Cook and Phillip Park, The Domain and the Botanic Gardens lie on the western boundary of the catchment, which are predominantly open, grassed area, as well as some sporting fields and other facilities.

2.1.2. Social Characteristics

Understanding the social characteristics of the area can help in ensuring that the floodplain risk management practices adopted are aligned with the communities at risk. For example, 'stable' communities (characterised by a high proportion of homeownership and low frequency of residents moving into or out-of the area) are more like to have a better understanding of the flood risks within the area.

Social characteristic data were obtained from the 2011 census (http://www.abs.gov.au/) for the study area. The census data shows that a significant number of households speak a language other than English at home (17-19%), for example French (1.9%) and Vietnamese (1.8%), which should be considered when organising flood awareness education or when issuing evacuation orders. The data also shows that a large number of people moved to the area within the 5-year period prior to the census at around 37-38% of the residents, and around 70% of residents are staying in a rented property. This suggests a high frequency of change of residents in the area, which may indicate a need for more frequently occurring flood awareness/community education programmes.

The catchment has a small dwelling size of only 1.7 people, and a high portion of single person dwellings (49.3% compared to the NSW average of 24.2%). This may need to be considered in any evacuation planning as it could indicate a higher than usual number of properties relative to population. There is also a small average number of motor vehicles per dwelling, with 46% of households having no motor vehicles (compared to a NSW average of 10.4%), which might also need to be considered in any assumptions regarding evacuation routes (i.e. that they should be traversable by foot rather than vehicle as due to the small proportion of vehicle owners in the catchment).

Demographically, the catchment has a lower than average portion of greater than 65 year olds (10.2% compared to 14.7% for NSW), and a lower than average portion of under 14 year olds (6.4% compared to 19.2% for the state), which suggests demographics shouldn't have a significant influence on the consideration of mitigation measures.

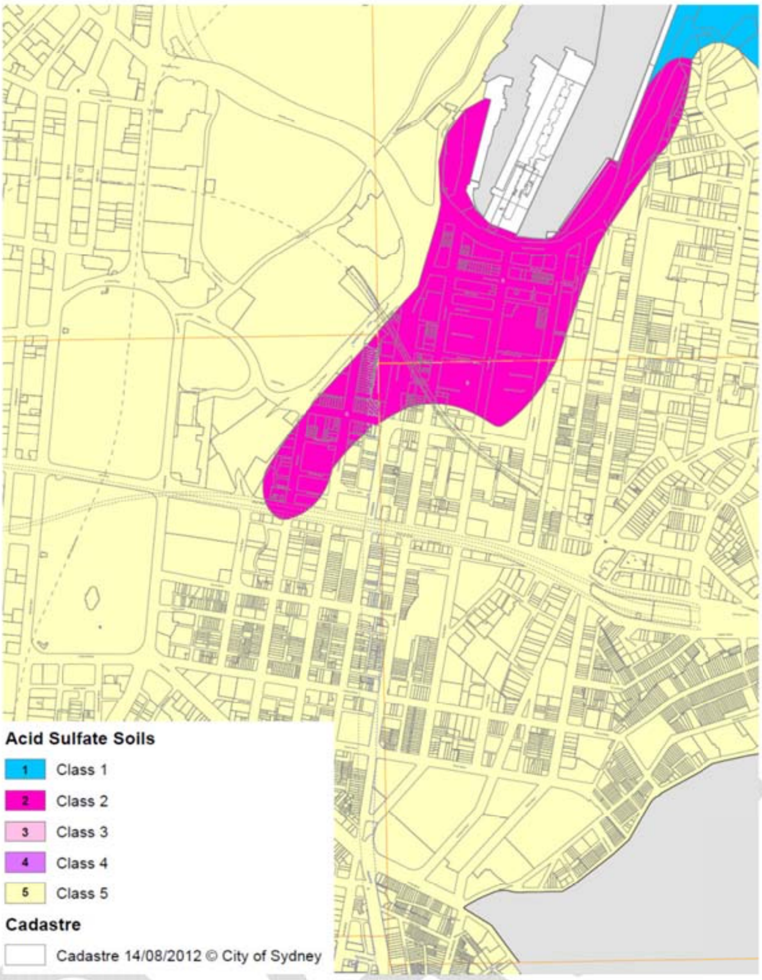
The suburb of Woolloomooloo has one of NSW's highest concentrations of homeless people, some of whom use public space that can be flood affected. Although homelessness is hard to quantify and measure, and can therefore not be afforded the same form of analysis that is given to other residents, any mitigation measures assessed by this study shall include consideration the use of public space as temporary or semi-permanent accommodation for homeless people.

2.1.3. Environmental Features

The natural environment in the Woolloomooloo catchment is limited to the trees in the area, as well as the limited park land. When considering environmental issues associated with flooding, focus is typically given to ecosystems located around a catchment's watercourses. In this catchment, there is no such watercourse, or associated ecosystems, as the drainage system is completely man-made. With respect to trees in the catchment, City of Sydney aspires to protect and expand the LGA's urban forest. This includes a list of protected Significant Trees, of which the London Plane trees on Victoria Street are listed. Mitigation measures assessed by this study will consider the value that is placed upon trees in the catchment when there is a potential impact.

Other environmental features of interest in the catchment are;

- The catchment is classified as a general conservation area with a number of conservation buildings identified. No aboriginal heritage sites have been identified in the catchment
- there are no Record of Notices of contaminated land in the catchment area
- The majority of the Woolloomooloo catchment has an Acid Sulphate Soils classification of 5 (works within 500m adjacent of an area classified 1 -4 and likely to reduced groundwater levels by 1m or more are likely to present an environmental risk), while there is also a significant area adjacent to the bay which is classed as 2 (any works undertaken in this area below the natural ground surface are likely to present an environmental risk). Maps of the Acid Sulphate Soils classification have been taken from the Sydney LEP (Reference 5) and are presented here.



Sheets ASS_015 and ASS_015 from Sydney LEP 2012

2.1.4. Historical Flood Events

In examining the flooding history it must be noted that the drainage characteristics of the catchment have been significantly altered as a result of urbanisation over the past 100 years. This includes construction of rail, road and drainage infrastructure that are likely to have had significant impacts on drainage behaviour. In recent times, construction of the Eastern Suburbs railway line to Bondi Junction and the Eastern Distributor road network have been major factors.

Frequent flooding including over floor inundation of some businesses and residences occurs in areas of the catchment including along Victoria Street, Stream Street, Crown Street and Dowling Street to the south of the railway viaduct. Flooding in many cases appears to be due to sags (localised depressions in roads) which trap overland flow and are unable to be effectively drained by overland flow paths. In other locations development has impeded natural overland flow paths and this has caused issues. One such example is Victoria Street. Flow, particularly from Orwell Street, used to fall off the cliff (due west) towards Brougham Street but is now diverted down Victoria Street, causing inundation of private properties and representing a significant hazard to pedestrians.

There have been many instances of flooding in the past with 8-9 November 1984, 5 August

1986, 10 April 1998 and 12 February 2010 being some of the most significant storm events recorded as causing extensive flooding throughout the catchment. During the 1980s it was reported that floodwaters were deep enough that cars were floating down Crown Street. However, at some locations, in Victoria Street for example, overfloor flooding of private property seems to occur on an annual to bi-annual basis.

During the public exhibition period feedback was provided by Victoria St residents in regard to a significant event which occurred on August 24th 2015. Information in regard to this event is provided in Section 4.4.

2.1.5. Early Catchment Conditions

The drainage features of the catchment reflect the location of the natural watercourse and shoreline that existed prior to urbanisation of the area. That is, the catchment's main trunk drainage line is located along a natural topographic depression, which contained a creek in the 19th century. In the 19th and 20th centuries, the area was developed with increasing density, and this creek was filled in and replaced with subsurface drainage. Similarly, the flat topography of the area south of Cowper Wharf Road is a result of reclamation works that enlarged Woolloomooloo.

Figure 5 shows the area's creeks as they were recorded on the 'Riley Estate' map (dated 1844), overlaid on the current 5% AEP peak flood depth. The figure shows that the main concentrations of flow are where creeks used to exist in the catchment, and where land has been reclaimed.

3. EXISTING FLOOD ENVIRONMENT

The existing flood risk for the Woolloomooloo catchment is defined by the design flood affection in the Flood Study (Reference 2). The design flood information is then used to determine the Hydraulic categories, Hazard classification and the Flood Emergency Response categories (the latter is detailed in Section 6.4). It also enables the identification of any key flood risk areas or 'hotspots' in the catchment. An overview of the previously undertaken climate change analysis is also given.

3.1. Hydraulic Categories

The 2005 NSW Government's Floodplain Development Manual (Reference 1) defines three hydraulic categories which can be applied to different areas of the floodplain; namely floodway, flood storage or flood fringe. Floodway describes areas of significant discharge during floods, which, if partially blocked, would cause a significant redistribution of flood flow. Flood storage areas are used for temporary storage of floodwaters during a flood, while flood fringe is all other flood prone land.

There is no single definition of these three categories or a prescribed method to delineate the flood prone land into them. Rather, their categorisation is based on knowledge of the study area, hydraulic modelling and previous experiences. Based on analysis of similar catchments, as well as literature review (Reference 8), the Flood Study (Reference 2) defined hydraulic categories as:

Floodway:		Velocity x Depth > 0.25 m^2/s AND Velocity >0.25m/s
	OR	Velocity > 1m/s
Flood Storage:		Land outside the floodway where Depth > 0.2m
Flood Fringe		Land outside the floodway where Depth < 0.2m

The hydraulic categories for the 5% AEP, 1% AEP and PMF events are shown on Figure 7 to Figure 9. In the 5% AEP event there is a significant flood storage area on Stream Street and Riley Street, Crown Street, Busby Lane and Palmer Street.

Areas of floodway in the catchment are not well delineated in frequent events, as the urbanised nature of the catchment means flow does not naturally accumulate into well-defined flowpaths. In the 5% AEP event, there is a floodway down Riley Street, which turns at Cathedral Street and then onto Palmer Street via Crown Street and Bossley Terrace. In the 1% AEP event, there are prominent floodways along many streets in the catchment, as nearly all runoff is flowing overland and not in the stormwater network.

3.2. Flood Hazard Classification

Flood hazard is a measure of the overall adverse effects of flooding and the risks they pose. The 2005 NSW Government's Floodplain Development Manual (Reference 1) describes two *provisional flood hazard* categories; High and Low, based on the product of the depth and velocity of floodwaters. These hazard categories do not consider other factors which may influence the flood hazard (Figure L2 of the Floodplain Development Manual); hence they are provisional estimates only with “true” hazard to be defined through the process of the current study. The boundary of the provisional High and Low hazard classification will change according to the magnitude of the flood in question.

Provisional hazard was established as part of the Flood Study (Reference 2) based on the Floodplain Development Manual criteria (Appendix L of the Floodplain Development Manual). Due to the combination of high flood depths and velocities, many regions of the catchment are affected by high hazard flows. Figure 10 to Figure 17 show the flow hazard classification throughout the catchment for the 50%, 20% 10%, 5%, 2%, 1% AEP and PMF events. As shown in the figures, in frequent events high hazard is limited to those areas identified as hotspots, for example Stream Street and Crown Street. These areas have hazardous depths of inundation, with more than a metre in Stream Street, which is relatively unused as a thoroughfare and has minimal residential frontage, whereas Crown Street has vehicle and pedestrian traffic and a number of residential properties.

Areas of high hazard are most prominent along the western trunk drainage line, approximately between Stream Street and the north end of Palmer Street. This section of high hazard, which is well defined in the 1% AEP event, is comprised of both hazardous depths (greater than 1 m) in unrelieved depressions and steeper roads with hazardous velocities (greater than 2 m/s), or a combination in large floods. In relatively frequent flood events, the areas of high hazard depth are Stream Street, which has close to 3 m of depth in a 50% AEP event, Busby Lane (1 m in the 50% AEP).

In a 1% AEP event, areas of high hazard are still quite limited, with the aforementioned Busby Lane and Stream Street areas, as well as:

1. Riley Street, which has over 1 m depth upstream of William Street, and shallower depths (less than 0.3 m) but high velocities (around 2 to 3 m/s) downstream of William Street, where there is a steep gradient.
2. Crown Street, which has around 1 m of depth.
3. Cathedral Street, which has around 0.5 m of depth and velocities of up to 2.5 m/s.
4. Palmer Street, which has depths of 0.5 to 1.5 m and velocities of up to 2 m/s.

To assess the true flood hazard, all adverse effects of flooding have to be considered. This includes the provisional (hydraulic) hazard, threat to life, danger and difficulty in evacuating people and possessions and the potential for damage, social disruption and loss of production including those detailed in Table 2. The classification is a qualitative assessment, which results in two categorisations:

High Hazard *- an area or situation where there is possible danger to personal safety, evacuation by trucks is difficult and able-bodied adults would have difficulty in wading to safety. There could also be potential for significant structural damage to buildings.*

***Low Hazard** - people and possessions can still be evacuated by trucks if necessary and able-bodied adults would have little difficulty wading to safety.*

Table 2: Hazard Classification

Criteria	Weight [1]	Comment
Size of the Flood	Medium	Relatively low flood hazard is associated with more frequent minor floods while the less frequent major floods are more likely to present a high hazard situation.
Depth & Velocity of Floodwaters	High	The provisional hazard is the product of depths and velocity of flood waters. These can be influenced by the magnitude of the flood event.
Rate of Rise of Floodwaters	Medium	Rate of rise of floodwaters is relative to catchment size, soil type, slope and land use cover. It is also influenced by the spatial and temporal pattern of rainfall during events.
Duration of Flooding	Low	The greater the duration of flooding the more disruption to the community and potential flood damages. Permanent inundation due to sea level rise is of indefinite duration.
Flood Awareness and Readiness of the Community	Medium	General community awareness tends to reduce as the time between flood events lengthens and people become less prepared for the next flood event. Even a flood aware community is unlikely to be wise to the impacts of a larger, less frequent, event.
Effective Warning & Evacuation Time	Medium	This is dependent on rate at which waters rise, an effective flood warning system and the awareness and readiness of the community to act.
Effective Flood Access	Medium	Access is affected by the depths and velocities of flood waters, the distance to higher ground, the number of people using and the capacity of evacuation routes and good communication.
Evacuation Problems	Low	The number of people to be evacuated and limited resources of the SES and other rescue services can make evacuation difficult. Mobility of people, such as the elderly, children or disabled, who are less likely to be able to move through floodwaters and ongoing bad weather conditions is a consideration.
Provision of Services	Low	In a large flood it is likely that services will be cut (sewer and possibly others). There is also the likelihood that the storm may affect power and telephones. Permanent inundation from sea level rise may lead to permanent loss of services.
Additional Concerns	Low	Floating debris, vehicles or other items can increase hazard. Sewerage overflows can occur when river levels are high preventing effective discharge of the sewerage system.

[1] Relative weighting in assessing the hazard for the Woolloomooloo catchment

The concept of rate of rise of flood waters is more applicable to mainstream flooding scenarios, where a fast rate of rise can leave residents unaware of the flood event, and they can become stranded. However, the rate of rise in this catchment is fast (up to 1-1.5 m/hour in the 5% AEP and 2 m/hour in the 1% AEP) and flood prone areas will become inundated soon after the rainfall event begins. If evacuation is required in the catchment, the fast rate of rise will likely mean it is undertaken after the peak flood level.

Flood awareness in the community appears to be moderate, with 60% of questionnaire respondents aware of flooding in the catchment (Reference 2) (this is likely to exaggerate the awareness, as aware residents are presumably more likely to respond). Given that only 5% of those surveyed responded, the confidence interval on the estimate is around 15% (i.e. the number of aware respondents is likely between 45 and 75%). The estimate is also complicated by the bias in the respondents, with those residents who are aware of flooding more likely to respond. Although it may be assumed that frequently flood-affected properties are aware of flooding, the high number of renters in the area means this awareness could too be exaggerated. Experience in similar urban catchments indicates residents are generally sceptical of the possibility of large floods and therefore may not ascribe the appropriate level of risk to floodwaters when they are encountered.

Effective warning and evacuation time in the catchment is relatively low, as the flooding is likely to be sudden, with a fast rate of rise For a resident without additional warning or forecast, flood events will initially resemble more benign (but still heavy) storms, with awareness of the flood coming from direct experience of it. However, effective access, which refers to an exit route that remains trafficable for sufficient time to evacuate people and possessions, is likely to be available to the majority of affected residents, as the flood extents are not wide. The areas where access is an issue are those areas identified as having high hydraulic hazard, shown on Figure 15 for the 1% AEP event. The vehicular and pedestrian access routes are all along sealed roads and present to unexpected hazards if the roads have been adequately maintained.

At depths of 0.3 m wading should be possible for most mobile adults. This obviously could be more of an issue for children, elderly or disabled people. The majority of flood prone properties in the catchment do have access with flood depths of 300mm or less. Areas that do have depths of 300 mm or more in the 1% AEP include:

- Stream Street, Yurong Street and Riley Street just south of William Street
- Crown Street and Bossley Terrace between Cathedral Street and Sir John Young Crescent
- Cathedral Street west of Crown Street
- Palmer Street north of Cathedral Street
- Harmer Street off Bourke Street
- Bourke Street north of Harmer Street
- Parts of Wilson Street, Dowling Street and Bland Street near Cowper Wharf Road
- Parts of Victoria Street, near Orwell Street

At a depth of 300 mm, larger vehicles can easily travel through water and aid evacuation. Nevertheless, for areas within the catchment without effective flood access, evacuation is generally not recommended considering the short duration of flooding experienced as residents are more likely to put themselves in harm's way by evacuating.

The impact of debris is unlikely to be a significant factor due to the low flood depths and/or velocities for large parts of the catchment. It would impact the time of inundation as waters would take longer to recede, however as the duration of the flooding is generally short across the catchment this is not considered significant. Figure 18 shows the length of inundation taken at each of the drainage pit inlets in the 1% AEP, 1 hour event. This shows that the duration of flooding is typically less than 1 hour except in the known trapped depressions (such as on Stream Street, Busby Lane, Crown Street, Bourke Street etc.) where it may take a few hours to drain, assuming the piped network is operating efficiently (i.e. without blockages).

3.3. Hotspots

Hotspots in the area are defined as those locations where there is a known flood issue. They are identified by considering accounts of previous floods, and by examining the flood behaviour as defined by the flood study. The latter involves identifying areas that exhibit high hazard flows, areas where flooding of properties occurs, and consideration of subsurface drainage capacity.

The flood study (Reference 2) identified several such hotspots, which the current study then re-examined. Floor level survey undertaken as part of the current study gave further information on flood affectation of property in the catchment. Similarly, a community questionnaire and newsletter gave new information on residents' experience of flooding (see Section 4.1.2). Description of each hotspot in the following sections refers to depths of hydraulic hazard, which is shown on Figure 10 to Figure 17, duration of flooding (Figure 18) and overfloor inundation (Figure 20).

3.3.1. Stream Street

The street, which follows the s-shaped alignment of a stream previously at the location, has a flood storage area at its north end, immediately upstream of William Street. Water pools when the pipe drainage to William Street is exceeded, which occurs in the 1 in 2 year ARI event. Floodwaters then accumulate in the area, which is around 2 m lower than William Street, to a depth of 3 m in the 10% AEP event. Overland flow is trapped by both the low ground elevation and the buildings at the north end of the street. Figure 23 shows the hotspot in detail, including the areas where runoff accumulates and the area's drainage.

Riley Street and Yurong Street, to the east and west of Stream Street respectively, are also part of the depression and are inundated in relatively frequent events. In a 10 year ARI, the affected section of Riley Street has over 1 m of inundation, while Yurong Street has up to 0.6 m. While the height of William Street prevents runoff from leaving the area, William Street itself has a dip in the east-west direction where runoff accumulates. There is between 0.2 m and 0.5 m of depth in the 10% AEP event and up to 0.8 m in the 1% AEP event.

The large depths of inundation that occur in the hotspot result in significant areas of high hydraulic hazard across the range of design events. In a 50% AEP event, the northern half of Stream Street and parts of Riley Street have high hazard ponding, while in the 1% AEP event the high hazard area extends to Yurong Street, more of Riley Street and parts of William Street. For a 1-hour duration storm event (the critical duration for the catchment), the duration of flooding in the depression is around 2-3 hours (depending on the drain performance), which means the ponding is brief overall, but lengthy relative to the rest of the catchment.

Flood affectation of properties in the hotspot is significant, with several properties on Riley Street inundated in relatively frequent flood events. There are around ten properties in the hotspot that have overfloor inundation in a 2% AEP event, including three on Riley Street that are inundated in a 50% AEP event. With regard to vehicular and pedestrian traffic, Stream Street is not used as a thoroughfare, and Riley Street has a cul-de-sac before William Street, however, it is used by pedestrians. In contrast, William Street is a major arterial road to the CBD and its inundation is hazardous to traffic, which will likely try to cross the floodwaters.

3.3.2. Busby Lane

Similar to Stream Street, Busby Lane is a flood storage area, with flow off Riley Street accumulating in the area. Piped drainage is relied on to transmit flow from the lane, as the topography slopes up from the area (towards both Riley Street and William Street), creating an unrelieved depression. The lane has a depth of around 1.1 m in the 10% AEP event at its northern end; while the 1% AEP event has depths of up to 1.5 m. Figure 23 shows the hotspot in detail, including the areas where runoff accumulates and the area's drainage.

The large depths of inundation that occur in the hotspot result in significant areas of high hydraulic hazard across the range of design events. In a 50% AEP event, the northern end of the lane has high hazard ponding, while in the 1% AEP event the high hazard area covers the northern half of the lane. As with Stream Street, the area has a long duration of flooding relative to the rest of the catchment, but can still be expected to drain within a few hours in a 1% AEP, 1 hour duration event, given the trunk drainage is functioning.

The hotspot has only minor property inundation and does not cut off any vehicle or pedestrian thoroughfares. As properties only back onto Busby Lane, significant inundation of property is limited to flooded parking garages, of which there are two at the northern end of the street. There is a risk of damage to cars within these garages, as they may be lower than the street level and so detain a significant volume of water.

3.3.3. Crown Street

The section of Crown Street between Cathedral Street and Sir John Young Crescent is inundated in frequent flood events. Similar to other hotspots nearby, there is a small depression along the section of the street, where the street slopes down and then up, with a maximum dip of around 0.75 m. Water pools in the depression, as well as at the west end of Bossley Terrace, when subsurface drainage is exceeded. There is up to 0.7 m depth in the 10% AEP event and up to 1.1 m in the 1% AEP event. Figure 23 shows the hotspot in detail, including the areas where runoff accumulates and the area's drainage.

Although there is widespread inundation of Crown Street and Bossley Terrace in relatively frequent events, high hydraulic hazard is not present for floods below the 5% AEP event. This is a result of the topographic depression causing water to accumulate rather than flow down the street, and so the high hazard is caused by the flow's depth (and not velocity). In the 1% AEP event, the majority of Crown Street between Cathedral Street and Sir John Young Crescent has high hazard inundation, as well as the part of Bossley Terrace perpendicular to Crown Street. As with Stream Street and Busby Lane, Crown Street acts as a flood storage in large events and so has a duration of flooding that is lengthy relative to the rest of the catchment, but is still quite brief, with a 1-hour design storm leading to inundation lasting several hours at most (depending on the performance of the drainage system).

The hotspot has significant property inundation, with many properties in area flooded above floor in a 5% AEP event. The affectation is concentrated on the east side of Crown Street, where fifteen properties are flooded overfloor in a 1% AEP event. The new residential development on the west side of the street is more elevated, and is not flooded in a 1% AEP event. There is also significant inundation of property on Cathedral Street adjacent to Crown Street, with around ten properties flooded over floor in a 5% AEP event. Crown Street has moderate vehicle and pedestrian traffic and there is a risk of people entering the floodwaters and becoming stranded or otherwise harming themselves.

3.3.4. Palmer Street

Water pools at the north end of Palmer Street where it passes under the elevated train line. There is a small depression in the road at this location, and water is also trapped by the Jersey Barriers dividing the street from the Eastern Distributor. Pit upgrades have recently been undertaken in the area. Flows can also spill onto the Eastern Distributor immediately to the east. The depth of inundation is 0.6 m in the 10% AEP event, and 1.3 m in the 1% AEP event. Figure 23 shows the hotspot in detail, including the areas where runoff accumulates and the area's drainage.

Similarly to Crown Street, there is not high hazard depth or velocity in frequent events, with only floods larger than the 10% AEP event showing significant amounts of high hazard flow. In a 1% AEP event the section of Palmer Street between its northern end and Bossley Terrace has high hydraulic hazard, which is a combination of high velocity closer to Bossley Terrace and hazardous depths towards the northern end. In a 1% AEP 1 hour storm event, Palmer Street near Bossley Terrace is drained within 1 hour, while the northern end of the street takes closer to 2 hours to drain.

The hotspot has several properties that are affected by overfloor inundation, and has significant vehicle traffic along it. Properties are located on the west side of the street (the Eastern Distributor is on the east side), with a single apartment building and a storage warehouse south of the rail overpass, and several houses at the northern end. Overfloor inundation is limited to the apartment buildings entrance (first inundated in a 1% AEP event), the warehouse (first inundated in a 20% AEP event) and some of the houses. As with Crown Street, there is vehicle traffic through the hotspot, and there is a risk that cars will enter floodwaters and become stranded.

3.3.5. Bourke Street

The north end of Bourke Street between Cowper Wharf Road and Wilson Street is inundated as Cowper Wharf Road has been raised above the natural elevation of the ground, creating an unrelieved area close to the catchment outlet at the bay. Bourke Street slopes down to 1.6 mAHD south of Cowper Wharf Road, which is around 2.2 mAHD. Despite its proximity to the bay, the level of Cowper Wharf Road has much greater influence on the flood level in the area than the ocean tailwater. The area has up to 0.2 m depth in the 20% AEP event and up to 0.8 m in the 1% AEP event. Figure 23 shows the hotspot in detail, including the areas where runoff accumulates and the area's drainage.

The tidal level also influences peak flood levels in the area, as it is adjacent to the trunk drainage outlet just north of Cowper Wharf Road. However, the influence is not widespread, with it generally limited to north of Plunkett Street. For example, in a 1% AEP event, a 1.4 mAHD tide produces peak flood levels around 0.2 m higher than a 0 mAHD tide, but the difference is limited to the area between Wilson Street and the outlet.

The topographic depression created by Cowper Wharf Road causes runoff to pond in the hotspot, creating low hydraulic hazard in most floods. In the 1% AEP event, the area has less than 1 m depth, resulting in virtually no areas of high hydraulic hazard. There is high hazard in the PMF event, as the water ponds to a depth of up to 1.3 m. Duration of flooding in the area is relatively short; for example, in a 1% AEP 1 hour event, there is a depth of 0.3 m for less than 1 hour.

The hotspot has several properties that are affected by overfloor inundation. Seven properties are flooded overfloor in a 1% AEP event, while several more are inundated in a PMF event. Flood levels along Bourke Street are generally elevated in the area and this benefits the degree of affectation. Floodwaters in the Bourke Street pose a risk to a vehicular and pedestrian traffic in the area, however, the depth and velocity of flow is not great enough to be considered to pose a risk to life to most people. The efficient discharge of runoff through the hotspot means the duration of flooding will be relatively short, for example, less than 15 minutes in a 1 hour storm.

3.3.6. Victoria Street

The section of Victoria Street near Orwell Street conveys overland flow in the gutter on the western side of the road, also inundating the footpath and houses on that side of the road. Several features contribute to the flood behaviour: the road cross-sectional shape is heavily sloped towards the western side of the street, the houses on that western side then block the flow (compared to the catchment's pre-developed state), and the limited pipe capacity in a flood event. The depth of flow is around 0.2 m in the 50% AEP event and 0.4 m in a 1% AEP event. Figure 28 shows the hotspot in detail, including the areas where runoff accumulates and the area's drainage.

Overland flow down Victoria Street is shallow and fast moving, and is generally not classified as having high hydraulic hazard in events up to and including the 1% AEP. Localised flow behaviour (which is not captured in the hydraulic model), such as the water cascading down the stairs to the basement levels of the houses, may be considered more hazardous than the footpath runoff, as a resident may be forced to use the stairs to enter or exit the basement level.

There is severe overfloor flood affectation in the hotspot, with a number of properties on the west side of Victoria Street experiencing inundation in relatively frequent flood events. There are nine properties downstream of Butler Stairs that are first inundated in between a 10% and 20% AEP flood event, mostly on their basement level. Several other properties are inundated in a 1% AEP or PMF event. The street has a significant volume of pedestrian and vehicle traffic, however, the concentration of the flow on the western footpath and gutter means cars may still use the road, and pedestrians can use the eastern footpath.

3.3.7. Earl Street

The section of Earl Street around 70 m from the street's southern end, where there is a bend in the road, has minor topographic features which concentrate flow towards the houses on Victoria Street which back onto Earl Street. The street is sloped towards its western side and there is a small topographic depression. A resident on Victoria Street has reported multiple occurrences of flow passing through their house towards Victoria Street. There is a depth of 0.3 m in the 20% AEP event and 0.4 m in the 1% AEP event. Two properties experience overfloor inundation in a 5% AEP event. The flow is not high hazard and no pedestrian or vehicle traffic is likely to be affected. Figure 26 shows the hotspot in detail, including the areas where runoff accumulates and the area's drainage.

3.4. Impact of Climate Change

The impact of climate change on flood behaviour has been assessed as part of the Flood Study (Reference 2) through a sensitivity analysis of rainfall increase and sea level rise due to climate change. The assessment followed the NSW State Government guidelines, which require testing of rainfall increases of 10, 20 and 30%, and sea level rise of 0.4 and 0.9 m by the years 2050 and 2100 respectively. Table 3 gives the results of the analysis.

Table 3: Results of Climate Change Analysis - 1% AEP Event Depths (m)

ID	Location	100 Year ARI Peak Flood Depth (m^3/s)	Rainfall Increase 10%	Rainfall Increase 20%	Rainfall Increase 30%	2050 Sea Level +0.4 m	2100 Sea Level +0.9 m
			Difference with 100 Year ARI Base Case (m^3/s)				
1	Francis Street	0.6	0.02	0.03	0.04	-	-
2	Francis Lane	1.9	0.03	0.06	0.08	-	-
3	Yurong Lane	3.4	0.06	0.12	0.17	-	-
4	Busby Lane	1.3	0.07	0.12	0.19	-	-
5	Sir John Young Crescent	1.2	0.07	0.12	0.17	-	-
6	Palmer Street	1.3	0.04	0.07	0.11	-	0.02
7	Cowper Wharf Road underpass	0.7	0.03	0.07	0.10	-	-
8	Bourke Street	0.9	0.03	0.06	0.09	0.05	0.13
9	The Domain	0.4	0.03	0.06	0.09	-	-
10	Victoria Street	0.4	0.02	0.05	0.07	-	-

The table shows that 1% AEP peak flood depths across the catchment will increase by around 0.05 m in a 10% rainfall increase, while a 30% rainfall increase will correspond to depth increases of around 0.1 m. The most sensitive areas are on Busby Lane, Yurong Lane and Sir John Young Crescent. The analysis also found that a rise in sea level has no impact in the majority of the catchment, with the only significant impact occurring at the downstream end of

Bourke Street near Cowper Wharf Road. This is due to the catchment's steep topography which means a higher sea level only impacts the very downstream end of the catchment, where the ground elevation is comparable to the sea level.

4. STAKEHOLDER CONSULTATION

4.1. Community Consultation

One of the key components of the FRMS process is to actively liaise with the community throughout the process, keep them informed about the current study, identify community concerns and gather information from the community on potential management options for the floodplain. The consultation programme consists of:

- Distribution of brochure and questionnaire survey;
- Media release;
- Public information sessions;
- Other stakeholder consultation; and
- Public exhibition

4.1.1. Previous Consultation

As part of the Flood Studies (Reference 2), community questionnaire surveys were undertaken during October-November 2012 to gather historical data for model calibration. 537 surveys were distributed to residents within the Woolloomooloo catchment. 38 responses were received, which equates to a return rate of 7%. Unfortunately few flood levels or depths were provided although the reported flood observations were able to be used as a means of model verification. Eight historical events from April 1998 onwards were identified as having caused over-floor flooding, and a total of ten flood events were identified in this period. Approximately 75% of respondents are aware of flooding or have some knowledge of flooding in the study area. The most frequent overfloor inundation was reported in Victoria Street, with floodwaters regularly inundating properties near Orwell Street.

4.1.2. Consultation as Part of This Study

Further community questionnaire survey work was undertaken during June-July 2014 to inform residents of the next stage of the floodplain management process as well as to gather flood information and community's preferred options for managing flood risks within the catchment. 571 copies of the newsletters and questionnaires were printed and delivered to the owners of properties likely to be aware of flooding issues. In total 54 responses were received constituting a 9% return rate and the results are as shown in Figure 19. The newsletter and questionnaire is shown in Appendix B.

34% of the respondents experienced some form of flooding within the catchment and seven respondents reported floodwaters entering their houses or businesses. Of the seven, three were in Victoria Street (in areas identified as hotspots), while the remainder were in Cathedral Street, Bourke Street and Brougham Street. The responses confirmed the general observation that overfloor flooding occurs at low-lying properties that have a significant overland flow path.

Several residents expressed concern in regards to the alignment and maintenance of localised drainage features. For example, tree roots were identified as diverting flow, and blockage of stormwater pits due to leaves was observed by several respondents. There was also comment on the success of recently implemented measures, for example, the upgraded pits in Victoria Street.

Among the preferred management options for managing flood risks within the catchment: defined flow paths, pit/pipe upgrades, retarding basins, strategic planning and flood related development controls were the most popular. The least desired options were levees and retarding basins.

4.1.3. Community Information Session

Two community information sessions were held. These were:

- July 25th at the Paddington Markets – WMAwater and City of Sydney staff manned a booth and discussed flooding issues in the catchment with interested members of the public. Several community members engaged with the material and made flooding specific observations; and
- August 1st at Kings Cross Organic Flood Markets – WMAwater and City of Sydney staff manned a booth and again discussed flooding issues with interested members of the public.

4.2. Floodplain Committee Meetings

The Floodplain Management Committee (FMC) oversees and assists with the floodplain risk management process being carried out within the Council LGA. The committee is comprised of representatives from various stakeholders, including local Councillors, emergency services, Sydney Water Corporation and community representatives. Progress on the current study has been regularly presented to the committee at FMC meetings (every 3 months), at which point questions or feedback from the various representatives was taken.

4.3. Internal Stakeholders Workshop

Workshops with internal stakeholders were held to gather feedback on the management measures being assessed for the study. The workshops, which were held in December 2014, consisted of presentation of the various measures, including their cost and impact on flooding and property affectation. Attendees included representatives from City of Sydney, OEH, SES and Sydney Water, and each provided input on the feasibility and suitability of the measures, as well as possible variations to the measures presented.

4.4. Public Exhibition

4.4.1. Summary of Submissions

The draft report has been exhibited. Approximately eight responses have been received in regard to the report. Of these eight, six refer to specific flooding issues at property. A summary of the issues raised is compiled below:

- Substantial flood events have occurred with some over floor flooding resulting on 25th April 2015 and 24th August 2015;
- Observations from the 24th August 2015 event include that:
    - flow was car bonnet level (for cars parked on western side of Victoria Street between Earl and Orwell Streets);
    - velocity and depth represent a real risk to life;
    - 1 m high surcharge from manhole in front of 201 Victoria St;
    - Worst flooding in 32 years of residence.
- Existing drainage is inadequate;
- Cars and bins in the kerb/gutter area block flow capacity and exacerbate the flooding issue;
- Design flood information presented in the report may be an underestimate of actual flood behaviour;
- Flooding that occurred on August 24th 2015 led to the inundation of numerous properties;
- Significant delay noted between rainfall intensity peaking and actual peak flow arriving; and
- An event on September 6th was also of significance.

4.4.2. Discussion

To set a context for the subsequent text it is worth noting that WMAwater obtained rainfall records from Sydney Water Corporation and find that the event of August 24th 2015 is up to a 10% AEP event for the 10 minute duration.

Clearly at least two significant events have occurred in Victoria St within 2015. These regrettable events provide the study with some very valuable feedback and the challenge now is to make the best of this feedback in the context of a study which is close to complete.

Submission feedback in regard to the events make clear the following:

- Actual flood behaviour is heavily influenced by blockage of the kerb/gutter interface and this can occur via parked vehicles and bins; and
- Current design flood levels incorporate an unrealistic assumption vis a vis the degree to which the kerb/gutter interface is available for the conveyance of flows.

In response to these submissions the option assessment discussion of Section 9.3 has been amended, as has the Plan.

5. ECONOMIC IMPACT OF FLOODING

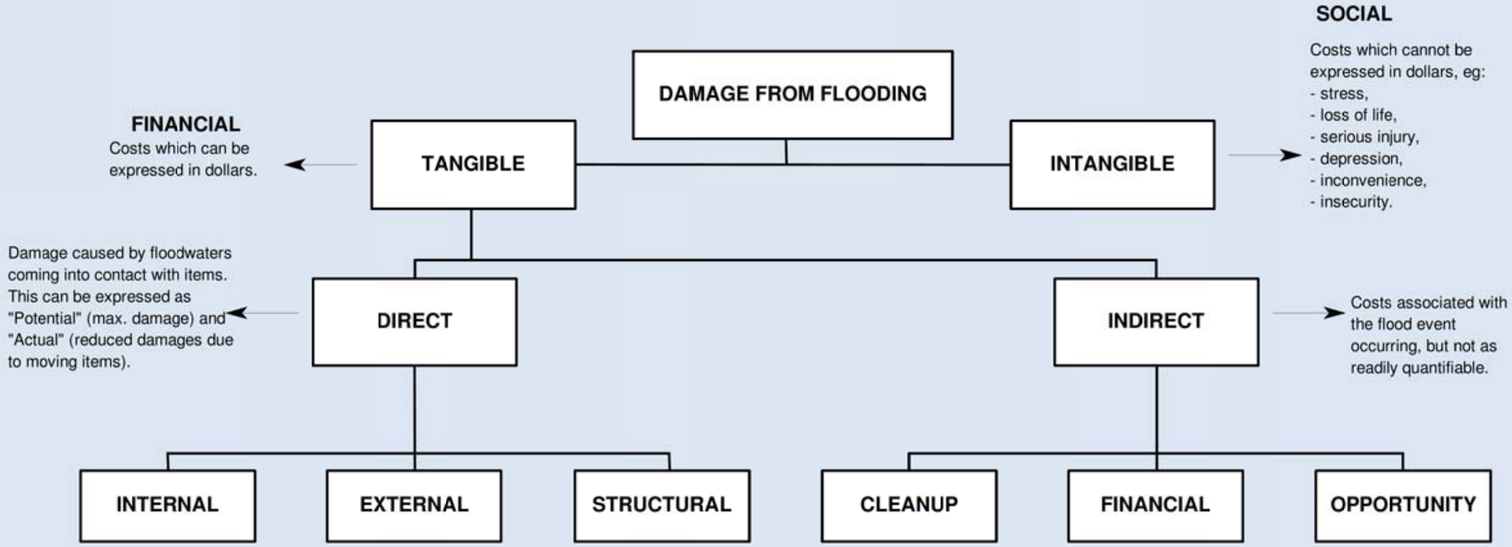
The impact of flooding can be quantified through the calculation of flood damages. Flood damage calculations do not include all impacts associated with flooding. They do, however, provide a basis for assessing the economic loss of flooding and also a non-subjective means of assessing the merit of flood mitigation works such as retarding basins, levees, drainage enhancement etc. The quantification of flood damages is an important part of the floodplain risk management process. By quantifying flood damage for a range of design events, appropriate cost effective management measures can be analysed in terms of their benefits (reduction in damages) versus the cost of implementation. The cost of damage and the degree of disruption to the community caused by flooding depends upon many factors including:

- The magnitude (depth, velocity and duration) of the flood;
- Land use and susceptibility to damages;
- Awareness of the community to flooding;
- Effective warning time;
- The availability of an evacuation plan or damage minimisation program;
- Physical factors such failure of services (sewerage), flood borne debris, sedimentation; and
- The types of asset and infrastructure affected.

The estimation of flood damages tends to focus on the physical impact of damages on the human environment but there is also a need to consider the ecological cost and benefits associated with flooding. Flood damages can be defined as being tangible or intangible. Tangible damages are those for which a monetary value can be easily assigned, while intangible damages are those to which a monetary value cannot easily be attributed. Types of flood damages are shown in Table 4.

The assessment of flood damages not only looks at potential costs due to flooding but also identifies when properties are likely to become flood affected by either flooding on the property or by over floor flooding as shown on Figure 20.

Table 4: Flood Damages Categories (including damage and losses from permanent inundation)



	INTERNAL	EXTERNAL	STRUCTURAL	CLEANUP	FINANCIAL	OPPORTUNITY
RESIDENTIAL	Contents of Buildings: Clothes, Carpets, Furniture, Valuables, Fittings, Appliances	External Items: Vehicles, Laundries, Caravans, Sheds, Tools, Gardens, Fences	Physical Damage to Buildings: Gyprock, Cupboards, Scour of Footings, Houses becoming buoyant (floating off footings)	Clean Carpets, Walls, Clothes; Re-instate Furniture; Remove Mud and Debris	Loss of wages, Living costs (temporary accomodation and food), Time to repair/replace damaged items	Not Applicable
RURAL	Contents of Buildings: Clothes, Carpets, Furniture, Valuables, Fittings, Appliances	External Items: Vehicles, Sheds (stables/barns), Machinery, Tools, Fences, Feed storage, Saddles, Crops &/or Stock, Irrigation Systems	Physical Damage to Structures: Damage to Homestead, Sheds, Access tracks, Protection levees	Clean Homestead and Out-buildings; Remove Debris; Dispose of affected crops &/or stock	Loss of Farm Production and Income, Re-instatement of Pastures, Supplementary feeding of stock (by hand or outside agistment), Stock movement/ transport, Living costs (temporary accomodation and food)	Sowing or harvesting of Crops, Sale of Stock (at depreciated value or dependent on market influences)
COMMERCIAL	Contents of Buildings: Products, Stock, Fittings, Tools, Machinery, Raw Materials	External Items: Vehicles, Machinery, Display, Raw Materials/Stockpiles, Fences	Physical Damage to Buildings	Dispose of damaged products, stock, materials; Cleaning and Re-instatement	Loss of Productivity and Income, Bank Interest Charges	Loss of existing &/or Potential Trade
PUBLIC AUTHORITIES	Contents of Public Buildings and Facilities	Public Property and Facilities: Parks, Signs, Machinery, Equipment	Physical Damage to Infrastructure: Electricity, Water, Telephone, Gas, Road & Rail Transport Links	Remove Mud & Debris from Facilities, Public & Private Property Repairs (temporary & permanent)	Disruption of Services, Community Service Relief Grants	Provision of Public Service