

CITY AREA CATCHMENT  
FLOODPLAIN RISK  
MANAGEMENT PLAN  
FINAL REPORT







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## CITY AREA CATCHMENT FLOODPLAIN RISK MANAGEMENT PLAN

### FINAL REPORT

SEPTEMBER 2016

| <b>Project</b><br>City Area Catchment Floodplain Risk Management Plan |                             | <b>Project Number</b><br>114095   |          |
|---|-----------------------------|---|----------|
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| <b>Date</b><br>6 September 2016                                       |                             | <b>Verified by</b><br> |          |
| Revision  | Description                 | Distribution  | Date     |
| 4   | Final                       | Sean Howie  | Sep 2016 |
| 3   | Final Draft                 | Sean Howie  | May 2016 |
| 2   | Draft for Public Exhibition |   | Jan 2016 |
| 1   | Draft Plan                  |   | Nov 2015 |

# CITY AREA CATCHMENT FLOODPLAIN RISK MANAGEMENT PLAN

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## FOREWORD

The NSW State Government's Flood Prone Land 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 Flood Prone Land Policy, the management of flood liable land remains the responsibility of local government. The NSW Government, and administered through the Office of Environment and Heritage (OEH), provides financial assistance and specialist technical advice to assist councils in the discharge of their floodplain management responsibilities. The Australian Government may also provide financial assistance in some circumstances.

The Flood Prone Land Policy provides for specialist technical and financial support to Councils by the NSW Government through the stages set out in the "Floodplain Development Manual – the management of flood liable land, NSW Government, 2005". This Manual is provided to assist Councils to meet their obligations and responsibilities in managing flood liable land. These stages are:

1. **Flood Study**
  - Determine the nature and extent of the flood problem.
2. **Floodplain Risk Management Study**
  - 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 City Area Catchment Floodplain Risk Management Plan constitutes the third stage of this management process. This plan has been prepared by WMAwater for the City of Sydney (Council) under the guidance of Council's floodplain management committee (Committee). This plan provides the basis for the future management of those parts of the City Area catchment which are flood liable.

## EXECUTIVE SUMMARY

The recommended Floodplain Risk Management Plan for the City Area catchment has been prepared in accordance with the NSW Floodplain Development Manual (Reference 1) and:

- Is based on a comprehensive and detailed evaluation of all factors that affect and are affected by the use of flood prone land; and
- Provides a long-term path for the future development of the floodplain.

The City Area catchment is located in Sydney's inner city suburbs of Millers Point, Dawes Point, The Rocks, Barangaroo, and parts of Sydney, in the City of Sydney Local Government Area (LGA). The 199 hectare catchment is fully urbanised, with runoff in the catchment draining to Circular Quay and Darling Harbour via the area's pit and pipe stormwater system. There are significant overland flowpaths in the catchment, which are active when the capacity of the pit and pipe network is exceeded. Flood liability exists across the area, including several locations where overland flow is trapped by unrelieved depressions in the catchment topography.

The City Area Catchment Floodplain Risk Management Study (Reference 2) undertook a detailed assessment of flood risk in the catchment. The assessment included a description of flood hazard in the catchment, as well as an estimate of the economic impact of flooding. The study gave a description of the flood emergency response arrangements in the area, as well as a review of the flood planning level and flood planning area.

The floodplain risk management study also included an investigation of possible options for the management of flood risk in the area. These included structural works, such as drainage upgrades and overland flowpaths, as well as planning measures and SES-related actions. The measures were assessed for their ability to reduce flood risk while also considering their economic, social and environmental impact. A multi-criteria matrix assessment was used to directly compare the options. Of the options investigated, 12 were recommended for implementation, with a priority and time frame assigned to each.

The Study and Plan were publicly exhibited from the 8<sup>th</sup> of March to the 11<sup>th</sup> of April 2016. Several submissions were received from community groups and individuals and have been summarised in the Study. The Floodplain Risk Management Plan was adopted by Council on the 15<sup>th</sup> of August 2016.

## **1. FINDINGS OF FLOODPLAIN RISK MANAGEMENT STUDY**

### **1.1. Background**

The City Area catchment is located in Sydney's inner city suburbs of Millers Point, Dawes Point, The Rocks, Barangaroo, and parts of Sydney (refer Figure 1). This region lies within the City of Sydney Local Government Area (LGA) and has been fully developed for urban and commercial usage, which provides little opportunity for water to infiltrate due to the high degree of impervious surfaces. Land use is predominantly high-density housing and commercial development, with some areas of open space including Observatory Park and parts of Hyde Park.

The catchment covers an area of approximately 199 hectares and drains into Sydney Harbour at various locations, with the majority of the catchment discharging to Sydney Cove via Sydney Water's main trunk drainage system. An extensive sub-surface drainage system exists, with Council's minor stormwater system draining the upper areas and entering Sydney Water (SWC) trunk assets in the lower catchment.

A number of locations within the catchment are flood liable, and flooding is known to occur in some areas for all rainfall events greater than the 0.5 EY. 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 where sub-surface systems are running at capacity. This creates a significant drainage/flooding problem in many areas throughout the catchment, with roads and pedestrian areas forming major flow paths, with associated high velocities and flood depths.

The City Area Catchment Flood Study (2014) was carried out to define existing flood behaviour for the City Area catchment in terms of flood levels, depth, velocities, flows, hydraulic categories and provisional hazard. The 1% AEP peak flood depth is shown on Figure 2, while Figure 3 shows the Probable Maximum Flood (PMF). As can be seen on Figure 2, there is significant overland flow in large flood events, with over 0.7 m of water in several areas, including the unrelieved depressions in King Street, Angel Place, Curtin Place, Bond Street and Hunter Street. Figure 4 and Figure 5 show the hazard categories for the 1% AEP and PMF events respectively. Areas of high hazard in the catchment generally correspond to the major overland flowpaths, with the majority of high hazard along the central flowpath in the catchment.

### **1.2. Flood Hazard Classification**

Classification of flood hazard in the catchment was based on a combination of the provisional flood hazard categories and a range of other factors that are not captured by the provisional categories. These factors include, but are not limited to: rate of rise of floodwater, duration of flooding, community awareness and effective warning time. A qualitative assessment of these factors was undertaken, the results of which are summarised in Table 1. The provisional hazard

categories complement this assessment, as they delineate areas of the floodplain where the depth or velocity of floodwaters is considered hazardous.

Table 1: Hazard Classification

| Criteria                                       | Weight <sup>(1)</sup> | 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                    | High                  | 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 | High                  | 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                            | Medium                | 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.  |

<sup>(1)</sup> Relative weighting in assessing the hazard for the City Area catchment

Detailed description of the flood hazard classification is given in Section 3.3 of the City Area Catchment Floodplain Risk Management Study.



### 1.3. Economic Impact of Flooding

The economic impact of flooding in City Area catchment was assessed as part of the floodplain risk management study. Damages were calculated for residential and commercial/industrial properties, based on a floor level survey of properties inundated in the 1% AEP event. The flood damages estimate does not include the cost of restoring or maintaining public services and infrastructure. It should be noted that damages calculations have only a very approximate damages estimate to any basements or cellars.

The damages assessment found that 118 properties within the catchment are liable to over floor inundation in the 100 Year ARI event, while 60 properties are liable in the 5 Year Event. The assessment estimated the average annual damage to be approximately \$1.9 million for the catchment. Table 2 gives the estimated tangible damages for the catchment (both residential and commercial/industrial properties)

Table 2: Estimated Combined Flood Damages for City Area Catchment

| Event                               | Number of Properties Flood Affected | No. of Properties Flooded Above Floor Level | Total Tangible Flood Damages | Average Tangible Damages Per Flood Affected Property |
|-------------------------------------|-------------------------------------|---|------------------------------|--|
| <b>2</b>                            | 47                                  | 40  | \$ 2,584,000                 | \$ 55,000  |
| <b>5</b>                            | 75                                  | 60  | \$ 3,512,000                 | \$ 46,800  |
| <b>10</b>                           | 95                                  | 74  | \$ 4,496,300                 | \$ 47,300  |
| <b>20</b>                           | 123                                 | 95  | \$ 5,968,800                 | \$ 48,500  |
| <b>50</b>                           | 136                                 | 105   | \$ 6,734,700                 | \$ 49,500  |
| <b>100</b>                          | 154                                 | 118   | \$ 7,702,600                 | \$ 50,000  |
| <b>500</b>                          | 171                                 | 131   | \$ 9,973,100                 | \$ 58,300  |
| <b>PMF</b>                          | 245                                 | 170   | \$ 18,452,800                | \$ 75,300  |
| <b>Average Annual Damages (AAD)</b> |                                     |   | <b>\$ 1,896,400</b>          | <b>\$ 7,700</b>                                      |

Detailed description and results of the damages assessment is given in Section 5 of the City Area Catchment Floodplain Risk Management Study.

## **2. RECOMMENDED MANAGEMENT MEASURES**

The City Area Catchment Floodplain Risk Management Study made a full assessment of the existing flood risk in the catchment. Based on this assessment of flood risk, the study investigated a range of management options for the area, which can be categorised as Response Modification Measures, Property Modification Measures and Flood Modification Measures, as per the NSW Floodplain Development Manual (Reference 1). Options were assessed for their efficacy across a range of criteria, which allowed them to be compared against one another and their overall effectiveness ranked. Measures which improved the management of flood risk in the catchment were selected and form the primary content of this draft Plan.

The measures have been categorised by their type (Response, Flood or Property) and given a priority ranking. The ranking is based upon a combination of reduction in flood risk, ease of implementation, cost/funding implications and outcomes based on the multi-criteria matrix assessment (refer Section 9.6 of the Study). More information on each measure is available in the Floodplain Risk Management Study, including discussion of its implementation and its effect on the existing flood behaviour.

### **2.1. Timeframe for Implementation**

Floodplain management measures recommended by this Plan have been assigned a timeframe for implementation, in order to form short term and long term strategies for the area's floodplain management. Use of different timeframes ensures that priority is given to those options which can be undertaken in the near future, while also retaining less feasible options for long term implementation.

Short term measures are those that are able to be implemented in the next 1-10 years, and are comprised of response modification and property modification measures, while long term measures are those that have greater constraints (usually financial or logistical) and are therefore planned to be implemented in the next 20-50 years. As discussed in the floodplain risk management study, the structural measures for the City Area catchment have numerous technical constraints and mostly do not have favourable benefit-cost ratios. For this reason, the measures should be undertaken in conjunction with other infrastructure works (for example, road upgrades) that mitigate their constraints.

The following section includes both a priority and a designated timeframe for each recommended management measure. Short term measures are shown on Figure 6, while Figure 7 shows the long term measures.

### **2.2. Flood Modification Measures**

The following sections detail the flood modification measures recommended for implementation in the catchment. Figure 7 shows the location of the measures in the catchment.

### **2.2.1. Trunk Drainage Upgrade – Alfred Street to Market Street (FM – CA01)**

Option FM – CA01 entails a wide-scale upgrade of the trunk drainage system in the catchment, in order to address the flood risk at several different hotspots. The measure, which involves upgrading the capacity of the pit and pipe system, and re-grading some sections, has been shown to have the following impacts:

- reduced peak flood depth on Pitt Street, King Street, Bond Street, Hunter Street, Angel Place, Curtin Place, Dalley Street and Underwood Street;
- reduced overfloor inundation of property in these areas;
- removal of high-hazard flow paths between Bond Street and Alfred Street; and
- reduced traffic impedance due to flooding on Pitt Street, George Street and King Street.

Although the measure produces a range of benefits to the area's flood risk, it is prohibitively expensive and involves very large capacity pipes that are unlikely to be technically feasible, due to the high density development that already exists in the area. The benefit-cost ratio of the option is 0.4.

The measure has been given a low priority in the Floodplain Risk Management Plan, based on its financial feasibility, benefit cost ratio and associated technical issues. This measure is recommended to be implemented by the City of Sydney and Sydney Water Corporation in the long term subject to further feasibility assessments.

### **2.2.2. Trunk Drainage Upgrade – New Drainage to Darling Harbour (FM – CA04)**

Option FM-CA04 involves a new large-scale drainage line connecting King Street near Pitt Street to a new outlet at Darling Harbour, aimed at alleviating flood risk at Pitt Street Mall, King Street and the hotspots downstream. The measure, which involves new inlet pits near and on King Street and a set of large stormwater pipes to Darling Harbour, has been shown to have the following impacts:

- Reduced peak flood level along the catchment's main flowpath, particularly at Pitt Street Mall and King Street, and less so in the downstream hotspots;
- Reduced overfloor inundation of property in these areas; and
- Removal of the high-hazard flow path along Pitt Street, as well as adjacent low points off of Pitt Street.

As with FM – CA01, the measure involves large-scale stormwater drainage that is prohibitively expensive and faces significant technical challenges to incorporate into the existing urban environment. The benefit-cost ratio of the option is 0.3.

The measure has been given a low priority in the Floodplain Risk Management Plan, based on its financial feasibility, benefit cost ratio and associated technical issues. This measure is

recommended to be implemented by the City of Sydney and Sydney Water Corporation in the long term subject to further feasibility assessments.

### **2.2.3. Overland Flowpath – Surface Adjustment to Pitt Street Mall (FM – CA05)**

Option FM – CA05 consists of slightly lowering a section of Pitt Street Mall, and is aimed at mitigating the flood affectation of properties along the mall. The lowered section would be covered with a grate or similar structure to maintain the existing ground level for pedestrians. The lowered ground level was shown to reduce the peak flood level by around 0.3 m, which corresponds to significantly less property inundation than what currently occurs.

The main constraints of the measure are incorporating its design into the high density of services which already exists along Pitt Street Mall, as well as fitting with the existing streetscape design. The benefit-cost ratio of the option is 4.5, although this may be a lower under a more detailed costing.

The measure has been given a medium priority in the Floodplain Risk Management Plan, based on its financial feasibility, benefit cost ratio and associated technical issues. The measure is recommended to be implemented by City of Sydney in the long term.

### **2.2.4. Overland Flowpath – Surface Adjustment to Martin Place (FM – CA06)**

Option FM – CA06 describes construction of two small open channels on Martin Place to control overland flow and the hazard to pedestrians in a flood. The lowered sections would be covered with a grate or similar structure to maintain the existing ground level for pedestrians. The reduction in peak flood level is around 0.05 m, which reduces the already shallow depth of inundation to less than 0.05 m. As with the previous option there are possible constraints with incorporating the lowered areas into the existing services. The measure has no measurable economic benefit as it does not reduce property flooding.

The measure has been given a low priority in the Floodplain Risk Management Plan, based on its reduction in hazard and technical issues. The measure is recommended to be implemented by City of Sydney in the long term.

### **2.2.5. Drainage Upgrade – Phillip Street (FM – CA08)**

Option FM – CA08 consists of a drainage upgrade on Phillip Street near Martin Place to drain the topographic sag that exists at the location. The additional drainage can be achieved with slightly higher pit and feeder pipe capacity to what currently exists. The main benefit would be increased road serviceability for Phillip Street and reduction in hazard to pedestrians. The measure has minimal economic benefit as it has little effect on property flooding.

The measure has been given a medium priority in the Floodplain Risk Management Plan, based on its reduction in hazard and relatively lower technical issues. The measure is recommended to be implemented by City of Sydney in the long term.

### **2.2.6. Data Collection – Catchment Specific Flood Damages Assessment for All Flood Modification Measures (FM – CA09)**

Option FM-CA09 consists of a specialised flood damages assessment of property in the Sydney CBD. The damages assessment involves estimating damage costs for different building types in the area and reassessing the damages and cost benefit assessments for all flood modification measures. It will allow much greater confidence in the economic damages assessment which will in turn improve the economic assessment of flood modification options.

The measure has been given a high priority in the Floodplain Risk Management Plan, based on its benefit to the economic assessment of the mitigation options. The measure is recommended to be implemented by City of Sydney in the short term.

## **2.3. Response Modification Measures**

### **2.3.1. Flood Warning (RM-CA01)**

Very limited flood warning is possible in the catchment; however, there is an opportunity to issue warnings through the City of Sydney Social Media and other methods. The nature of the catchment means that flood-producing rainfall is difficult to forecast, and there is negligible time between the rain occurring and the flood peak being reached. This prevents the implementation of conventional flood warning systems where a flood height is predicted and an evacuation order or other options can be undertaken. Given this constraint, it is recommended that warnings be issued as the flood is occurring, through the EMPLAN Process. There may also be opportunity to issue warnings as SMS alerts or through online social media and existing electronic signage.

The measure has been given a high priority in the Floodplain Risk Management Plan, based on its positive effect on SES operations, and its financial feasibility. The measure is recommended to be implemented by all relevant authorities in the short term.

### **2.3.2. Flood Emergency Management (RM – CA02)**

Emergency response arrangements during a flood can be formalised in a Local Emergency Management Plan (LEMPAN) for the area, including the recommended evacuation arrangements. A LEMPLAN and Consequent Management Guide - Flood should be developed by the Local Emergency Management Committee to identify evacuation centres for the area, use of Variable Message Signs for use during a flood, and description of the flood behaviour, including vulnerable buildings, facilities and roads. It is recommended that wherever possible, evacuation in the catchment should involve moving from a ground or below ground floor to a higher floor in

the building, given that virtually all buildings have higher floors, there is no expected risk of structural failure, and most flooding is short-lived (less than one hour).

The measure has been given a medium priority in the Floodplain Risk Management Plan, based on its positive effect on SES operations. The LEMPLAN should be developed by the Local Emergency Management Committee, likely as part of other emergency response arrangements.

### **2.3.3. Public Information and Raising Flood Awareness (RM – CA03)**

The success of any flood warning system and the evacuation process in reducing flood losses and damages depends on:

- *Flood Awareness*: How aware is the community of the flood threat? Has it been adequately informed and educated?
- *Flood Preparedness*: How prepared is the community to react to the threat of flooding? Do they (or the SES) have damage minimisation strategies (such as sand bags, raising possessions) which can be implemented?
- *Flood Evacuation*: How prepared are the authorities and the residents to evacuate households to minimise damages and the potential risk to life during a flood? How will the evacuation be done, where will the evacuees be moved to?

Public information and the level of public awareness are keys in reducing flood damages and losses. A more aware community will suffer less losses and damage than an unprepared community.

The measure has been given a medium priority in the Floodplain Risk Management Plan, based on its positive effect on SES operations and risk to life. The measure is recommended to be implemented by City of Sydney in the short term.

## **2.4. Property Modification Measures**

### **2.4.1. Flood Planning Levels (PM – CA01)**

The flood planning level (FPL) is used to define land subject to flood related development controls and is generally adopted as the minimum level to which floor levels in the flood affected areas must be built. The FPL includes a freeboard above the design flood level. It is common practice to set minimum floor levels for residential buildings, garages, driveways and even commercial floors as this reduces the frequency and extent of flood damages. Freeboards provide reasonable certainty that the reduced level of risk exposure selected (by deciding upon a particular event to provide flood protection for) is actually provided.

The measure has been given a high priority in the Floodplain Risk Management Plan, based on its positive effect on long term floodplain risk management in the catchment, and its economic merits. A review of the FPLs put forward by Council in their *Interim Floodplain Management Policy*

(Reference 4) was carried out as part of the Floodplain Risk Management Study and it was recommended that case studies be provided to illustrate how these levels could be applied to individual developments to assist in development applications.

### **2.4.2. Development Control Planning (PM – CA02)**

Within the City Area catchment there is continuing pressures for both redevelopment of existing buildings as well as for new developments. The strategic assessment of flood risk can prevent development occurring in areas with a high hazard and/or with the potential to have significant impacts upon flood behaviour in other areas. It can also reduce the potential damage to new or redeveloped properties likely to be affected by flooding to acceptable levels.

The measure has been given a high priority in the Floodplain Risk Management Plan, based on its positive effect on long term floodplain risk management in the catchment, and its community acceptance and financial feasibility. Recommendation for an update of the planning documents (i.e. Sydney DCP 2012 and Sydney LEP 2012) has been discussed in the Floodplain Risk Management Study in order to inform of the development controls as published in the Interim Floodplain Management Policy (Reference 4). Inclusion of these provisions would ensure that the controls can be enforced which also take into consideration the potential impact of climate change. The update is recommended to be implemented within City of Sydney in the short term.

### **2.4.3. Flood Proofing (PM – CA03)**

An alternative to house raising for buildings that are not compatible or not economically viable, is flood proofing or sealing off the entry points to the building. This measure has the advantage that it is generally less expensive than house raising and causes less social disruption. Flood proofing requires sealing of doors and possibly windows (new frame, seal and door); sealing and re-routing of ventilation gaps in brick work; sealing of all underfloor entrances and checking of brickwork to ensure there are no gaps or weaknesses in mortar. It is generally only suitable for brick buildings with concrete floors and it can prevent ingress from outside depths of up to one meter. Greater depths may cause structural problems (buoyancy) unless water is allowed to enter. Generally an existing house can be sealed for approximately \$10,000. New development and extensions allow the inclusions of flood appropriate materials and designs meaning the actual cost of flood proofing can be significantly less when compared to buildings requiring retro-fitting of flood proofing measures.

The measure has been given medium priority in the Floodplain Risk Management Plan, based on the number of properties it can benefit and its economic merits. The measure is recommended to be implemented by local business owners in the short term.

## **2.5. Recommended Management Measures – Table**

The recommended measures described in the previous sections are summarised in order of priority. The table provides a reference point for the Plan's recommendations, and represents one of the main outcomes of the floodplain risk management process for the City Area catchment.

Through the flood mitigation measure development process, at some locations more than one measure has been tested for the mitigation of flood risk. These will tend to have some variance in their impact, so for example Pitt Street flooding is reduced by both FM – CA01, FM – CA04 and FM-CA05, with FM – CA01 having the most widespread benefit. Nevertheless, in most cases it may be that one of these measures is preferred for implementation rather than multiple measures.

However, given the scale of these works and the fact that their feasibility and eventual cost will be significantly impacted by existing services, further analysis is required prior to a decisive selection being made. This analysis should focus specifically on feasibility of construction and if feasible, cost estimates should then be estimated by a quantity surveyor. It is recommended that the further feasibility analysis is carried out when appropriate capital is available for the works.



Table 3: Recommended Management Measures

| REF <sup>1</sup> | MEASURE  | PURPOSE  | PRIORITY        | RESPONSIBILITY                   | TIME FRAME | COST  |
|------------------|--|--|-----------------|----------------------------------|------------|---|
| PM-CA02          | <b>Update Sydney DCP 2012 and LEP 2012 based on FRMS&amp;P outcomes and to inform Council's Interim Floodplain Management Policy (Section 9.4.2)</b> | Prevent development occurring in high hazard areas or impacting existing flood behaviour             | High Priority   | City of Sydney                   | Short term | Internally within Council                                       |
| PM-CA01          | <b>Review FPLs following completion of FRMS&amp;P for City Area catchment. (Section 9.4.1)</b>   | Reduce the damages of flood affected properties by having elevated floor level                       | High Priority   | City of Sydney                   | Short term | Internally within Council                                       |
| RM-CA01          | <b>Review flood warnings on website or social media. Investigate feasibility of flood warning systems (Section 9.4.4)</b>                            | Improve public awareness during a flood event, reduce number of vehicles entering hazardous ponding. | High Priority   | SES, supported by other agencies | Short term | Internally within SES, with Council, RMS, and other authorities |
| FM-CA09          | <b>Carry out a catchment specific flood damages assessment for the Sydney CBD (Section 9.3.9)</b>  | Allow for an improved cost-benefit analysis of the flood modification options.                       | High Priority   | City of Sydney                   | Short term | Internally within Council                                       |
| RM-CA03          | <b>Develop ongoing flood awareness and public information programmes for the area. (Section 9.4.6)</b>   | Increase community's awareness during and after a flood event to reduce damages and risk to life     | Medium Priority | City of Sydney and SES           | Short term | Internally within Council and SES                               |

Table 3: Recommended Management Measures

| REF <sup>1</sup> | MEASURE   | PURPOSE  | PRIORITY        | RESPONSIBILITY                                    | TIME FRAME | COST  |
|------------------|---|--|-----------------|---|------------|---|
| RM-CA02          | <b>Prepare REMPLAN AND LEMPLAN (Section 9.4.5)</b>  | Minimise the risk associated with evacuations, determine when evacuation is required                           | Medium Priority | Regional and Local Emergency Management Committee | Short term | Internally within Regional and Local Emergency Management Committee |
| PM-CA03          | <b>Investigate flood proofing techniques for flood affected properties. (Section 9.4.3)</b> | Reduce the damages of flood affected properties by preventing ingress of floodwaters.                          | Medium Priority | Property owners                                   | Short term | Internally within Council   |
| FM-CA05          | <b>Overland Flowpath – Surface Adjustment to Pitt Street Mall. (Section 9.3.5)</b>          | Reduce the damages of flood affected properties, reduce hazardous overland flowpath, improve FPL requirements. | Medium Priority | City of Sydney                                    | Long Term  | Approx. \$226,500 capital, \$10,000 ongoing (annual)                |
| FM-CA01          | <b>Trunk Drainage Upgrade – Alfred Street to Market Street. (Section 9.3.1)<sup>2</sup></b> | Reduce the damages of flood affected properties, reduce hazardous overland flowpath, improve FPL requirements. | Low Priority    | City of Sydney and Sydney Water Corporation       | Long Term  | Approx. \$30,080,100 capital, \$12,540 ongoing (annual)             |
| FM-CA04          | <b>Drainage Upgrade – New Drainage to Darling Harbour. (Section 9.3.4)<sup>2</sup></b>      | Reduce the damages of flood affected properties, reduce hazardous overland flowpath, improve FPL requirements. | Low Priority    | City of Sydney and Sydney Water Corporation       | Long Term  | Approx. \$21,704,800 capital, \$8,200 ongoing (annual)              |

Table 3: Recommended Management Measures

| REF <sup>1</sup> | MEASURE  | PURPOSE                            | PRIORITY        | RESPONSIBILITY | TIME FRAME | COST   |
|------------------|--|------------------------------------|-----------------|----------------|------------|--|
| FM-CA08          | <b>Drainage Upgrade – Phillip Street. (Section 9.3.8)</b>                      | Reduce hazardous ponding           | Medium Priority | City of Sydney | Long Term  | Approx. \$575,800 capital, \$8,200 ongoing (annual)  |
| FM-CA06          | <b>Overland Flowpath – Surface Adjustment to Martin Place. (Section 9.3.6)</b> | Reduce hazardous overland flowpath | Low Priority    | City of Sydney | Long Term  | Approx. \$216,700 capital, \$10,470 ongoing (annual) |

<sup>1</sup>Reference of measure in the City Area Catchment Floodplain Risk Management Study

<sup>2</sup>Further investigation is required should this be implemented

### **3. ACKNOWLEDGEMENTS**

WMAwater wish to acknowledge the assistance of the City of Sydney Council staff and the Floodplain Management Committee in carrying out this study as well as the NSW Government (Office of Environment and Heritage) and the residents and business operators of the City Area catchment. This study was jointly funded by the City of Sydney Council and the NSW Government. The cover page image is used courtesy of Wikimedia Commons user Adam.J.W.C.

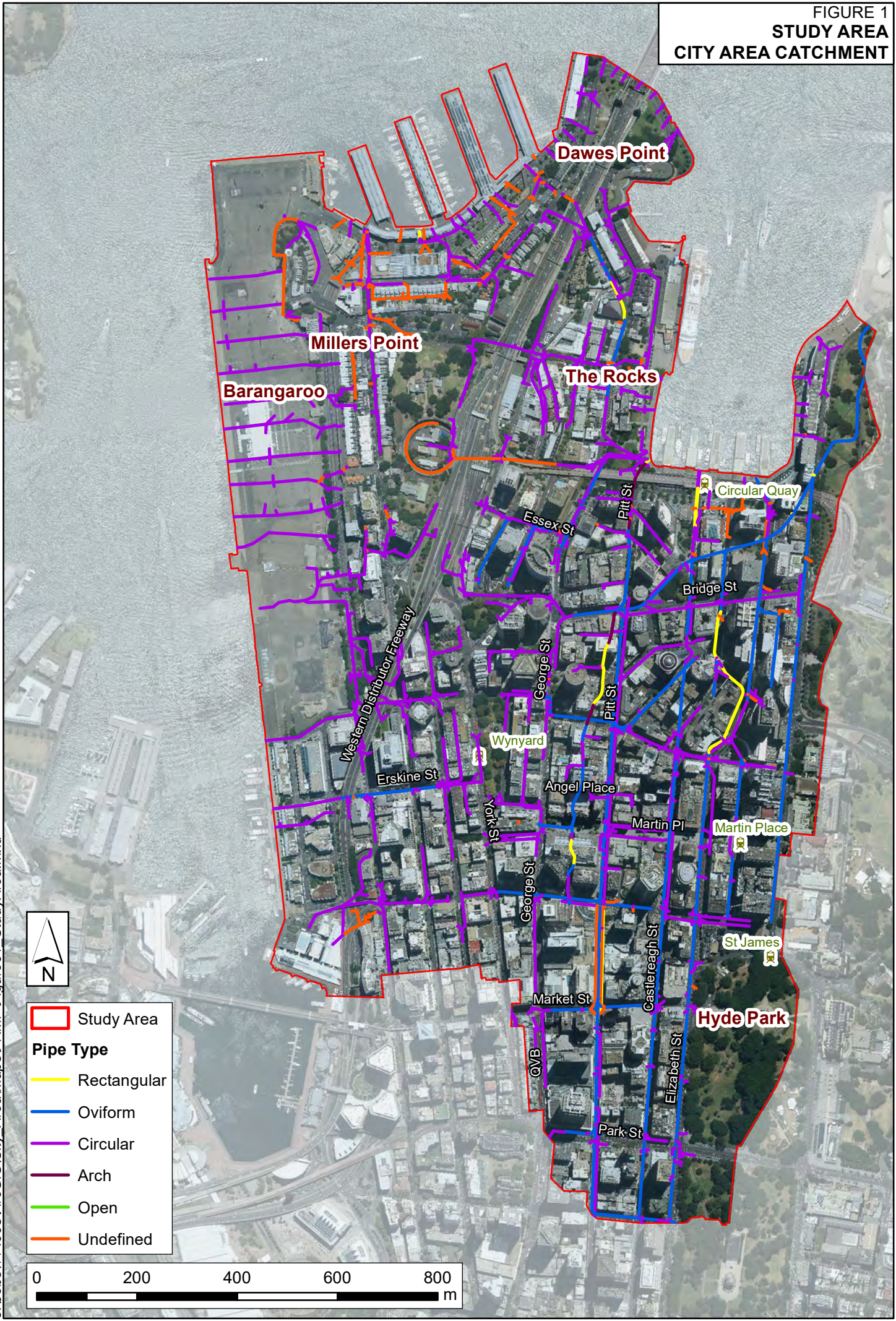
#### **4. REFERENCES**

1. NSW Government (2005) Floodplain Development Manual – the Management of Flood Liable Land, Department of Infrastructure, Planning and Natural Resources
2. WMAwater (2015), City Area Catchment Floodplain Risk Management Study, Report
3. BMT-WBM (2014), City Area Catchment Flood Study, Report
4. City of Sydney (2014), Interim Floodplain Management Policy



Figures

FIGURE 1  
STUDY AREA  
CITY AREA CATCHMENT



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- Study Area
- Pipe Type**
- Rectangular
- Oviform
- Circular
- Arch
- Open
- Undefined

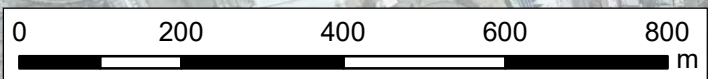








FIGURE 2  
**PEAK FLOOD DEPTH**  
**1% AEP DESIGN FLOOD EVENT**



|   |             |
|---|-------------|
|  | Study Area  |
| <b>Depth (m)</b>  |             |
|  | 0.10 - 0.25 |
|  | 0.25 - 0.50 |
|  | 0.50 - 0.75 |
|  | 0.75 - 1.0  |
|  | > 1.0       |

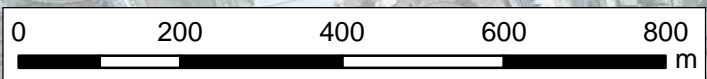










FIGURE 3  
**PEAK FLOOD DEPTH**  
**PMF DESIGN FLOOD EVENT**



|   |             |
|---|-------------|
|  | Study Area  |
| <b>Depth (m)</b>  |             |
|  | 0.10 - 0.25 |
|  | 0.25 - 0.50 |
|  | 0.50 - 0.75 |
|  | 0.75 - 1.0  |
|  | > 1.0       |

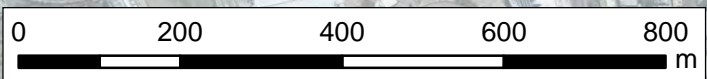
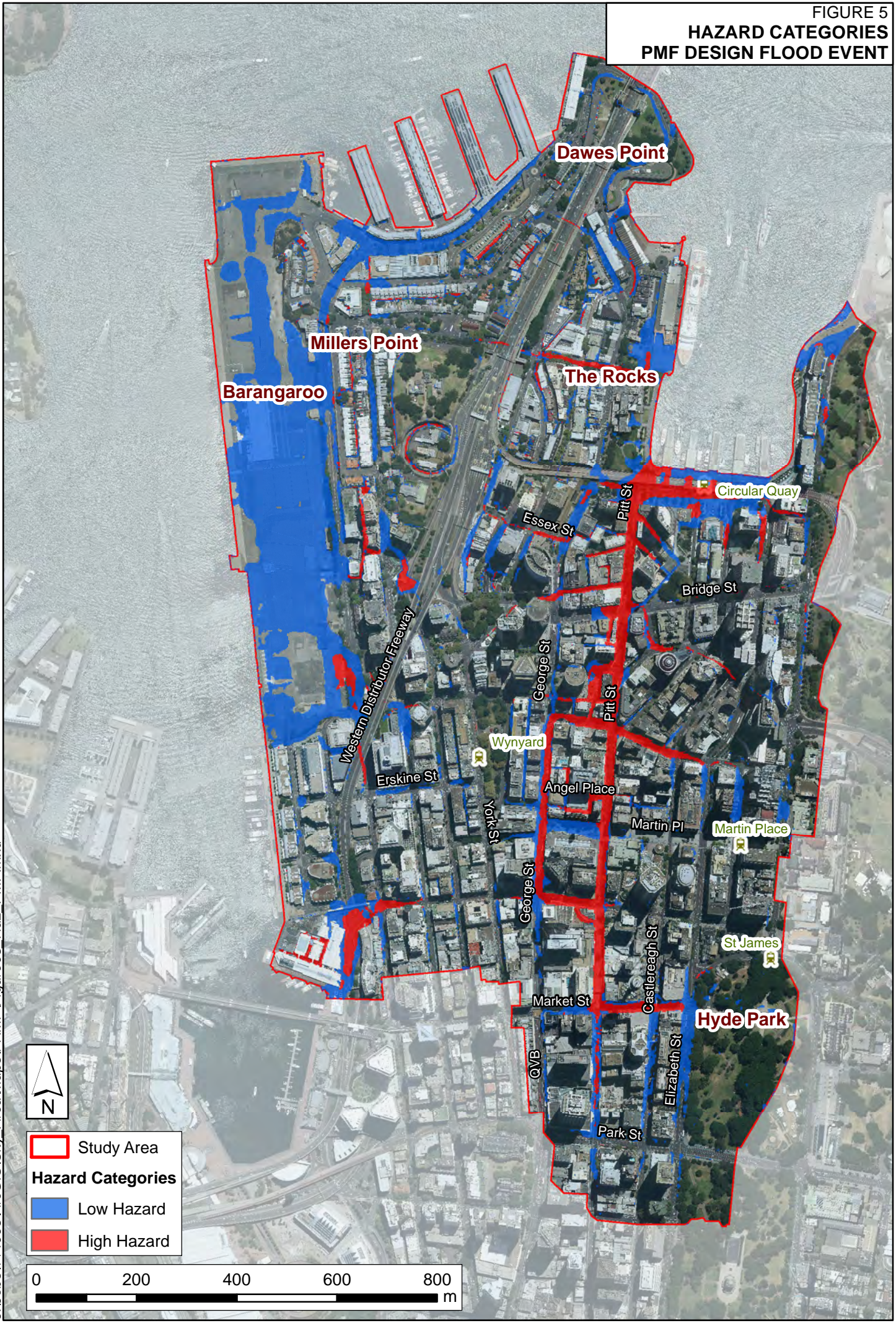


FIGURE 4  
HAZARD CATEGORIES  
1% AEP DESIGN FLOOD EVENT



FIGURE 5  
HAZARD CATEGORIES  
PMF DESIGN FLOOD EVENT



**CITY AREA  
SHORT TERM FLOOD RISK  
MITIGATION MANAGEMENT OPTIONS**

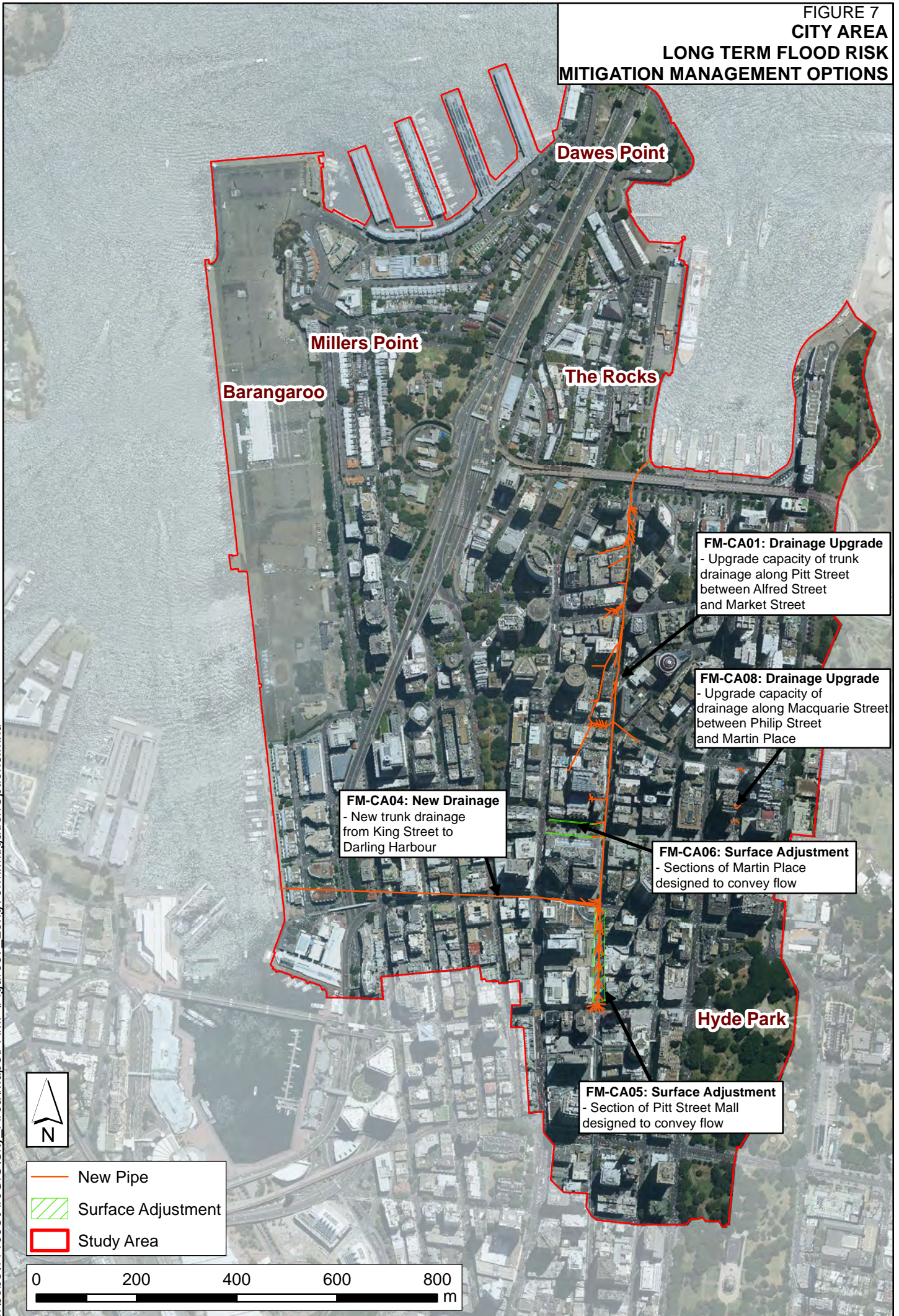
| Catchment Management Measures |   |
|-------------------------------|---|
| Reference                     | Measure   |
| PM-CA02                       | Update Sydney DCP 2012 and LEP 2012 based on FRMS&P outcomes and to inform Council's Interim Floodplain Management Policy |
| PM-CA01                       | Review FPLs following completion of FRMS&P for City Area Catchment  |
| RM-CA01                       | Use of Variable Message Displays on affected roads as part of emergency response arrangements.                            |
| FM-CA09                       | Undertake catchment specific flood damages assessment for the Sydney CBD  |
| RM-CA03                       | Develop ongoing flood awareness and public information programmes for the area.   |
| RM-CA02                       | Evacuation planning as part of REMPLAN and LEMPLAN.   |
| PM-CA03                       | Investigate flood proofing for frequently flood affected properties.  |



**RM-CA01: Variable Message Displays**  
 - Improve public awareness during a flood event,  
 reduce number of vehicles entering hazardous ponding






**FIGURE 7  
CITY AREA  
LONG TERM FLOOD RISK  
MITIGATION MANAGEMENT OPTIONS**



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-  New Pipe
-  Surface Adjustment
-  Study Area

